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Preface and acknowledgments

The second International Symposium on Performance Science, ISPS 2009, explored the theme *Performing Excellence* from interdisciplinary perspectives across the arts, as well as the natural, social, and applied sciences. Hosted by the National Institute of Creative Arts and Industries at The University of Auckland, the conference brought together delegates from over 30 countries to debate and to *experience* performing excellence through a wide array of theoretical, practical, and methodological perspectives.

This proceedings volume represents the lively discussion that ensued. Covering such topics as motivation and the development of expertise, the psychology and physicality of performance, performers' health, and the perception, analysis, and evaluation of performance, the 100 articles contained herein offer a glimpse into a growing and vibrant field.

We are grateful to several individuals and organizations whose generous support and contributions have made ISPS 2009 possible. Firstly, we wish to thank the many artists and scientists who have contributed their valuable work to both the conference and to this volume. We are also deeply indebted to The University of Auckland, Royal College of Music, and members of the Scientific and Organizing Committees for providing unwavering support for this event, from the early planning stages onwards. We are delighted to acknowledge the following partners of ISPS 2009: the Asia-Pacific Society for the Cognitive Sciences of Music (APSCOM), British Council, European Association of Conservatoires (AEC), International Association for Dance Medicine and Science (IADMS), International Society for Music Education (ISME), Performing Arts Medicine Association (PAMA), and Society for the Psychology of Aesthetics, Creativity, and the Arts. Finally, we would like to acknowledge the following individuals, who have given unreservedly of their time and ingenuity in putting this event together: Claire Speedy and Steve Burns at The University of Auckland for their tireless work in bringing this event together, and Rosie Burt-Perkins and Terry Clark at the Royal College of Music for invaluable help in editing and revising the proceedings manuscript.

Aaron Williamon
Sharman Pretty
Ralph Buck

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Keynote paper

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Performance, science, and society

Robert Winston

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The evaluation of music and musicality is of growing interest to scientists. Various technologies, particularly functional brain imaging, have increased our understanding of the perception of music, pitch, and rhythm, and research into the physiology of performance and the physics of acoustics are now important academic disciplines. There is now awareness that inspiration, intuition, and emotion are as important to the exploration of neuroscience as they are to composing and performing. Music is an art that gets closest to the basis of our humanity and opens windows of perception in unique and varied ways. This is why music is so important in human experience—from Shostakovich reflecting on death in intensive care at the end of his Fifteenth Symphony, to the Prince ludicrously elevated from his melancholy in Prokoviev's *March of the Love for Three Oranges*. And this aspect of music, its ability to manipulate our mind, has been used in various ways—from musak in supermarkets, to the pipes at Culloden or the drums and trumpets of soldiers marching into battle, from Furtwangler conducting Wagner in front of the Nazi faithful, to Puccini at a football match. This paper examines some of the relationships between music, science, and society.

Keywords: brain imaging; physiology; physics; musical perception; inspiration

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Wednesday
16 December 2009

Keynote paper

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Discovering deliberate practice activities that overcome plateaus and limits on improvement of performance

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Since Sir Francis Galton's book on *Hereditary Genius*, many scientists have argued that heritable factors set limits of performance and only allow a select few individuals to attain exceptional levels. However, recent research rejects the associated learning theory and its implied performance plateaus and shows that expert performance is mediated by acquired complex cognitive mechanisms. It describes different types of deliberate practice activities that develop and refine mental representations, which in turn permit attained performance to exceed performance resulting from extensive experience only. Empirical investigations are reviewed to show that expert performance and outstanding achievements will be primarily constrained by individuals' engagement in deliberate practice and the quality of the available training resources.

Keywords: deliberate practice; expert performance; innate talent; cognitive mechanisms; skill acquisition

Everyone has experienced the excitement associated with being introduced to a new activity and rapidly reaching an acceptable level of performance. In the beginning there are often dramatic improvements within the first few hours of introductory engagement in popular games, such as darts, volleyball, and shuffle board. Sir Francis Galton (1869/1979) summarized the popular view that performance improvements are rapid only in the start of initial training and that subsequent increases become increasingly smaller, until the performance reaches a plateau and "[M]maximal performance becomes a rigidly determinate quantity" (p. 15). According to this view, heritable capacities and innate talents set the upper bounds for an individual's physical and mental achievements. Once the performance has become immediate (automatic), then it does not seem possible that any additional amount of practice can increase the performance further. This assumed inability to influence performance through any type of practice or training provided the foundation for Galton's compelling arguments that individual differences in performance must be determined by stable unmodifiable factors, such as individual differences in innate endowment.

In the nineteenth and early-twentieth centuries, most scientists assumed an important boundary between mind and body. Consequently, when a person's performance was reported to be automatic, it no longer would reflect conscious thinking, and therefore, the speed of the execution had to be limited by physical and biological characteristics of one's body and nervous system. In his pioneering book, *Hereditary Genius* (1869/1979), Galton presented evidence that height and body size were genetically determined and, thus, could not be altered by practice. In direct analogy he proposed that similar genetic mechanisms must determine all other aspects of one's physiology, such as size of brain and speed of neurons and, therefore by inference, all mental capacities.

The most important contemporary theories of skill acquisition (Anderson 1982, Fitts and Posner 1967) are consistent with Galton's general assumptions and fit with casual observations on the development of everyday activities. After being introduced to activities such as driving a car, typing, or playing golf, an individual's primary goal is to reach an acceptable level of performance. During the first phase of learning (Fitts and Posner 1967), novices try to understand the activity and concentrate on completing their attempts successfully, as is illustrated by the cognitive phase (black segment) of the lower arm of Figure 1.

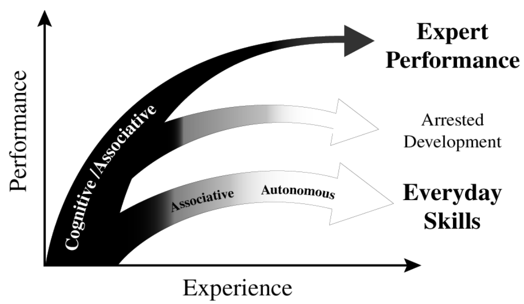

Figure 1. An illustration of the qualitative difference between the course of improvement of expert performance and of everyday activities. (Adapted from Ericsson 1998, p. 90. © European Council for High Ability, used by permission.)

With more experience in the associative phase (grey segment in Figure 1), large mistakes become increasingly rare, performance appears smoother, and learners no longer need to concentrate as hard to perform the task. After a limited period of training and experience—frequently less than 50 hours for most recreational activities—an acceptable standard of performance is attained. Once performance is autonomous (white segment in Figure 1), individuals no longer attempt further modifications and improvements, and this typically leads to a stable plateau of performance, which is consistent with Galton's (1869/1979) description. Galton, however, would argue that these stable plateaus exist not only for the acquisition of acceptable performance in casual, recreational activities, but also for the acquisition of exceptional ability in most domains.

This view of acquisition of skill is consistent with findings for amateurs' performance in tennis and golf, where they improve initially but then stay at a stable of performance level for decades of regular engagement. Performance in everyday skills, such as driving and typing (Keith and Ericsson 2007), also are remarkably stable across decades of regular activity. Finally, professional performance does not improve with experience beyond the first few years of initial experience (Ericsson 2004, Ericsson and Lehmann 1996, Ericsson *et al.* 2007). In fact, sometimes job performance decreases as function of job experience since graduation (Choudhry *et al.* 2005).

MAIN CONTRIBUTION

In most domains of professional and leisure activity, the majority of people reach stable levels of performance (plateaus) that are maintained for years and decades. These attained levels of performance are not rigidly limited by some upper bound. In their review, Ericsson *et al.* (1993) found many documented examples of individuals who, for requirements for promotion in the job, dramatically increased their performance by training—such as typing speed. In leisure activities, it is not uncommon that an adult starts taking lessons with a golf or tennis coach and, after a period of training, improves their performance. In the same review, Ericsson *et al.* (1993) proposed that for many different activities there existed deliberate practice activities that could change aspects of performance and over time increase the overall performance on tasks representative of the activity, such as time to type an unfamiliar paragraph, run 100 meters, or win chess games.

Deliberate practice differs from the mere experience of doing the task in many different ways. Perhaps the most striking way concerns the mental attitude of the individual. During deliberate practice the individual has the goal of improving some measurable aspect of their performance. For example, a recreational golfer aims their putt toward the hole on the green and either misses or drops the ball in the hole. Every time the golfer putts the ball, it is a different situation and the golfer would not know whether the mistake was caused by their putting technique, the slope of the green, the resistance of the grass, or whatever. During deliberate practice on a practice green, the golfer has the opportunity to make the same putt many times (Ericsson 2001). If the golfer closes her eyes and strokes 10 putts without seeing the results, the balls will not have the exact same trajectory and will not stop at the exact same spot on the green. In fact, the balls will form a cluster and the diameter of this cluster will be a very good predictor of golf putting performance. Elite golf players will have a tighter cluster than less skilled recreational players, but every player will show considerable variability. Hence, even world-class players can never be certain that they would sink putts over 10 feet. In fact, all that they can control is that the putt will stop within a circle near the hole. Several of the best golf players in twentieth century reported that realizing that they could not control whether a given putt would drop in the hole and therefore should not be upset with themselves as long as the putt stopped near the hole in the circle (defined by their reproducible accuracy). Based on this analysis, it is clear that training one's putting stroke, so it can be controlled to give the same/similar result for putts of different lengths is an aspect that can be much better developed on the practice green by repeated shots and systematically varied putts. Similarly, learning to read the varied shape of the green with "hills" and "valleys" so one can image the path of one's putt is also a skill that can be improved more effectively by immediate feedback and opportunities for repeated shots to explore the consequences of differences in speed over inclined planes and slopes. In a similar manner, golfers learn to better plan the ball trajectories of drives and other longer shots by getting repeated opportunities with immediate feedback.

Deliberate practice can be focused on those aspects of the game that are weakest and have the most room for improvement. During typical everyday experience in the domain, the probability that a golfer would encounter a sequence of sand trap shots in a given round of golf is small, but during practice the coach could work on sand trap shots for a full hour. Likewise, a deliberate practice session can be designed to focus on any particular aspect of someone's performance.

Identifying the aspects that should be the focus of deliberate practice requires some assessment, typically by coach or teacher. It is possible to design tasks that the individual performs several times that allow the teacher to better assess current problems or anticipated future issues with some parts of performance. In everyday life, beginners are searching for quick fixes that allow them to rapidly reach an acceptable performance. In contrast, teachers are focused on future performance and on the student acquiring the appropriate fundamentals, so that the student can master more complex techniques and reach higher levels of performance. In many domains, such as music, ballet, and gymnastics, teachers over time have developed a curriculum where there is consensus on the best ordering of techniques to be mastered in order to reach the highest levels of performance (Bloom 1985). For many domains of expertise, such as scientific research, writing, and art, there is currently less consensus on the preferred curriculum and even if a curriculum would benefit the development of creative performance.

Deliberate practice should be scheduled when the performers are rested and maximally alert, and the duration of training must be adapted so they avoid fatigue and thus are able to maintain their highest level of concentration and performance during the entire training session.

Deliberate practice requires a close connection between the actual performance and the training tasks. It is essential that some aspect of current performance is taken as the focus and that training tasks are intermittently exchanged for the real-world context so that transfer of improvements during training is successfully incorporated in the corresponding real-world performance. It is possible that the training tasks lead to performance improvements that depend on the crutches and the scaffolding during training and thus cannot be connected to the aspects of the real-world performance that were the original stimuli for the design of the practice activities.

In the rest of the paper I will discuss how these ideas have allowed researchers to identify the deliberate practice activities that have a high correlation with attained performance in numerous domains (Ericsson 2006).

Overcoming plateaus in chess

If you were a chess player in a chess club in the 1950's and were able to beat all the other players, could you, and if so how would you be able to improve your performance? At that time there were no chess computers that played chess at a world class level, and it was not that common that people travelled to tournaments to play the best players in the state, country, or around the world. Based on some informal interviews and analyses, Ericsson *et al.* (1993) proposed that it was essential for effective learning that one encountered challenging situations, where the probability of making mistakes and failure was relatively high. We proposed that one method for doing this in chess would be to buy books and chess magazines with published games between international level and world-class chess players. The aspiring chess expert would then simulate playing against these players by analyzing each position in the chess game and by trying to find the best move for every position in the game. If the chess player selected a move that matched the one picked by chess master then the chess player did as well as the master. More importantly, if the chess players picked a different move from the master then there is an opportunity for learning and improvement. Through further analysis, the chess player could attempt to figure out why the chess master's move was superior. The next step would be to think through how the chess players' processes involving search and move selection should be changed to be able to find this move as well as similar moves in other chess positions. A few aspiring chess experts reported spending 3-5 hours every day engaging in this type of solitary analysis along with studies of variants of chess openings. Subsequent studies have found that serious chess players spend as much as four hours every day engaged in this type of solitary study (Charness *et al.* 2005). Most important, these studies show that the accumulated hours of solitary analysis of chess playing is the best predictor of someone's chess skill. Somewhat surprisingly the amount chess playing with friends is not associated with increased chess-playing skill. Furthermore, these studies show that the size of someone's chess library, that is the number of chess books and chess magazines, is correlated with better chess skill—perhaps because they were necessary for solitary chess study before the emergence of chess playing computer programs and internet data bases. By spending additional time analyzing the consequences of moves for a chess position, players can increase the quality of their selections of moves. With more study, individuals refine their representations and can access or generate the same information faster. As a result, chess masters can typically recognize a superior move virtually immediately, whereas a competent club player requires much longer to find the same move by successive planning and evaluation rather than recognition (de Groot 1966). With additional time the master can often generate even better moves.

In the classical model of skill acquisition (Fitts and Posner 1967), more experience allows the person to generate the same move faster through automation. In contrast, the nature of the improvement in chess concerns the ability to generate different and better moves based on refined acquired representations and associated analysis and search (de Groot 1946/1978). The same type of improvement, based on deliberate practice and the acquisition of complex representations supporting planning, evaluation, and online monitoring of performance (cf. Ericsson and Kintsch 1995) can explain gradual and extended increases in performance in a wide range of domains, such as billiards, golf, music, Scrabble, darts, and surgery (Ericsson 2006).

Deliberate practice in typing

Most adults are able to type, yet there are often large individual differences in their style and efficiency. Adults typically do not think about their typing and simply do it, thus typing would seem to meet the criterion of low effort or even autonomous performance. A recent review (Keith and Ericsson 2007) has found that estimates of how much someone has been typing appear to be a poor predictor of measurable typing speed under standardized conditions. How could someone improve their typing performance after having typed at a similar speed for decades? The answer is clearly supported by a number of training studies. The key to improved speed in typing is to find some time during the day (Dvorak *et al.* 1936) when one is able to fully concentrate for 15-25 minutes. During that time, one finds something to copy and increases one's comfortable typing speed to a speed 15-30% faster than normal. During this faster speed it becomes apparent that some key strokes or key-stroke combinations are slower and associated with hesitations. One then works on mastering these weaknesses by focused practice and then by interweaving them into speeded typing. In an interactive fashion, we speed up one's typing to find the problems causing slower typing and then practice until the speed of typing has increased and then repeat the process. The general approach of this type of deliberate practice is to find methods to push performance beyond its normal speed—even if that performance can be maintained only for a short time. This methodology offers the potential for identifying and correcting weaker components that will improve performance.

How is it possible to improve the speed of habitual and effortless behavior? Researchers have studied the individual differences in typing speed of skilled typists and unskilled participants by having them type passages from a collection of unfamiliar texts as fast as they can without making errors. High-speed films of finger movements show that the faster typists start moving their fingers toward their desired locations on the keyboard well before the keys are struck. The superior typists' speed advantage is linked to their perceptual processing of the text beyond the word that they are currently typing (Salthouse 1984). By looking ahead in the text to identify letters to be typed, they can prepare future keystrokes in advance. This evidence for anticipation has been confirmed by experimental studies where expert typists have been restricted from looking ahead. Under such conditions their typing speed is dramatically reduced and approaches the speed of less skilled typists.

In sum, the superior speed of reactions by expert performers, such as typists and athletes, appears to depend primarily on cognitive representations mediating skilled anticipation, rather than faster basic speed of their nervous system (Abernethy 1991). For instance, expert tennis players are able to anticipate where a tennis player's shots will land even before the player's racquet has contacted the ball (Williams *et al.* 2002). Eye-movements of expert tennis players show that they are able to pick up predictive information from subtle, yet informative, motion cues, such as hip and shoulder rotation, compared to their novice counterparts. They can also use later occurring and more deterministic cues, such as racket swing, to confirm or reject their earlier anticipations.

Deliberate practice in other domains

In many domains performers and teachers have accumulated knowledge about effective methods of training and deliberate practice. They have developed curricula in a wide range of domains of expertise, such as music, ballet, gymnastics, martial arts, and so on. This implies that at some point in history one or more individuals must have discovered one of these methods for the first time. There are many documented instances of such discoveries in sports. For example, the famous long distance runners during the middle of the twentieth century, such as Emil Zatopek, developed different variants of interval training, where the runners alternate periods of fast running speed—much faster than their regular speed for endurance races—and slower speeds or even just rest (Billat 2001). These runners were vastly superior to their contemporaries, and it is likely that their superiority could be attributed to their superior training, as more recent runners are able to clearly surpass these classic runners based on the current running techniques that rely on their training innovations. Similar training innovations are found in virtually every domain of expertise.

In my early work with Bill Chase (Ericsson *et al.* 1980) on the acquisition of exceptional memory, I was fortunate to observe how our first participant, SF, encountered a plateau of performance. We were convinced that he had reached his highest level of performance at digit span after not making any improvements beyond lists with around 50 digits for over 10 hours of continued training. To test if he had reached an unmodifiable limit we presented him much longer digits (around 60 digits), and he found that he could almost recall these much longer lists. We also presented the digits at a somewhat slower rate (at 1.5-2 s per digit instead of the standard 1 s per digit) to help him test out better methods for encoding the digits. These tests convinced Bill and me, and most importantly SF, that he could still improve his performance. SF later reached a digit span of 82 digits.

For the last few decades, I have been searching for documented instances where motivated healthy individuals have reached unmodifiable plateaus that constrain their performance in a given domain of expertise. So far I have mostly encountered people who gave up their efforts because they did not think that they could reach the performance of other people, rather than that they had reached their own limits.

IMPLICATIONS

For a long time, the belief that individuals' innate capacity limits their attainable level of performance has been accepted based on indirect and weak evidence. In contrast, the theoretical framework of deliberate practice asserts that improvement in performance of aspiring experts does not result from automation due to further experience. By increasing the challenge of training, individuals can remain in the cognitive phase (see the upper curve in Figure 1) and keep engaging in deliberate practice to acquire and refine complex cognitive mechanisms that mediate how the brain and nervous system control performance.

The time has come to seek out detailed information on performance plateaus encountered by individuals motivated to improve. Scientists should document their existence and examine their structure with experiments and analyze the past training and current performance. This evidence on performance limits will allow us to evaluate different theories of the determinants of expert level performance, as well as motivate the development of new training curricula and associated deliberate practice activities in order to assess whether these plateaus reflect unmodifiable limits to the development of performance.

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Symposium:
Physical and psychological vulnerabilities in music and dance students

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Suffering for one's art: Performance related musculoskeletal disorders in tertiary performing arts students in music and dance

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The study reports the results of an intake questionnaire assessing point prevalence of performance related musculoskeletal disorders (PRMD) and pain in 151 tertiary level performing arts students in music and dance. Forty percent reported having received a medical diagnosis for a condition related to playing their instrument or performing their dance style. The most common diagnoses for music students were repetitive sprains and strains such as tennis elbow, carpel tunnel syndrome, tendonitis, tenosynovitis, and muscle tightness, including temporo-mandibular joint syndrome, tight embouchure, muscle spasm, numbness, and cramping. Sixty-four percent of the dance students had serious injuries such as broken bones, joint dislocations, cruciate ligament and meniscus tears and strains, other muscle tears, and sprains/strains in biceps, hamstrings, and ankles, tightening in hamstrings and hips, and bunions. Only 27% of the total sample reported no current pain from a PRMD; 11.3% reported suffering daily or almost daily from a PRMD. Given the high injury rates among performing arts students, injury surveillance systems may be a cost effective way to identify high risk injuries in specific cohorts, and to apply appropriately specific management and prevention strategies for musicians and dancers during their training in order to assist in the development of sustainable careers.

Keywords: performance related musculoskeletal injury; musicians; dancers; tertiary students; injury surveillance

Musicians and dancers (secondary, tertiary, and professional) are at high risk of strain and injury in the execution of their art (Barton *et al.* 2008). Approximately half of professional musicians and music students experience significant symptoms (Norris 1993, Zaza 1998) with a point prevalence of performance related musculoskeletal disorders (PRMD) ranging from 39% to 87% in adult musicians and from 34% and 47% in secondary students (Zaza 1998). Musculoskeletal injury is also the most frequent medical problem among classical and modern dancers (McBryde *et al.* 2007), with 97% of all dancers surveyed sustaining injuries over an eight month period (Ostwald *et al.* 1994). Overuse injuries account for 60-76% of all dance injuries (Bronner *et al.* 2003). Potential risk factors associated with developing PRMD in musicians include gender (females at greater risk; Barton *et al.* 2008), years of playing, instrument played (string and keyboard players at greater risk; Bruno *et al.* 2008), playing-related physical (long hours, over-practicing) and psychological stressors (self-pressure/academic), lack of preventative wellness behaviors (taking breaks), and previous trauma (Wu 2007). This study reports the results of a PRMD questionnaire to provide information regarding the point prevalence of PRMD and pain experienced by tertiary level performing arts students in music and dance as a basis for subsequent targeted preventive action.

METHOD

Participants

The sample comprised 151 students, aged from 17-50 years, with a mean age of 21.44 years (SD=5.9); 109 (72%) music and 42 (28%) dance students—54 (36%) males and 97 (64%) females—attending the National Institute of Creative Arts and Industries, University of Auckland, in March 2009. These numbers represented 48% (music) and 79.2% (dance) of the total cohort. Students completed a comprehensive questionnaire at the commencement of the academic year.

Materials

Performance related musculoskeletal variables: Performance related musculoskeletal disorders (PRMDs) were defined as "any pain, weakness, numbness, tingling or any other symptoms that interfere with your ability to play your instrument/perform your dance routines at the level to which you are accustomed. This definition does not include mild short-lived aches or pains." The following variables were selected as the dependent measures of PRMDs:

- PRMD frequency: assessed on a 10-point Likert scale (0=never, 10=daily)
- PRMD severity (worst ever): assessed on a 10-point Likert scale (0=no pain, and 10=worst imaginable)
- Current pain or injury from any cause
- PRMD duration of symptoms (in days): students indicated the duration of a current PRMD if they had one
- Pain severity for pain right now
- Pain severity for pain at its most severe

Body Mass Index (BMI): BMI is a measure of body fat based on height and weight that applies to adult men and women. People may be categorized into four weight groups based on their BMI as follows: underweight: <18.5, normal weight: 18.5-24.9, overweight: 25.0-29.9, obese: ≥30.0. Students were assessed for BMI to ascertain whether there were any differences in PRMD and pain according to weight.

Procedure

Ethics approval for the study was granted by the University of Auckland Human Participants Ethics Committee. The study was introduced to students in the first lectures of the semester through brief presentations to class groups by the lecturers and researchers. Participation information sheets were distributed to all eligible students, and those who were interested were invited to attend classes set aside for the completion of the surveys.

RESULTS

Demographics: There were 151 students [109 (72%) music and 42 (28%) dance students; 54 (36%) males and 97 (64%) females; mean age=21.44 years (SD=5.9), range 17-50 years]; 52 students (34%) were in their first year, 54 (36%) in second year, 27 (18%) in third year, 1 in fourth year (0.7%), and 17 (11%) were postgraduate students; piano students (24%), guitar (13%), violin (9%), saxophone (9%), cello (6%), drums (6%), trumpet (6%), viola (6%), flute (5%), and clarinet (5%). The remainder was studying double bass, French horn, trombone, tuba, and bassoon. The majority of dance students were studying contemporary (38%) or hip hop (29%), then jazz (14%), classical (7%), cultural (7%), tap (2%), and ballroom (2%). Of the total group, 63 (40%) reported having received a medical diagnosis for a condition related to playing their instrument or performing their dance style. Of the 109 music students, 37 (33%) reported one or more diagnoses from medical practitioners that comprised mainly repetitive sprains and strains (tennis elbow, car-

Table 1. PRMD and pain factors and descriptive and F-statistics by group.

		N	*Mean*	*SD*	*Max*	*Min*	*F*	*Sig*
PRMD frequency	Music	109	2.79	2.84	0	10	2.997	0.086
	Dance	42	3.71	3.21	0	10		
	Total	151	3.05	2.97	0	10		
PRMD severity	Music	109	3.00	2.60	0	8	1.583	0.210
	Dance	42	3.62	2.97	0	10		
	Total	151	3.17	2.71	0	10		
Pain severity now	Music	48	2.79	2.09	0	8	0.374	0.543
	Dance	27	3.11	2.31	0	8		
	Total	75	2.91	2.16	0	8		
Pain most severe	Music	48	6.25	2.10	2	9	5.852	0.018
	Dance	27	7.33	1.33	4	10		
	Total	75	6.64	1.92	2	10		
Pain duration of symptoms	Music	48	388.92	472.77	1	1680	0.003	0.960
	Dance	27	395.33	613.33	2	2184		
	Total	75	391.23	523.58	1	2184		

pel tunnel syndrome, tendonitis, tenosynovitis, and muscle tightness, including temporo-mandibular joint syndrome, tight embouchure, muscle spasm, numbness, and cramping). Of the 42 dance students, 27 (64%) reported medical diagnoses that included serious injuries such as broken bones, joint dislocations, cruciate ligament and meniscus tears and strains, other muscle tears, and sprains/strains in biceps, hamstrings, and ankles, tightening in hamstrings and hips, and bunions. Thirteen students (8.6%) reported that they had undergone surgery that they believed had an impact on their ability to play music or dance. Three nominated abdominal surgeries (appendectomy, bowel, and caesarean section), one had surgery for the removal of a cancerous tumor and the remainder nominated limb surgeries on broken bones in arms and fingers, and knee reconstructions. On the 10 point scale for PRMD frequency, where 10 represents daily occurrence, 27% (n=40) of students reported no current PRMD; 23.8% rated their PRMD frequency as 5 or higher, of whom 17 (11.3%) reported daily or almost daily occurrence of a PRMD. Forty-four students (22.5%) rated their PRMD severity above 5, and 10 students (6.6%) rated their PRMD severity to be as close to or actually the worst severity that they could imagine. Seventy-five students (50%; 48 (44%) music students and 27 (64%) dance students) reported experiencing a current

Table 2. PRMD and pain factors and descriptive and F-statistics by gender.

		N	*Mean*	*SD*	*Max*	*Min*	*F*	*Sig*
PRMD frequency	Male	54	2.04	2.53	0	10	10.331	0.002
	Female	97	3.61	3.05	0	10		
	Total	151	3.05	2.97	0	10		
PRMD severity	Male	54	2.20	2.31	0	10	11.443	0.001
	Female	97	3.71	2.78	0	9		
	Total	151	3.17	2.71	0	10		
Pain severity now	Male	24	2.33	1.97	0	7	2.530	0.116
	Female	51	3.18	2.22	0	8		
	Total	75	2.91	2.16	0	8		
Pain most severe	Male	24	5.67	2.08	2	9	10.177	0.002
	Female	51	7.10	1.68	2	10		
	Total	75	6.64	1.88	2	10		
Pain duration of symptoms	Male	24	187.75	302.98	1	1008	5.667	0.020
	Female	51	486.98	578.16	1	2184		
	Total	75	391.23	523.58	1	2184		

pain, 11.3% of whom reported suffering daily or almost daily pain. Fifty-three percent (n=40) said that their current pain was caused by playing their instrument/dancing. Seventy-two percent (72%; n=54) indicated that their current pain had a negative impact on their ability to play their instrument/dance.

Subgroup analyses: Subgroup analyses were conducted to ascertain whether PRMD and pain patterns were related to group (music or dance), gender, or body mass index (BMI<18.50 or >18.50). Dance students recorded higher mean ratings than music students for the most severe pain ever experienced (see Table 1). With the exception of current pain severity, females reported higher mean ratings on all the other PRMD and pain factors (see Table 2). Fifteen percent (n=22) of students were underweight, 70% (n=104) were of normal weight, 12% (n=18) were overweight, and 3% (n=5) were obese. Chi square analysis indicated that there were no differences in the proportions of underweight, overweight, or obese students by group or sex, and no relationship between BMI and any PRMD or pain measure.

DISCUSSION

Findings confirmed high injury rates and PRMD prevalence of performing arts students; dancers (64%) had double the rates of musicians (33%); 53% reported that their current pain was caused by their instrument/dancing. No significant differences were found between instrument groups or dance styles in terms of PRMD and pain prevalence. Females reported higher rates of PRMD and pain. BMI was not associated with either PRMD or pain. These results reinforce the need for injury management programs and injury prevention education to support sustainable careers in the performing arts. Translational research, development, and implementation are needed in both educational and professional contexts to address the unacceptably high prevalence of PRMD in performing arts students (Wynn Parry 2004).

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Practicing perfection: The physical costs of practice in tertiary music and dance students

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Despite the many physical demands involved in practice in music and dance, little attention has been paid to the impact of practice on the musculoskeletal system of young performers. We, therefore, assessed whether the amount of daily practice and the practice and rehearsal routines of tertiary music and dance students were related to the frequency and severity of reported performance related musculoskeletal disorders (PRMD) in 109 music and 42 dance (36% males) from The National Institute of Creative Arts and Industries, University of Auckland. Music students practiced, on average, 156 minutes per day, compared with 107.5 minutes for dance students. Music students spent an average of 401 minutes and dance students spent an average of 369 minutes per week rehearsing with others. Contrary to prediction, linear regression analyses showed no relationship between PRMD frequency, severity or duration, and any of the practice factors assessed. Although excessive practice is frequently cited by performing artists as one of the contributors to PRMD, this study did not confirm a relationship between practice and PRMD in this sample. It is possible that the amount of practice (2.6 hours per day in music students and 1.8 hours for dancers) fell below the threshold for a pain inducing practice period, particularly as these students reported taking rest breaks after 48 (dancers) and 60 (music) minutes' practice. Further research is needed to assess the relationship between PRMD and practice.

Keywords: practice; practice routines; musicians; dancers; performance related musculoskeletal disorders

Tertiary students in music and dance practice for many hours per day over many years, often commencing in early childhood, to perfect their art, with the hope that the years of practice will gain them a place in a leading orchestra or dance company. To achieve this goal, dancers and musicians place their bodies under tremendous stress on a regular basis, with pain and injury often being considered an occupational hazard (Brandfonbrener 2003, Bruno *et al.* 2008, Garrick and Lewis 2001, Hoppmann 2001, Hoppmann and Reid 1995, Kelman 2000). However, despite the many physical demands involved in practicing music and dance, little attention has been paid to the impact of practice on the musculoskeletal system. Systematic reviews of literature (Bragge *et al.* 2006, Wu 2007) have identified practice as a risk factor, citing long hours and over-practicing as contributors to injury, in particular the development of overuse syndromes. Hoppman and Patrone (1989) showed that longer daily practice time was significantly related to development of musculoskeletal problems, and Zetterberg *et al.* (1998) found that practice hours were related to problems in the neck and upper extremity of musicians. Bejjani *et al.* (1996) observed that overuse syndrome occurs in up to 50% professional symphony orchestra musicians and 21% music students. Morse *et al.* (2000) found that "the relationship of hours played to pain is complex, and may well be affected by risks from non-music jobs, which are very common among amateur musicians" (p. 85). Musculoskeletal injury is the most frequent medical problem among classical and modern dancers (Milan 1994, Ostwald *et al.* 1994, McBryde *et al.* 2007). Ostwald *et al.* (1994) revealed that over an eight month period, 97% of all dancers surveyed had sustained injuries. Overuse injuries account for the majority (60-76%) of all dance injuries and these are most likely to occur when fatigued or overworked (Bronner *et al.* 2003). However, there are no studies assessing the relationship between musculoskeletal disorders and practice in dance. This study assessed whether amount of daily practice and practice and rehearsal routines of tertiary music and dance students were related to frequency, severity, and duration of reported PRMDs.

METHOD

Participants

The sample comprised music and dance students in all years who were attending the National Institute of Creative Arts and Industries, University of Auckland, in March 2009. The sample comprised 151 students, 109 (72%) music and 42 (28%) dance students. These numbers represented 48% (music) and 79.2% (dance) of the total cohort. There were 54 (36%) males and 97

(64%) females. They ranged in age from 17-50 years, with a mean age of 21.44 years (SD=5.9). Students completed a comprehensive questionnaire at the commencement of the academic year.

Materials

A comprehensive questionnaire was developed to explore the relationship between practice and performance related musculoskeletal disorders in this population. The variables of interest in this paper are described below.

Practice variables: Six variables were selected as the dependent measures of practice as follows: (1) days per week of practice, (2) hours/minutes practice in one day, (3) length of practice before taking a rest, (4) time in minutes, weekly, rehearsing with others, (5) length of rest break before resuming practice, and (6) total practice, calculated using the algorithm: (days per week of practice ^{x} minutes practice in one day ^{x} rehearsal time).

Performance related musculoskeletal variables: Performance related musculoskeletal disorders (PRMDs) were defined as "any pain, weakness, numbness, tingling or any other symptoms that interfere with your ability to play your instrument or dance at the level to which you are accustomed. This definition does not include mild short-lived aches or pains." Three variables were selected as the dependent measures of performance related musculoskeletal disorders as follows: (1) PRMD frequency (n=151): rated on a 10-point Likert scale (never=0, daily=10), (2) PRMD severity (most ever) (n=151): rated on a 10-point Likert scale (no pain=0, worst imaginable pain=10), and (3) PRMD duration of symptoms (in days) (n=75): students rated the duration of a current PRMD if they had one.

Procedure

Ethics approval for the study was granted by the University of Auckland Human Participants Ethics Committee. The study was introduced to students in the first lectures of the semester through brief presentations to class groups by lecturers and researchers. Participation information sheets were distributed to all eligible students and those who were interested were invited to attend classes set aside for the completion of the surveys.

RESULTS

Descriptives, practice variables: Music students practiced, on average, 5.83 days per week (SD=1.23, range=2-7 days). Dance students practiced on average 3.64 days per week (SD=1.87, range 1-7 days). Music students practiced, on average, 156 minutes (SD=73.67, range=45-360 mins) per day, compared with 107.5 minutes (SD=71.1, range=30-300 mins) for dance students. This difference was statistically significant ($F_{1,149}$=13.42, p=0.001). Music students reported practicing on average for 61.1 mins (SD=40.4, range=0-240 mins); dance students practiced on average 47.9 minutes (SD=32.4, range=0-120 mins) before taking a break. This difference fell just short of significance ($F_{1,149}$=3.6, p=0.06). Music students reported that they took, on average, a 19 min rest (SD=29.8, range=0-240 mins) compared with dance students, who broke for an average of five minutes (SD=4, range=0-15 mins) before resuming practice. This difference was statistically significant ($F_{1,149}$=9.1, p=0.003). Music students spent an average of 401.2 mins per week (SD=308.2, range=0-1800 mins) rehearsing with others; dance students spent an average of 368.9 mins (SD=380.4, range=0-1800 mins) rehearsing with others. This difference was not statistically significantly different ($F_{1,149}$=0.287, p=0.59). Data on "total practice" were available for 147 students. The mean total involvement in some form of weekly practice was 1180 mins per week (19.67 hours) [SD=673.2 mins (11.2 hours), range=60-2880 mins (1- 48 hours)].

Descriptives, performance related musculoskeletal variables: Music students' average rating for PRMD frequency was 2.79 (SD=2.84, range=0-10), PRMD severity was 3.0 (SD=2.60, range=0-8), and duration of symptoms for the 48 reporting a current PRMD was 388.9 days (SD=472.8 days, range=0-1680). For dance students, PRMD frequency was 3.8 (SD=3.2, range=0-10), PRMD severity was 3.7 (SD=2.9; range=0-10), and duration of symptoms for the 27 reporting a current PRMD was 401.6 days (SD=632.96 days, range=2-2354).

Analyses: A series of linear regression analyses were conducted to assess the association between practice and rehearsal routines and frequency, severity, and duration of PRMDs. Because they were assessed on different scales, the dependent measures were converted to Z scores prior to analysis. The dependent variables were PRMD frequency, severity, and duration, and the independent variables were minutes practiced per day, length of rest breaks between practice sessions, amount of rehearsal time per week, and total practice. As predicted, there was a significant relationship between the amount of practice and length of rest breaks before resuming practice (R^2=0.56), with longer practice sessions tending to be followed by longer rest breaks. The relationship between PRMD frequency and PRMD severity was also significant and in the expected direction (R^2=0.48, $F_{1,149}$=136.7, p=0.001). However, contrary to prediction, there was no relationship between PRMD frequency, severity, or duration, and any of the practice factors assessed. For the dependent variable total practice, there was no relationship between practice and any of the PRMD variables (R^2=0.83, $F_{1,149}$=1.26, p=0.29). Inspection of the standardized Beta coefficients indicated that the strongest relationship was between PRMD severity and total practice (β=.26, t=1.58, p=0.12). Because of the very great differences in amount of weekly practice in this sample, two groups were created by median split into “practiced less than 1080 minutes per week” (52.4% of sample) and “practiced more than 1080 minutes per week” (47.6% of sample). One way analysis of variance (ANOVA) was conducted on these groups with PRMD duration, frequency, and severity as the dependent variables. There were no significant differences on any of these three variables between low and high practice groups: PRMD duration ($F_{1,73}$=0.33, p=0.07), frequency ($F_{1,145}$=0.12, p=0.73), and severity ($F_{1,145}$=0.97, p=0.33). This analysis was run separately for musicians and dancers, and again there were no significant differences between high and low music or dance practicers and PRMD outcomes.

DISCUSSION

Contrary to prediction, there was no significant relationship between practice and PRMD frequency, severity, or duration in this sample. It is likely that the amount of practice fell below the threshold for a pain-inducing practice period. For those students suffering PRMDs, practice may act as a risk factor or contributor in exacerbating their injuries, although may not necessarily be the root cause of their injury. A number of factors not assessed in this study may contribute to the relationship between practice and PRMDs. These include correct performance technique, technically correct practice, physical characteristics, and level of fitness of participants and work history. Further research is needed to assess the relationship between PRMD and practice.

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The factor structure of the revised Kenny Music Performance Anxiety Inventory

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This study assessed the factor structure of the revised Kenny Music Performance Anxiety Inventory (KMPAI) using a sample (n=151) of tertiary music and dance students attending the National Institute of Creative Arts and Industries, University of Auckland. The scale consists of 40 items that assess the factor structure of the revised, expanded KMPAI to ascertain whether it captured the latent etiological factors identified by emotion theory underlying performance anxiety. Students completed the (revised) Kenny Music Performance Anxiety Inventory at the commencement of the 2009 academic year. Principal component analysis (with varimax rotation) of the KMPAI revealed three latent factors and 12 underlying factors, as follows: early relationship context comprising generational transmission of anxiety and parental empathy; psychological vulnerability comprising controllability, depression, hopelessness, and trust; and proximal performance concerns comprising somatic anxiety, pre- and post-performance rumination, self/other scrutiny, performance outcome concerns, memory reliability, and commitment to performance. These results provide initial evidence of the complex structure of music performance anxiety, particularly in its severe form, and indicate that management and treatment of the condition will need to be tailored to the individual's pattern of contributing causal features.

Keywords: music performance anxiety*;* Kenny Music Performance Anxiety Inventory; factor structure; musicians; dancers

Current conceptualizations of music performance anxiety tend to focus on state cognitive and somatic anxiety prior to or during performance and fail to take account of the etiological complexity of the condition (Kenny and Osborne 2006). Kenny (2004, 2009) developed the Kenny Music Performance Anxiety Inventory (KMPAI) to include the assessment of underlying psychological vulnerabilities according to Barlow's emotion based theory of the etiology of anxiety disorders, as well as pre-performance experiences, as a step in aiding the development of a more comprehensive conceptualization of the condition and to provide a more appropriate focus for comprehensive treatments for performing artists suffering from performance anxiety. The aim of this study was to assess the factor structure of the revised, expanded KMPAI to ascertain whether it captured the latent etiological factors identified by emotion theory (Barlow 2000).

METHOD

Participants

The sample comprised music and dance students in all years who were attending the National Institute of Creative Arts and Industries, University of Auckland, in March 2009. The sample comprised 151 students: 109 (72%) music and 42 (28%) dance students. These numbers represented 48% (music) and 79.2% (dance) of the total cohort. There were 54 (36%) males and 97 (64%) females. They ranged in age from 17-50 years, with a mean age of 21.44 years (SD=5.9).

Materials

Students completed the revised Kenny Music Performance Anxiety Inventory (KMPAI, Kenny 2009) as part of a comprehensive survey of at the commencement of the academic year. This is a 40 item version of the earlier inventory (see Table 1).

Procedure

Ethics approval for the study was granted by the University of Auckland Human Participants Ethics Committee. The study was introduced to students in the first lectures of the semester through brief presentations to class groups by lecturers and researchers. Participation information sheets were distributed to all eligible students and those who were interested were invited to attend classes set aside for the completion of the surveys.

Table 1. Rotated factor structure of the revised 40 item Kenny Music Performance Anxiety Inventory.

Factor		*Factor loading*
1.	*Depression/hopelessness (psychological vulnerability)*	
	I often feel that I am not worth much as a person	0.665
	Sometimes I feel depressed without knowing why	0.646
	I often feel that I have nothing to look forward to	0.602
	I often feel that life has not much to offer me	0.542
	I often find it difficult to work up the energy to do things	0.474
	Sometimes I feel anxious for no particular reason	0.460
	I worry that one bad performance may ruin my career	0.426
	I am often concerned about a negative reaction from the audience	0.335
	I find it easy to trust others (-)*	0.332
2.	*Worry/dread (negative cognitions)*	
	Thinking about the evaluation I may get interferes with my performance	0.630
	During a performance I find myself thinking about whether I'll get through it	0.613
	I often prepare for a concert with a sense of dread and impending disaster	0.600
	Even in the most stressful performance situations, I am confident that I will perform well (-)*	0.586
	My worry and nervousness about my performance interferes with my focus and concentration	0.540
	Even if I work hard in preparation for a performance, I am likely to make mistakes	0.417
3.	*Proximal somatic anxiety*	
	Prior to, or during a performance, I experience increased heart rate like pounding in my chest.	0.761
	Prior to, or during a performance, I experience shaking or trembling or tremor	0.609
	Prior to, or during a performance, I feel sick or faint or have a churning in my stomach	0.582
	Prior to, or during a performance, I get feelings akin to panic	0.573
	Prior to, or during a performance, I have increased muscle tension	0.425
	Prior to, or during a performance, I experience dry mouth	0.411
	I remain committed to performing even though it terrifies me	0.399

Note. (-)* indicates reverse scored items.

Table 1 (cont.)

Factor	*Factor loading*
4. *Parental empathy*	
My parents were mostly responsive to my needs (-)*	0.836
My parents always listened to me (-)*	0.704
My parents encouraged me to try new things (-)*	0.660
5. *Memory*	
When performing without music, my memory is reliable (-)*	0.901
I am confident playing from memory (-)*	0.802
6. *Pre- and post-performance rumination*	
After the performance, I replay it in my mind over and over	0.619
I worry so much before a performance, I cannot sleep	0.524
7. *Generational transmission of anxiety*	
One or both of my parents were overly anxious	0.638
Excessive worrying is a characteristic of my family	0.624
As a child, I often felt sad	0.431
8. *Self/other scrutiny*	
I am concerned about my own judgment of how well I will perform	0.638
After the performance, I worry about whether I played well enough	0.413
I am concerned about being scrutinized by others	0.323
9. *Controllability*	
I generally feel in control of my life (-)*	0.609
I never know before a concert whether I will perform well	0.478
10. *Opportunity cost*	
I give up worthwhile performance opportunities due to anxiety	0.534
11. *Trust*	
I find it difficult to depend on others	0.641
12. *Pervasive anxiety*	
From early in my music studies, I remember being anxious about performing	0.515

RESULTS

Principal axis factoring (with varimax rotation) of the KMPAI revealed 12 underlying factors, which can be subsumed under the following categories (number in parentheses indicates subscale number as indicated in Table 1):

- Early relationship context: (7) Generational transmission of anxiety, (4) Parental empathy
- Psychological vulnerability: (1) Depression/hopelessness, (9) Controllability, (11) Trust, (12) Pervasive performance anxiety
- Proximal performance concerns: (3) Proximal somatic anxiety, (2) Worry/dread (negative cognitions), (6) Pre- and post-performance rumination, (8) Self/other scrutiny, (10) Opportunity cost, (5) Memory reliability

DISCUSSION

These results provide initial evidence of a complex structure for music performance anxiety, particularly in its severe form, that is consistent with the emotion based theory of the anxiety disorders. These data indicate that management and treatment of music performance anxiety will need to take account of multiple factors in its etiology and maintenance, with a broader focus than proximal performance concerns. Results of this study will need to be replicated on other samples and tested on professional musicians to cross-validate the factor structure of the revised KMPAI beyond student populations.

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Thematic session:
The vocabulary of performance

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Linguistic limitations of describing sound: Is talking about music like dancing about architecture?

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Verbalizing sound quality presents a challenge to musicians and pedagogues in describing a complex sensory phenomenon. Verbal descriptions may only be effective when a performer's sound translates easily and completely into words. A verbal overshadowing (VO) effect may occur when a verbal description distorts the recall of the original aural memory. The aim of this study is to examine the impact of verbal overshadowing in a music performance context. This exploratory pilot project builds on VO research in other fields to assess the value and limitations of language in describing performers' sound quality. Outcomes will have implications for musicians and pedagogues in the use of language in music teaching and learning.

Keywords: music perception; verbalization; auditory recognition; music performance; singing voice

Verbal overshadowing (VO) can occur when we use words to describe sensory experiences (such as sight, taste, or hearing). Numerous studies have examined this phenomenon in face, taste, and sound recognition and report that verbal description, or verbal encoding, impairs later recall of the respective experience. Individuals were less likely to identify the target stimuli from a line-up (Parr *et al.* 2002, Perfect *et al.* 2002, Schooler and Engstler-Schooler 1990). The perception and description of music performance presents a similar sensory challenge. Can words adequately capture sound quality in a music performance? And if so, which terms or group of terms are most effective in expressing sound quality?

The VO effect has been most apparent in face recognition, where witnesses to crimes have to describe the perpetrator of a robbery in detail and later select their face from a photographic line-up. The act of verbal description has negatively influenced individuals' ability to recognize the face they described in words (Schooler and Engstler-Schooler 1990). Empirical studies have confirmed this VO effect in facial recognition by comparing verbal description groups with memory-only control groups. More recent studies have demonstrated that there is a similar VO effect on listeners' ability to recognize spoken voices following verbal description while no-description control groups were able to isolate the voice from a line-up (Perfect *et al.* 2002, Vanags *et al.* 2005). Interestingly, expert wine-tasters were more likely than novices to recognize wine-relevant odors by their verbal labels (Parr *et al.* 2002) despite the fact all tasters had knowledge of language used to describe wine. Novices may have lacked the ability to separate perceptual and linguistic skills while experts' superior perceptual skills protected them from linguistic interference to taste recognition.

In music, the modality of the stimuli (aural) does not match the task (verbal description), yet we rely on verbal descriptors to explain and communicate our perception of sound quality in training and assessment. There is growing interest in the way listeners perceive, rate, and describe music performances. Like the witnesses above, listeners form a global impression of the performance or performer and use a limited selection of verbal descriptors to explain the reasons for their judgments. They focus on the more easily verbalized technical and performance components rather than describing overall quality (Davidson and Coimbra 2001, Stanley *et al.* 2002). In fact, examiners have even noted candidates' dress and stage manner to facilitate later recall of individual singers' performances for discussion and assessment (Davidson and Coimbra 2001). It is more natural to conceptualize sound as belonging to a sound-producing object, rather than analyze the components that make up the sound (Ekholm *et al.* 1998). The use of language may effectively hinder our recall of performers and performances.

While there is a growing body of knowledge focused on categorizing terminology used in describing vocal quality, there is still much to be learned about verbal descriptors in listeners' perception of music performance. Communication may focus on the most easily verbalized characteristics in the sound rather than individual composition of these characteristics that makes a sound unique (Kenny and Mitchell 2006, Mitchell and Kenny 2006). Verbalization, rather than enhancing interpretation of sound qualities, may have a disruptive effect on listeners' recall and communication of music performance. The main objective of this project is to examine impact of verbal description on the recall of music performances and, specifically, singers. It investigates whether verbal overshadowing (VO), or putting a sound "into words," distorts listeners' memory and subsequent recall of the original performance or performer. This paper presents work in progress, the full details of which will be reported in subsequent publications.

METHOD

Participants

Singers and listeners were recruited from the staff and students at the Sydney Conservatorium of Music (SCM).

Materials

Singers (n=6) performed two short song excerpts in a sound-treated studio at SCM and recorded using a matched pair of stereo microphones (Neumann KU100, ORTF configuration). Samples of their recordings were played to listeners in the perceptual test.

Procedure

Listeners (n=24) were asked to attend a single listening session at SCM and were informed that the purpose of the study was to investigate the effect of visual and verbal tasks on the ability to recognize aural stimuli. Audio samples were played to listeners from a CD player via circum-aural closed-back stereo monitoring headphones (Sennheiser HD 270) to ensure that each listener heard the same quality of sample. Listener participants were assigned to either a *verbal description* group or a *non-description* control group.

Listeners were presented with a short sample of a single singer performing *song 1* (for encoding) on CD. Singer presentation was randomized from the six singers. Listeners were then asked to perform a visual maze task on paper (a filler-task) for 10 mins. In the following 5 mins, the experimental group was asked to write a detailed description of the voice they heard at the start of the test, while the control group completed an anagram puzzle. Finally, both groups were presented a line-up of six voices singing a short excerpt from *song 2* and were asked to identify the original voice they heard and to rate their confidence in their response on a scale of 1-10 (1=not confident, 10=very confident).

RESULTS

Listeners' responses were examined for correct voice identification by each group (verbal description and non-description control). Ten of 24 listeners

Table 1. Correct and incorrect voice line-up identifications, and mean confidence scores for the verbal description and non-description groups.

	Verbal description group	*Non-description control group*
Correct identification	4	6
Incorrect identification	8	6
Mean score (SD) for confidence in choice	5.7 (2.1)	6.3 (2.2)

correctly identified their target voice from the line-up. Table 1 shows the distribution of responses by experimental group. Fifty percent of the control group and 33% of the verbal description group correctly identified their target voice.

Verbal descriptions

For the written descriptions of target voices, listeners were instructed to focus on the characteristics of the voice singing the target song rather than the song the singer sang. Most listeners identified that the singer was a soprano, although some listeners debated whether their target singer might be a mezzo soprano, with comments such as: "slightly darker sound than for soprano" and "voice in a lower timbre to that of a soprano." Eight listeners mentioned their target singer's use (or lack) of vibrato—for instance, "singer does not use an abundance of vibrato," "smooth even vibrato on long notes but none on shorter notes," and "vibrato enlarged at the end of phrase; vibrato change may be for emotional purpose?".

Seven listeners mentioned the singer's diction or articulation of language: "good diction," "the articulation of the words was extremely clear," and "when singing, the words are clearly understandable." Listeners made general judgments about the quality of their target voices without expressing the reasons that motivated their statements: "not very expressive at all, after thinking about it; quite boring," "not the style of music I listen to but singer is good," "quality of the instrument has potential, needs refinement of technique to bring out the individual voice, but she is still young," and "sings in an unemotional way (possibly she doesn't know/understand what she's saying)." Some listeners mentioned words usually associated with classical singing voice, such as "rich and smooth," "bell-like," "round," and "covered" while others used technical descriptors like "support" and "projection." For two listeners, the sound they heard evoked a mental picture of the target voice singing: "English accent/Anglo-Saxon, blonde, quite tall" and "image evoked based on sound: larger brunette female…solid, fairly tall."

DISCUSSION

This is the first study to investigate the effect of VO in the perception of music performers. Verbal description decreased listeners' likelihood of identifying the target voice but only showed a slight reduction in listeners' confidence in their identification choice. Listeners were less likely to pick the correct voice but were not aware that verbalizing their perception of the target voice reduced their ability to achieve correct identification.

Listeners' responses in this study follow a similar test of spoken voice recognition (Perfect *et al.* 2002), where only 50% of listeners in the non-verbal group and 21.4% of the verbal description group correctly identified the target voice from a line-up. This project will confirm if music listeners are similarly susceptible to the effects of VO when they describe singing voices.

Listeners' descriptions of the target voices illustrated the limits of language to communicate music perception. Examination of the comments further confirmed that vocal quality is difficult to articulate or itemize (Davidson and Coimbra 2001, Ekholm *et al.* 1998). While verbalizing sound quality in this context proved an unusual challenge, listeners still resorted to descriptions of the song, or indeed of the person singing, rather than attempt to describe the idiosyncrasies of each voice.

These preliminary results form part of a more extensive study investigating the nature of VO effects in music listeners and the extent to which the results from VO studies in other domains generalize to the musical context. Moreover, this ongoing work is also highlighting the complexities and ambiguities in describing singing voices linguistically.

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The influence of listeners' singing experience and the number of singers on the understanding of sung text

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An important aspect of perceiving sung music is understanding the words. Previous research has suggested several factors affecting the intelligibility of sung text. This study investigates two of those factors: the number of singers and the singing expertise of the listener. We expected more singers to cause greater variability in the acoustic signal and be harder to comprehend. Listeners who are themselves experienced singers are more likely to be attuned to factors affecting singers' diction and were expected to be better than non-singers at understanding the sung text. Forty eight participants, half accomplished singers and half self-reported non-singers, listened to four 8-bar unaccompanied songs twice (in order to test for familiarity) and wrote out the texts as they heard them. Two performances were given by a soloist, two by a trio of singers in unison. Participants were significantly better at understanding the words on the second hearing than the first, and singers significantly better than non-singers overall. There was no effect of the number of singers. Hence familiarity and singing experience both benefited sung text understanding. An effect of the number of singers may be more apparent when comparing a soloist with a choir.

Keywords: singing; intelligibility; expertise; ensemble; lyrics

Much music is sung, whether accompanied or *a cappella*, and whether solo or ensemble. An important aspect of perceiving sung music is the extent to which the words can be understood. Much of the existing empirical research on intelligibility has focused on isolated vowels sung by solo singers, at various pitches (Sundberg 1987, Benolken and Swanson 1990, Hollien *et al.*

2000). Recently, however, Collister and Huron (2008) compared the intelligibility of solo sung versus spoken whole words, investigating consonant confusions as well as vowels. Their results showed many more identification errors for sung words.

Intelligibility is clearly an issue, however, for groups of singers such as choirs: Fisher (1991) developed a research-informed "articulatory diction development method" in response to the finding that "approaches to choral diction...are based primarily on tradition and personal preference" (p. 270); Racette *et al.* (2000) suggest that choral singing may be more effective than solo singing for improving word intelligibility (for aphasics) since it "may entrain more than one auditory-vocal interface" (p. 2571), while Emmons and Chase (2006) argue that, in the interests of better diction, consonants should be "approximated" and vowels modified.

Two years ago, we reported the results of a survey of listeners' views on factors that might affect the intelligibility of sung text (Fine and Ginsborg 2007a). Almost 400 open-ended statements were provided by 94 respondents, most of whom devoted much of their music listening to vocal and choral music, and stated that the intelligibility of sung text was important to them when listening to lyrics in their own, or another language. We had suggested four possible broad categories of factor, relating to performer(s), environment, listener, and music and/or lyrics. As expected from the research on intelligibility cited above, a third of all statements concerned performer-related factors including articulation, diction and enunciation, breathing and phrasing, communicating text, expression and stage presence, voice quality, and range. One additional factor suggested was "choral ensemble."

We then explored the effect of expertise. Our respondents were roughly equally divided between experts (professional, semi-professional, and student singers, and some singing teachers) and non-experts (amateur singers and non-singers) (Fine and Ginsborg 2007b). The singing teachers—perhaps as they are in the business of improving singers' skills, including intelligibility—made the highest proportion of performer-related statements.

We are now investigating some of the factors nominated by our survey respondents in subsequent empirical research, in order to increase our understanding of how to enhance the intelligibility of sung text and improve singers' diction through more effective vocal pedagogy. The present study investigates two factors: (1) number of singers and (2) listeners' experience of singing. More singers are likely to cause more variability and "noise" in the acoustic signal, thus making its decoding and understanding more difficult; indeed, some questionnaire respondents reported that choirs are generally harder to understand than solo singers. If listeners are themselves experienced singers, they are more likely to be attuned to factors affecting singers' diction, and they may be better than non-singers at resolving the acoustic signal into recognizable words.

Our aims were, therefore, twofold. First, we asked if sung text is harder to understand when performed by a group of singers rather than a soloist. We predicted that a single singer would be easier to understand than multiple singers, even when singing in unison. Second, we investigated the extent to which the listener's singing experience affects his or her ability to understand sung text, even when the piece of music is unfamiliar. It was hypothesized that expert singers would be better at comprehending sung text because of their own experience of singing words.

METHOD

Participants

There were 48 participants (15 M, 23 F), with a mean age of 36.2 years (one participant did not give her age). Half were self-reported singers (mean age=36.9 years) and half self-reported non-singers (mean age=35.6 years).

Materials

Four songs, consisting of 8-bar melodies in duple time by Glinka and Hundley, were used. Texts by Shanks and Purdy were set respectively to two of these songs. A sequence of numbers interspersed with shorts words ("and," "no," and "the") were set to the same melodies to create the other two songs. All four songs have been used in previous research on singers' memory (Ginsborg 2002). The songs were recorded both by a solo soprano and by a trio (F, M, M) singing in unison. All stimuli were recorded in the same room at 48 kHz, 24 bit resolution onto a digital audio workstation, and then encoded as mp3 files at a constant bit rate of 320 kilobits per second (kbit/s). The microphone was a Neumann KM130 omnidirectional condenser placed about 30 cm from the singer(s). All songs were unaccompanied. Stimuli were played to participants as mp3 files on a laptop using its internal speakers. All participants stated that the stimuli were loud enough.

Procedure

Participants first completed a short questionnaire asking about their singing experience and how much they listened to sung music. They heard a short practice stimulus (4-bar melody in duple time), and then listened to four of the eight melodies, two solo and two ensemble. The exact melodies used were counterbalanced, so each stimulus was heard by 24 participants.

Each test stimulus was presented twice and the participants were instructed to write down the words they heard sung. On the first hearing of each song, a pause was given after each line to allow the participant to catch up (as the focus of the study was perception rather than memorization ability). The second time through, the stimulus was played without breaks. Different pens were used on each hearing so that writing differences by hearing were apparent during subsequent scoring.

The productions were then scored as follows. An error was counted for every word missing or incorrectly heard, and for each additional word. Incorrect order of words or numbers was not counted as an error, as memory was not being tested. Errors were then subtracted from the total number of words in the song (varying from 22 to 27), and then the performance score was transformed into a percentage, used in the analyses below.

RESULTS

The participants were asked for their singing experience on a 5-point Likert scale (1=non-singer, 2=occasional singer, 3=keen amateur singer, 4=semi-professional singer, 5=professional singer). They were split into two groups (24 had answered 1-2, 24 answered 3-5). On average, the singers had sung for 22.8 years, tended to rehearse for 3.7 hours per week, and reported listening to sung music 6.9 hours per week. On average, the non-singers had sung for 0.9 years, did not rehearse at all, and reported listening to sung music for 10.5 hours per week.

Mean performance data (understanding sung text) are shown in Table 1. A mixed Analysis of Variance (ANOVA) was carried out. The within-subject variables were number of singers (solo vs. ensemble) and hearing (first vs. second). The between-subject variable was singing experience (singer vs. non-singer). The dependent variable was % performance score. Hearing was highly significant ($F_{1,46}$=82.13, $p<0.001$), with better performance on the second hearing (94.8%) than the first (90.1%). Singing experience was also significant ($F_{1,46}$=5.95, $p<0.02$), with singers scoring 94.1% and non-singers scoring 90.8%. However, number of singers was not significant (92.9% solo, 92.0% ensemble).

The relationships between experience and performance factors were investigated. Overall performance significantly correlated with singing experience (r_{48}=0.31, $p<0.05$), number of years singing (r_{48}=0.33, $p<0.05$), hours of singing per week (r_{48}=0.45, $p<0.01$), and number of hours listening to sung

Table 1. Sung text understanding performance (mean percentage data).

	Solo		*Ensemble*	
	First hearing	*Second hearing*	*First hearing*	*Second hearing*
Singers	92.1	96.4	91.3	96.6
Non-singers	89.3	93.9	87.6	92.5

music per week (r_{48}=-0.31, p=0.05). Not surprisingly, singing experience also correlated with years singing (r_{48}=0.84, $p<0.001$) and number of hours singing per week (r_{48}=0.77, $p<0.001$). When the singers and non-singers were investigated separately, the only significant correlations were, for singers, age and years singing (r_{23}=0.84, $p<0.001$) and, for non-singers, overall performance and hours listening to sung music (r_{24}=-0.53, $p< 0.01$), which was unexpectedly a negative correlation.

It was notable that certain words were more often misheard than others. A preliminary survey shows the following words were misheard or omitted by more than a quarter of the participants (n=12): "run," "fields," "still," "no," "the," and "are." In particular, non-numeric words were often missed in the number stimuli, perhaps due to the lack of semantic context. The patterns of words misheard varied slightly between the solo and the ensemble stimuli.

DISCUSSION

Overall, participants could understand the sung words well (92% accuracy). The hypothesis that experienced singers would find it easier to understand sung text than inexperienced or non-singers was supported, both by more accurate text identification for singers than for non-singers and a significant correlation between singing experience and overall performance. This may be because singers are used to producing sung text themselves, and therefore better attuned to understanding text sung by others. They will also have experience of being in rehearsals and performances, and hearing others sing while knowing the words themselves, forging a stronger connection between the words and their sung acoustic signals.

However, the results do not support the hypothesis that ensemble singing is harder to understand than solo singing, with no significant difference in performance evident between the two conditions. This may be because the three singers involved all concentrated on making diction as clear as possible so there were few substantial differences between the stimuli in the acoustic signal. Another possible reason is that ensemble effects only really become apparent when there are many singers (even small choirs normally contain at least eight singers). These results are considered inconclusive and are not sufficient to reject the hypothesis; further study will be undertaken with larger ensembles, and also consider the effect of harmony versus unison singing. Hearing the song for a second time significantly improved intelligibility and underlines the importance of familiarity and repeated hearings on listeners' ability to understand sung text. However, there were certain words that were still hard to understand on the second hearing. In future studies, it would be interesting to investigate the acoustic properties of these words and also the effects of the presence or absence of semantic context on intelligibility.

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The PC-survey: How does use of performance cues vary across musicians, instruments, musical styles, and performances?

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Performance cues (PCs) are the mental landmarks that a musician monitors to track the progress of a piece as it unfolds during performance. We describe a survey to determine how PC use is affected by experience, instrument, musical style, and by the goals of the performance. We summarize results from longitudinal case studies in which PCs were reported to suggest the kind of variation to be found. Understanding how musicians use PCs should improve pedagogy by increasing our understanding of how musicians memorize.

Keywords: music performance; memory; performance cues

Performance cues (PCs) are the landmarks in a piece of music that a musician thinks about during performance. They provide a mental map of the piece that allows the performer to monitor the music as it unfolds and to recover from mistakes and memory lapses. PCs are prepared during practice so that they come to mind automatically on stage, giving the musician the ability to focus on each aspect of the piece at the right moment, providing the flexibility needed for musical spontaneity and to recover from disruptions.

We know that musicians use PCs from longitudinal case studies in which experienced performers recorded their practice as they prepared new pieces for performance and then reported the PCs that they used (Chaffin 2006, Ginsborg *et al.* 2006, Chaffin *et al.* 2002, in press). The validity of the reports was supported by behavioral evidence from practice, polished performance, and written recall.

MAIN CONTRIBUTION

Here, we describe a survey of PC use designed to find out how the number and type of PCs that a musician uses is affected by experience, instrument, musical style, and type of performance. We plan to ask musicians to report PCs for two pieces (one easy, one harder to prepare) that they have already prepared or are in the process of preparing for performance. Although we call it a "survey," each musician's contribution is more like a case-study, but with no recording of practice. Colleagues and their graduate students at a variety of institutions will conduct an open-ended series of independent but related studies, each composed of several of these case studies and each contributing to a central database. In this way, we will build up a more comprehensive picture of PC use. Meanwhile, the local investigators will answer specific questions about factors affecting PC use such as, for example, effects of conservatory training.

We will describe the procedure to be used in the survey and then report results from longitudinal case studies conducted to date to provide an indication of the kinds of results that we expect to obtain.

Types of PC

We have found it useful to distinguish five main types of PC: structure, expression, interpretation, basic technique, and shared. Structural PCs are critical places in the formal structure such as harmonic and melodic boundaries. Expressive PCs represent turning points in the musical feeling (e.g. excited or sad). Interpretive PCs represent the changes in tempo, dynamics, timbre, or color that accomplish these expressive effects. Basic PCs represent details of technique that must be implemented in order to be able to produce these musical gestures as planned, such as a fingering required to set up the hand for what follows. Shared PCs coordinate ensemble playing.

Basic PCs vary considerably across instruments. Many instruments require attention to fingering, while a singer might think instead about breath control. String players must attend to left hand shifts and to right hand changes in bowing direction. Some kinds of interpretive PCs appear to be common across instruments (e.g. phrasing, dynamics, and tempo), while others are instrument specific (e.g. pedaling on the piano, intonation for strings, word meaning for singers).

Several PCs may refer to a single place in the music (see Figure 1). For example, basic, interpretive, and expressive PCs at the same spot might indicate a pianist's decision to use the "1st finger" (basic) in order to play forte (interpretation) because this is the "emotional climax" (expression). The presence

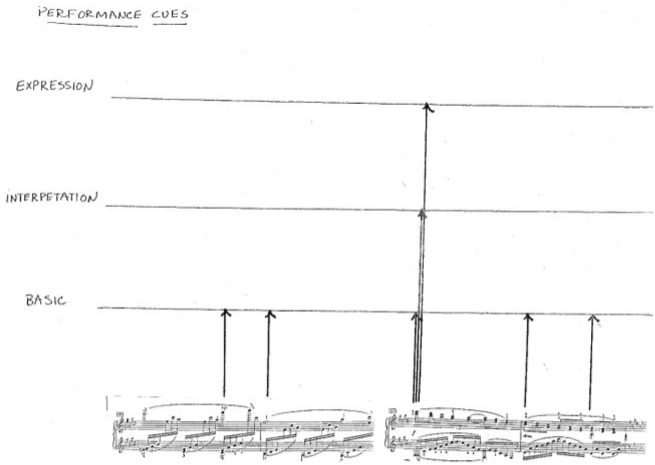

Figure 1. One page of a PC report by pianist Gabriela Imreh for Claude Debussy's Clair de Lune showing expressive, interpretive, and basic PCs.

Figure 2. Excerpts from PC reports made by cellist Tânia Lisboa for J. S. Bach's *Cello Suite VI* (Prelude) on four separate copies of the score for (1) structure (top left: harmonic (H), melodic (M), and lower level (L_3) boundaries), (2) expression and interpretation (top right, interpretive PCs in parentheses), (3) hand position and intonation (bottom left, red and black respectively), and (4) bowing and fingering (bottom right, red and black respectively). (See full color version at www.performancescience.org.)

of the three different PCs would indicate that the pianist was prepared to think of any or all of these aspects at this point.

The musician does not necessarily think of every PC in very single performance. In reporting the presence of a PC, the musician is saying that s/he is prepared to think about this feature of the music during performance, if necessary. On a good day, the pianist in the above example may decide to leave the fingering and the *forte* to take care of themselves while focusing on the climax. On a bad day, the same pianist may be fighting to get the notes right and let the forte and climax take care of themselves in order to focus on the fingering. One benefit of well prepared PCs is that they allow the musician to give very similar performances under very different conditions, including changes in their own mental and emotional states.

Reporting PCs

In the initial research on PCs, pianist Gabriela Imreh reported PCs on a specially prepared version of the score (see Figure 1, Chaffin 2006). Subsequently, most musicians have marked PCs on multiple copies of a published score. For example, cellist Tânia Lisboa used four separate copies of the score (see Figure 2, Chaffin *et al.* in press).

Some preliminary comparisons across musicians and pieces

To show how PCs can be compared across musicians and pieces, we have summarized PC reports from nine longitudinal case studies, using previously published and unpublished data from our laboratory. Three pianists provided reports for the *Italian Concerto (Presto)*: a professional (Imreh) and two university student piano performance majors, one MA and one BA-level. Imreh also provided reports for a second piece, *Clair de Lune* by Claude Debussy. We also have reports by three other professional soloists for cello (Lisboa), voice (Ginsborg), and piano (Silva), and by two students: a BA-level trumpet performance major and a 14-year old piano student.

Figure 3 shows the number of PCs of each type for each piece. To allow comparison across pieces, frequencies were normalized by dividing by the number of beats in each piece. Despite the small sample, there are suggestive differences. The trumpet and grade-school students reported fewer PCs than other musicians by an order of magnitude. For the *Presto*, the two students reported fewer PCs than the professional. The professional pianist (Imreh) reported fewer PCs for the easier (for her) *Clair de Lune* than for the challenging *Presto*. With the exception of the *Presto*, the four professionals all reported similar numbers of PCs.

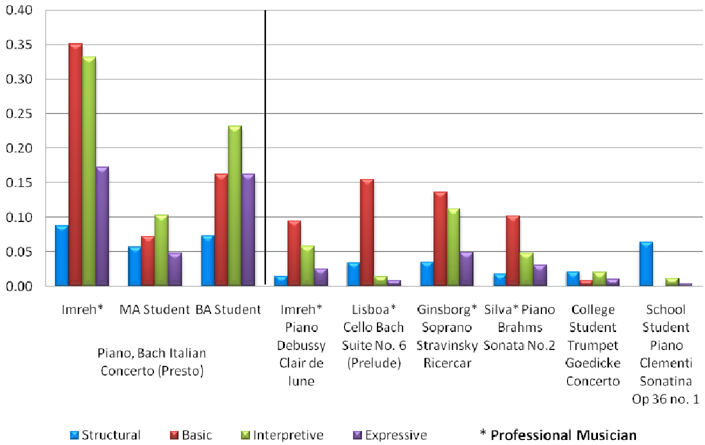

Figure 3. Number of performance cues per beat for different musicians and pieces. (See full color version at www.performancescience.org.)

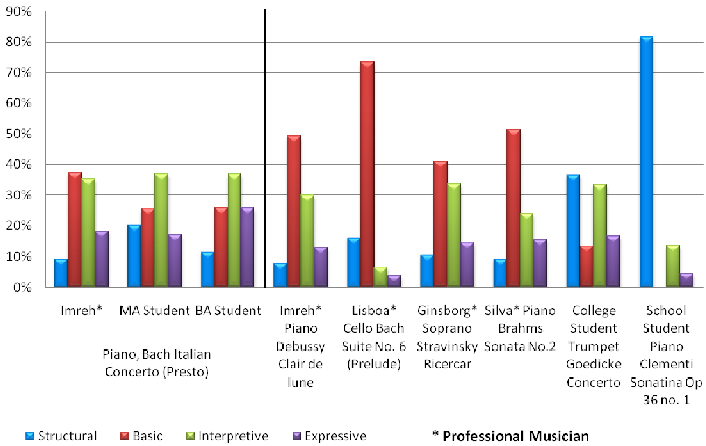

Figure 4. Percentage of performance cues of each type, normalized over number of beats. (See full color version at www.performancescience.org.)

Figure 4 shows the number of PCs of each type as a percentage of the total reported (normalized by number of beats). Experience mattered; the professionals used more basic PCs, the college students more interpretive PCs, the grade school student (and trumpeter) more structural PCs.

IMPLICATIONS

All the longitudinal case studies of experienced soloists preparing new works conducted by our laboratory have found that the musicians engaged in extended practice of PCs. This suggests that PCs are necessary for reliable performance, perhaps because motor memory is unreliable (Chaffin *et al.* in press). While the proposed survey is unlikely to discover whether some musicians do *not* use PCs, it should identify the factors that affect PC use and establish the range of variability in the use of PCs.

We hope that PC surveys will become commonplace in music conservatories and departments. We believe that the self-study involved provides musicians with insight into their own learning and memorization. All of the musicians who have participated in the longitudinal case studies that form the basis for this work report that they found the process of self-study to be beneficial (Chaffin *et al.* 2002, pp. 266-268; Chaffin *et al.* in press). In addition, we expect the conclusions will be of value to music pedagogy and also to the psychology of music performance.

Materials for conducting PC surveys can be found on our website at www.htfdcc.uconn.edu/psyclabs/musiclab.html.

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Thematic session:
Performance analysis

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Finger motion in piano performance: Touch and tempo

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This study investigated movement properties of pianists' fingers with three-dimensional motion capture technology while pianists performed melodic passages at a range of tempi. The main question was whether finger motion dynamics change with performance tempo, an important issue for practicing and training. Kinematic landmarks determined from the finger trajectories changed considerably as the tempo became faster; piano touch was under deliberate control only at slow tempi. Individual differences in performance speed led to specific claims about desirable finger dynamics for successful piano playing.

Keywords: motion capture; piano performance; finger dynamics; proportionality; touch

Piano pedagogues disagree on how performers should develop the ability to perform scale passages evenly and dexterously at very fast rates. One side points out the importance of practicing fast sequences at very slow tempi, while others hold that practicing at the intended fast tempo is more appropriate. The main argument of the latter is that movement strategies change considerably across different tempi—for example, as human gait changes from walking to running—and movements that are learned while practicing slowly are not useful at fast tempi. We address here whether kinematic properties of finger movements scale proportionately with performance tempo.

We investigated the movements of pianists' fingers and hands as they performed melodies at a wide range of tempi to test the proportionality hypothesis. Furthermore, we examined how pianists' touch—the way pianists' fingers approach the piano keys—is affected by tempo by measuring keystrokes containing a finger-key landmark, a marker for a pianist's touch. This work aims to generate potential recommendations for piano pedagogy, based on observations of skilled pianists performing at different tempi.

METHOD

Participants

Twelve highly-trained pianists participated in the study. They were 20 to 33 years old (mean=27.0 years; NB. one participant was 61 years old with 40 years of experience in playing the piano) and had 10-25 years of piano lessons (mean=18.7 years); most were piano performance students in Montreal.

Stimuli and design

One isochronous melody (the "fast" melody) was created that was easy to perform with the right hand and could be continuously repeated (see notation in Figure 2); it was designed to be performed at very fast tempi (tempo conditions were 7, 8.4, 9.6, 10.7, 11, 7, 12.3, 14 and 16 tones/s, presented on different trials); the pianists decided at what tempo they stopped performing (open-ended design). The tempo was indicated by a metronome in a synchronization-continuation paradigm. For comparison, we include data from two "moderate" melodies that contained 16 tones and were performed at moderate to medium fast tempi (2, 4, 6, and 7 tones/s), as reported earlier (Goebl and Palmer 2008).

Procedure

A passive motion capture system (Vicon 460) equipped with six infrared cameras tracked the movements of 4 mm reflective markers glued on pianists' finger joints, hand, and wrist at a sampling rate of 250 frames/s. The motion trajectories of the five finger-tip markers were smoothed with functional data analysis techniques (Ramsay and Silverman 2005) and analyzed in the vertical dimension (height above piano key surface).

Kinematic landmarks were extracted prior to each keystroke (see also Figure 2): the key-bottom landmark (KB, the finger is stopped by the keybed) and the maximum finger height (mxH, to be interpreted as the beginning of the finger movement) for all keystrokes. An additional finger-key landmark sometimes occurs when fingers strike the keys from a distance above the key surface (struck touch, see Askenfelt and Jansson 1990) and the acceleration peak is larger than a threshold of 10 m/s^2 (for details, see Goebl and Palmer 2009). A pressed touch does not feature such a landmark. In addition, we determined the peak velocity at which the finger arrives at the key surface.

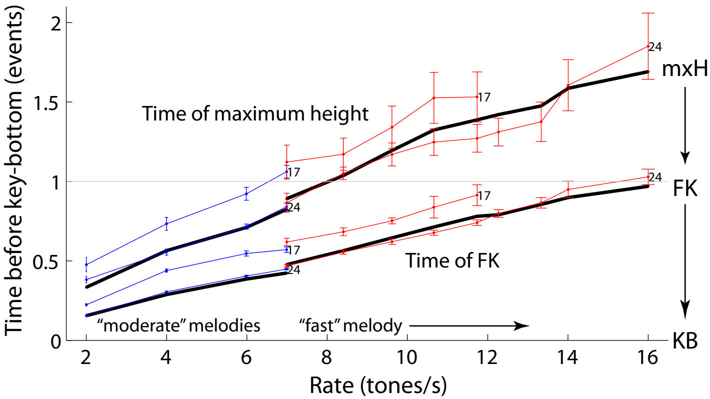

Figure 1. Time of maximum height (mxH, upper graphs) and time of finger-key contact (FK, lower graphs) in number of events prior to note onset (key-bottom, KB) by performed tempo. Thick line is the mean of 12 pianists; Pianists 17 and 24 are plotted separately. (See full color version at www.performancescience.org.)

RESULTS

The open-ended design of the "fast" melody generated the following results: all pianists were able to perform up to a rate of 11.7 tones/s (sixteenth notes at 176 bpm, beat=quarter note); 8 played up to 12.3, 7 up to 13.3, 6 up to 14.0, and only 3 up to 16.0 tones per second (considerably faster, for example, than the metronome markings of Chopin's Op.25/11). The "fast" pianists had similar amounts of piano lessons and years of playing, compared to the "slower" pianists; the only difference was the weekly practice, significantly higher for the "fast" players (25 vs. 13 hours). The following analyses attempt to identify kinematic properties that distinguish the fast players from the slow players.

Figure 1 shows the average timing values of the identified landmarks by tempo condition for the moderate melodies (2-7 tones/s) and the fast melody (7 tones/s and faster). Timing has been normalized on an event-to-event basis relative to KB contacts to allow comparisons across tempo conditions. At about 8 tones/s, the movement initiation (time of maximum height) toward the current keystroke occurs more than one keystroke before (starts to overlap with) the previous keystroke (KB). Furthermore, the time of FK contact approaches the time of the previous keystroke at the fastest rates. This overlap in movement landmarks between current and previous keystrokes may be

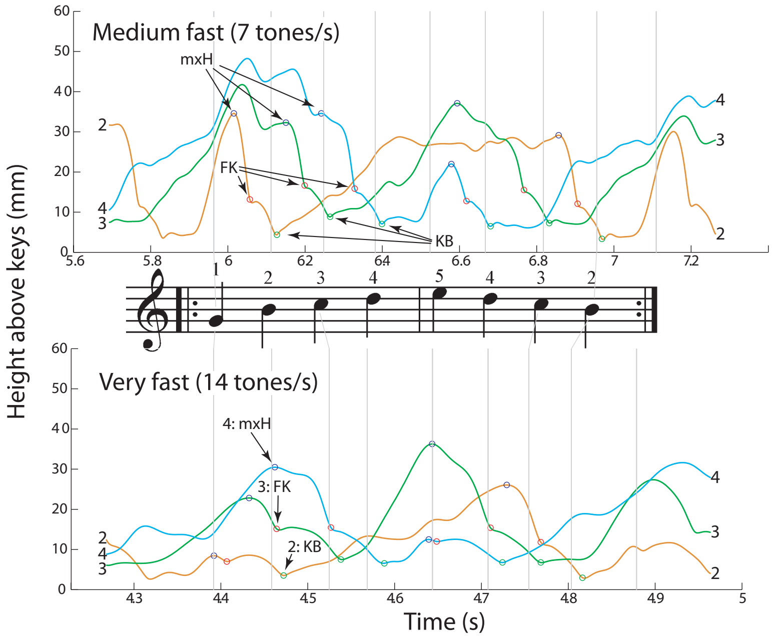

Figure 2. Finger trajectories of index (2), middle (3), and ring finger (4) of Pianist 24 playing one cycle of the "fast" melody at a medium fast tempo (upper panel) and a very fast tempo (lower panel). Three kinematic landmarks are labeled in the finger trajectories before each keystroke: the maximum height (mxH), the finger-key contact (FK), and the key-bottom contact (KB). Vertical lines denote MIDI onset times. (See full color version at www.performancescience.org.)

a speed-limiting feature in piano performance. This is shown further in Figure 2 for one pianist's trajectories of index, middle, and ring fingers. In the medium-fast condition (7 tones/s, top panel), the index finger's keystroke was finished striking the second tone (B4) before the next keystroke (middle finger, C5) was initiated (mxH); at very fast rates (14 tones/s, bottom panel), the index finger had not yet reached key-bottom for the same tone while the next (middle) finger had already made key contact (FK), and the second-next (ring) finger (D5) had started its descent towards the key.

To demonstrate that landmark overlap is important for performing at fast rates, we contrasted two different pianists. Pianist 17 is a "slow" player who mastered the minimal number of tempo conditions; she played the piano over the past 15 years, but stopped a year ago; she practices 7 hours per week and

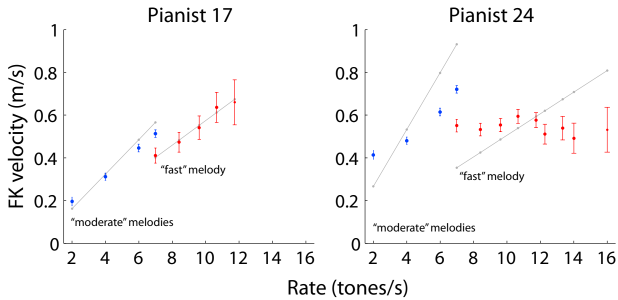

Figure 3. Finger velocity in meters per second at finger-key contact (FK) against performance rate, separately for Pianist 17 (left) and Pianist 24 (right). Proportional scaling with rate is plotted with solid lines.

performs occasionally in church. Pianist 24 was able to produce the very fast tempo conditions; he played the piano for 20 years and still studies piano actively; he practices 21 hours per week and performs in public 4-5 times per year. The individual landmark timing for these two pianists is shown in Figure 1. Pianist 17 needed longer than Pianist 24 to perform a keystroke at a given tempo. Thus, her keystroke landmark timing overlaps with those of previous keystrokes at slower tempi than do Pianist 24's keystroke landmarks. Moreover at each pianist's fastest performed tempo condition, the FK timing occurred close to the arrival (KB) of the previous keystroke

Goebl and Palmer (2008) identified two groups of pianists who differed in their playing behavior across tempo conditions: a "low-FK" group who showed a positive relation between FK landmark proportion and tempo (low at slow tempo conditions) and a "high-FK" group with high (close to 1) FK proportions for all tempo conditions. These two groups differed also at the velocity with which their fingers arrived at the key surface (FK velocity): the velocities of the low-FK group scaled proportionately with the tempo conditions, but not those of the high-FK group. The fingers of the low-FK group arrived at the key surface with twice the velocity when the performance tempo doubled.

We analyzed the same FK measures for the pianists performing the "fast" melody in this study; they all showed ceiling effects in their FK proportions at all tempi faster than 7 tones/s and no proportionality overall in the FK finger velocities. The FK measures were also contrasted for the two exemplary pianists; their mean finger velocities at finger-key contact are plotted against the full range of performed tempi in Figure 3 for the moderate melodies (2-7 tones/s) and the fast melody (7 tones/s and faster). The "slow" pianist (17) showed approximate proportionality across the tempi, whereas the "fast" pianist (24) did not. These findings suggest that the link between performed tempo and FK velocity might be detrimental to fast playing because proportionality cannot be maintained at extremely fast speeds.

DISCUSSION

Pianists' finger movement dynamics changed across different performance tempi; finger movements at key contact changed considerably as pianists accommodated faster tempi. Overall, these findings suggest that practicing at the final tempo is important from a motor control perspective. Furthermore, individual differences indicated that dissociating different finger movement properties from performance tempo may be essential for fast piano playing. However, individual cases of finger velocity-tempo proportionality implied that practicing slowly should be done very softly (that is with low FK velocity) so that finger movements at slow rates become more similar to those typically seen at final fast rates.

This research demonstrates how motion-based approaches could be established more widely in the future to enhance our understanding of the complex movement patterns executed by skilled pianists and to develop potential recommendations for piano pedagogy.

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Quantitative multidimensional approach of technical pianistic level

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The purpose of this study is to examine whether it is possible to define quantitatively the technical level of a pianist by summarizing the individual characteristics of the pianist's technical ability in a few—at most three—independent variables. These variables could be used in competitions and examinations as well as by piano teachers to measure students' progress, or by the students themselves in their daily work.

Keywords: pianistic level; principal component analysis; pianist motor skill; correlation of difficulties; MIDI

A statistical approach to measuring the biomechanical characteristics of piano playing was used by Altenmüller and Jabusch (2005) to measure pianist's focal dystonia, then by the same authors (2007, 2009) to measure the development of adults' and children's motor skill, using the Musical Instrument Digital Interchange (MIDI) recording format. An ordinary MIDI file contains a succession of events, each event being characterized by three parameters: occurrence time of the event (T), duration (D), and pitch (P). From these parameters, many characteristics (tone overlap, equality of produced sound velocity, equality of rhythm, etc.) can be computed, each variable giving an insight of the technical level of a pianist. The advantages and disadvantages of MIDI coding are widely discussed by Clarke (2004). Keyboard technical skill and how to improve it was studied early, for example by J. S. Bach (Klavierübung) and D. Scarlatti (Exercizi), and C. P. E Bach wrote a treatise "Essai sur la véritable manière de jouer les instruments à clavier" in 1762. A systematic study of piano playing difficulties was completed by Alfred Cortot (1928), with the author recommending a detailed daily work based on five-finger exercises, scales, arpeggios, trills, double notes, and octaves, with daily key transposition. This well known book is the basis of the daily training of pianists. Our purpose is, from a sample of these typical training patterns, to extract the qualities and flaws of a pianist, and summarize them by synthetic graphs and synthetic variables.

METHOD

Participants

Eighteen pianists (mean age 22.5 years, ranging from 12-59), from middle level music conservatories to professional level participated in the experiment. They had played piano for a mean of 14.5 years (range=4-52) and received either course credit or payment for their participation.

Materials

The pianists performed on a classical upright piano (Yamaha U2) with MIDI interface. MIDI data were collected on a DELL® laptop PC, by using the Cubase SX® program. All statistic programs were written in the Matlab® programming language by members of the LEAD-CNRS laboratory.

Procedure

The pianists were submitted to a series of exercises containing the most common classical difficulties in piano playing (scales, trills, and arpeggios). In order to obtain a "photograph" of the pianist, a few attempts only (up to 5) were authorized for each exercise. The tempo of each exercise was free. The pianists were allowed 20 minutes for warming up and getting used to the piano prior to the actual performances. Not all the pianists used this warm up time. An operator was always present to guide the participants, verify the fingering, and record the performances. The detailed exercises were as follows:

- Four *scales* (E*b* major, E major, B*b* major, E*b* minor) were requested from participants, played on four octaves twice without interruption, hands together at a pitch distance of one octave. The choice of scales was motivated by the fact that these scales have a very natural fingering, so all pianists used the same fingering. There were two easy scales (E*b* major, E major), one more difficult (B*b* major), and a difficult scale (E*b* minor).
- All the possible combinations of fingers (1-2, 1-3, ...4-5) were used for the *trill* exercise.
- Eight *arpeggios* (C major, C major 4/6, D*b* major, D*b* major 4/6, C# minor, C# minor 4/6, B*b* minor, B*b* minor 4/6), played on four octaves twice without interruption, hands together at a pitch distance of one octave.

Fingering was verified by the operator to be 1-2-3 for the right hand and 1-4-2 for the left hand for the natural arpeggio state, 1-2-4 for right hand and 1-3-2 for left hand in the upward direction, and the reverse for the down direction.

RESULTS

Defining and computing the relevant variables

For all exercises, the first indices of quality are a high tempo and few false notes. But these are not the only qualities of a good piano technique; for scales and arpeggios, the main word characterizing the quality of playing is "homogeneity." This means rhythmic homogeneity for each hand, rhythmic homogeneity between hands, homogeneity of velocity (intensity of key depressing force) for each hand, velocity homogeneity between hands, and overlap homogeneity (legato homogeneity). Of course, in an artistic performance of a piece of music, this homogeneity is not observed; all the discrepancies in an artistic performance are voluntary acts, guided by the artistic sensibility. But the homogeneity required in the exercises is the way to gain the control of the movements, in order to play with expression.

We then retained seven variables: (1) tempo (TPO), (2) tempo coefficient of variation (CVTPO), (3) number of false notes (FN), (4) intra-hand velocity standard deviation (STDVEL), (5) intra-hand overlap standard deviation (STDOVL), (6) lag time between hands (LAGLR), and (7) velocity difference between hands (DVELLR). For trills, only the first five variables were used, since the exercise was performed hand-by-hand.

Why a free tempo?

In the experiments of Jabusch *et al.* (2004, 2007, 2009), the authors fixed the tempo of the exercises (scales) and allowed the subjects to repeat them 10-15 times. They then computed a "mean scale" for each subject. Our point of view is slightly different. An important part of the technical level is the pianist's awareness of his own skill—e.g. "I will not begin a scale at a metronomic tempo of 160 if I know that I will not finish the scale." We then left the subjects free to choose their tempos and considered the tempo variable as a level variable among others.

Principal component analysis (PCA) (Hotelling 1933) for scales

We present complete results and graphs for the E*b* major scale. Table 1 shows the correlation matrix of the seven variables for the scale. It is not surprising

Table 1. Correlation matrix between the seven quality variables for E*b* major scale.

	Tempo *(TPO)*	*False notes* *(FN)*	*Inter hand velocity variations* *(DVELLR)*	*Intra hand velocity STD* *(STDVEL)*	*CV tempo* *(CVTPO)*	*Overlap STD* *(STDOVL)*	*Time lag between hands* *(LAGLR)*
TPO	1	-0.179	**-0.610**	-0.165	-0.468	-0.503	-0.198
FN	-0.179	1	-0.024	0.422	**0.682**	0.187	**0.686**
DVELLR	-0.610	-0.024	1	0.291	0.128	0.516	0.134
STDVEL	-0.165	0.422	0.291	1	0.220	0.242	**0.724**
CVTPO	-0.468	0.682	0.128	0.220	1	0.540	0.432
STDOVL	-0.503	0.187	0.516	0.242	0.540	1	0.159
LAGLR	-0.198	0.686	0.134	0.724	0.432	0.159	1

that the tempo variable is negatively correlated with all other variables: intuitively, tempo is a positive index of quality, while the other variables are negatives. Some other correlations, intuitively expected, can be noticed: for example, the high correlation (0.682) between the false notes and CV. Tempo variables can be understood as "a false note induces a stress for the pianist, then an irregularity of tempo." In the same way, the high correlation between the CV tempo and the time lag can be understood as "a false note in one hand does not affect the other hand, and then increases the time lag between hands."

Figure 1 shows the graphic results of the E*b* major PCA, which is consistent with respect to the correlation matrix. The left part of the figure is the correlation circle, which represents the correlations between variables and principal components. The first two principal components account for about 70% of the total variance of the data, and thus the bi-dimensional representation is reliable. As expected, the tempo variable is opposed to all others. It is very interesting to see that the correlation between tempo and false notes is low (-0.179). A good pianist can do many wrong notes—a known joke of Alfred Cortot: "if you picked all my false notes in a concerto, it could be a second concerto."

In order to interpret the graph of subjects, let us describe some of them: pianists 3, 4, and 9 are beginning the second cycle of studies in a regional conservatory, pianist 18 is a concert pianist, pianist 2 is a piano teacher, and pianist 1 is an amateur (the author). All other pianists are second or third cycle students in a regional conservatory. Then the first principal component

Table 2. Metronomic and adjusted tempos (scores) for the E*b* major scale.

Subject	*1*	*2*	*3*	*4*	*5*	*7*	*9*	*10*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Tempo	86.7	79.2	65.9	31.0	36.7	71.7	54.5	41.8	35.6	64.8	85.5	94.6	71.7	64.2	143.3
Score	63.0	59.8	26.7	1.7	16.6	50.0	13.8	25.1	7.1	30.1	62.7	64.0	49.2	38.7	125.0

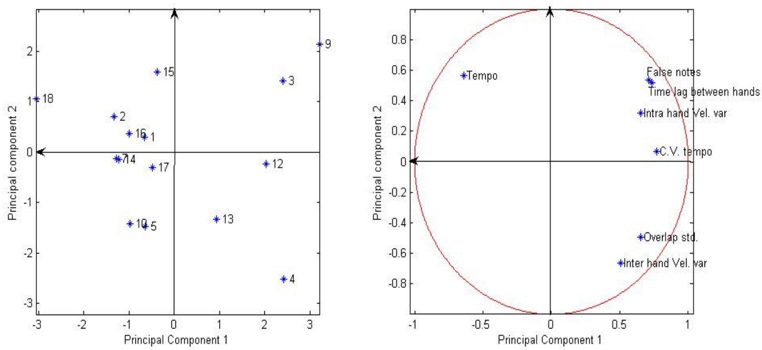

Figure 1. Principal component analysis of the E*b* major scale. The right panel represents the variables and the left panel the subjects.

can be easily interpreted as the technical level axis. The second axis can describe more precisely the flaws of the pianist: for example, a pianist far above the second axis is characterized by many false notes, a bad synchronism between hands, but a good legato (little overlap STD).

DISCUSSION

The PCA analysis appears to be a good visualization tool for a synthetic presentation of the technical level of a pianist. The results for trills and arpeggios are similar to those of scales. All the default variables are positively correlated, and all negatively correlated with the tempo variable. As we stated in the section on PCA above, the principal components cannot be used as they are, but they suggest an overall evaluation in a form opposing the tempo with all the other variables. For example, for the E*b* major scale, the first principal component has the following equation:

$$PC1=-0.3595*TPO+0.3991*FN+0.2860*DVELLR+ 0.3682*STDVEL+0.4331*CVTPO+0.3668*STDOVL+ 0.4147*LAGLH$$

All the coefficients have the same magnitude. The idea is then to give the results to the musician in the form of an adjusted tempo, very understandable by musicians:

TPOADJ=PC1/-.3595=TPO-1.1102*FN-0.7956*DVELLR
-1.0244*STDVEL-1.2049*CVTPO-1.0205*STDOVL -1.1537*LAGLH

This formula gives the results in Table 2. Under this system, a pianist who plays fast and has many flaws gets the same score as a pianist who plays slower but with good legato, good rhythmic homogeneity, few false notes, etc.

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I wish to thank Konrad Maria Engel for kindly accepting to lend his talent to our experiments, to Eckart Altenmüller and Hans Christian Jabusch for fruitful help and discussions, to Chloé Fourier and Michel Cara the indefatigable "operators," and to Véronique Assadas for her stylistic help.

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Evaluation of a scale performance on the piano using spline and regression models

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Recently, many systems have been developed for supporting novice and/or beginner pianists. Even though these systems use a set of performance data, they cannot properly evaluate performance proficiency because a procedure for calculating proficiency has not been proposed. To solve this problem, we have developed an evaluation model by introducing a spline curve or regression curve, assuming it to be a standard for evaluating proficiency for scale performances from an aesthetic viewpoint. This paper introduces other models for evaluation, comprised of a standard curve for evaluating a piano performance. Curves used are (1) a spline curve and (2) regression curves using n-dimensional models ($1 \leq n \leq 10$). Investigated here is the effectiveness of the curves, so as to determine a better curve for automatically evaluating performance. As a result, correlation coefficients between scores predicted by the spline curve model and evaluation scores by experts were 0.65, whereas the average of correlation coefficients between scores predicted by regression curves models and evaluation scores by experts was 0.58. In other words, a correlation coefficient of the spline curve model is confirmed to be higher than those of regression curve models. Therefore, it was confirmed that the spline curve model is more effective than n-dimensional curves at automatically evaluating performance.

Keywords: piano; scale performance; spline curve; n-dimensional curve; MIDI

In recent years, a lot of people who have wanted to learn how to play the piano have been able to create easily an environment in which to learn due to the development of the MIDI keyboard. However, most people who start often give up practicing the piano. There are many reasons for this: (1) specialists' instructions cannot be given due to temporal and spatial restrictions, (2) the piano performance cannot be objectively evaluated, (3) beginners cannot plan how to teach themselves the piano, (4) beginners tire of practicing if they only use textbooks, and (5) it takes a lot of time to master the piano. To overcome these difficulties, many systems have been developed for supporting novice players and/or beginner pianists. However, even though these systems record and use a set of performance data, they cannot appropriately evaluate a performance with the deviations from a metronome in artistic terms. To solve this problem, we have developed a method to evaluate automatically the skill level and proficiency for performing a one octave scale (e.g. Akinaga 2006).

METHOD

Materials

This study uses the following evaluation models: spline curves and regression curves. The spline curve used here is the interpolated curve that passes through the representative points. The representative points are determined by finger crossing in three ways. Our previous study aimed to evaluate a performance containing artistic expressions such as intonation. Therefore, spline curves were introduced as a standard for evaluating performance proficiency. An example of a spline curve is shown in Figure 1. Regression curves used in this study are n-dimensional polynomial ($1 \le n \le 10$). When $n=1$, the model means a straight line, or when $n=15$, the model means the actual performance. When n increases, obtained regression curves become closer to the actual performance.

Procedure

Investigated here is the effectiveness of the proposed models using regression curves, so as to determine a better model for automatically evaluating performance. Correlation coefficients between predicted scores proposed by models and evaluation scores evaluated by experts were calculated in order to compare spline curve models to regression curves models.

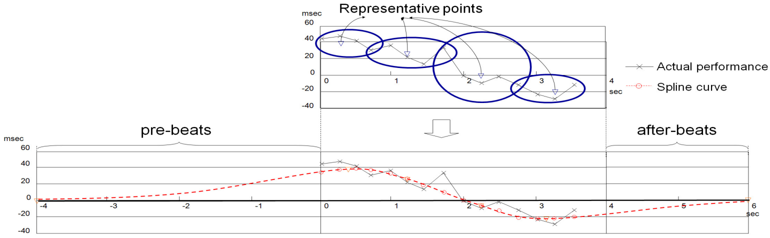

Figure 1. Example of a spline curve.

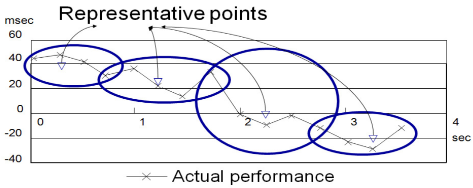

Figure 2. Representative points of condition 1.

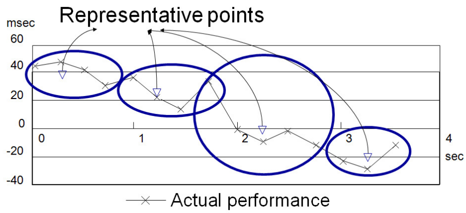

Figure 3. Representative points of condition 2.

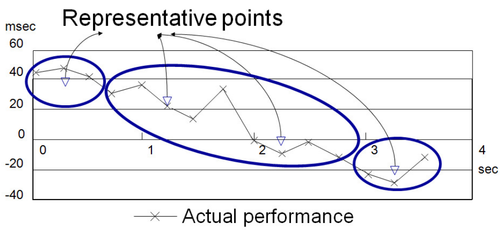

Figure 4. Representative points of condition 3.

Spline curve models

Condition 1. Fifteen inputted notes are categorized into four clusters. Centers of each cluster are assumed as representative points. In these conditions, the clusters are comprised of "C-D-E-F," "F-G-A-B-C," "C-B-A-G-F," and "F-E-D-C," respectively. Representative points of condition 1 are shown in Figure 2.

Condition 2. Fifteen inputted notes are categorized into four clusters. Centers of each cluster are assumed as representative points. In these conditions, the clusters are comprised of "C-D-E," "F-G-A-B-C," "C-B-A-G-F," and "E-D-C," respectively. Here, overlapping notes for crossing fingers belong to a cluster, whereas in condition 1 they belong to both clusters. Representative points of condition 2 are shown in Figure 3.

Condition 3. Fifteen inputted notes are categorized into three clusters. Centers of each cluster are assumed as representative points. In these conditions, the clusters are comprised of "C-D-E," "F-G-A-B-C-B-A-G-F," and "E-D-C," respectively. Unlike condition 2, here two clusters around fingerings of returning are categorized into a cluster. Representative points of condition 3 are shown in Figure 4.

RESULTS

Determination coefficient

The determination coefficients between proposed evaluation models and actual performance were calculated in order to compare spline curve models to regression curves models. The results of the determination coefficient are shown in Figure 5.

Performance of evaluation models

The correlation coefficient between scores predicted by proposed evaluation models and scores evaluated by experts were calculated in order to compare spline curve models to regression curves models. The results of the determination coefficient are shown in Figure 6.

DISCUSSION

Figure 5 shows the determination coefficient between proposed evaluation models and the actual performance. As a result, the determination coefficients for spline curve models are relatively lower than those for n-dimensional curves ($3 \leq n \leq 10$). Figure 6 shows the correlation coefficients between scores predicted by proposed evaluation models and scores evaluated by ex-

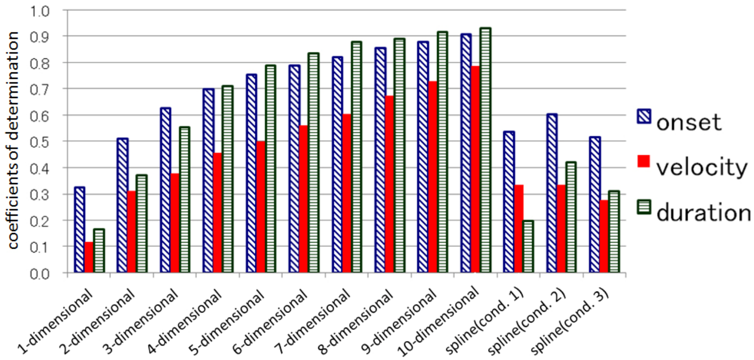

Figure 5. Results of calculating coefficients of determination between actual performance and spline/n-dimensional curves.

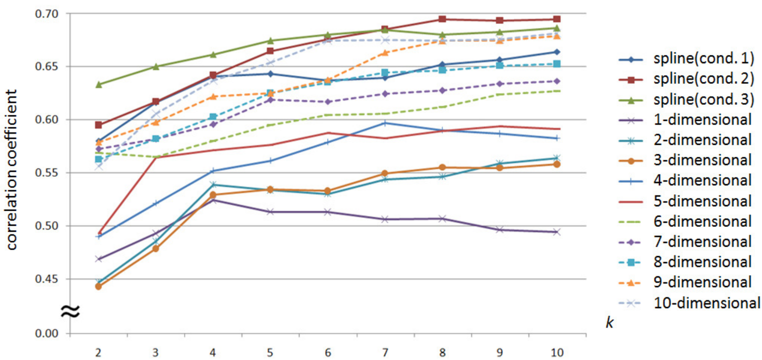

Figure 6. Result of calculating correlation coefficients for proficiency scores between those given on average by experts and those given by spline/n-dimensional curves. (See full color versions at www.performancescience.org.)

perts. As a result, the average of correlation coefficients between predicted scores predicted by the spline curve model and scores evaluated by experts was 0.65, whereas the average of correlation coefficients between scores predicted by regression curves models and scores evaluated by experts was 0.58.

Correlation coefficients between scores predicted by regression models and scores evaluated by experts increased when n increased. In other words, when the models are similar to actual performance, it was recognized to obtain evaluation scores similar to those given by experts. Interestingly, the correlation coefficient of the spline curve model and tenth-dimensional model are almost the same in terms of correlation. In this study, the spline curve model passes through six representative points. Therefore, essentially the correlation coefficient of the spline curve model and six-dimensional model should be almost the same value. However, the correlation coefficient of spline curve model is higher than that of the six-dimensional model. These results show that the spline curve model is thought to be better than n-dimensional models for automatically evaluating performance.

Acknowledgments

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Symposium:
Performance science: Implications for educational and professional practice

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Profiling musicians' health, wellbeing, and performance

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This study profiles music students' physical and mental fitness for performance. Participants were recruited from the Royal College of Music (RCM, n=59) and Royal Northern College of Music (RNCM, n=32), and standardized measures of health promoting behaviors, anxiety, perfectionism, cardiovascular fitness, and physical strength and flexibility were employed to assess students' performance-related health and wellbeing. The resulting profile indicates that (1) students tend to fall outside of their target BMI, with more students falling below their target than above it, (2) cardiovascular fitness is most frequently below average or average, with under 40% of students achieving above average cardiovascular fitness, (3) student fatigue correlates variously with aspects of perfectionism, trait anxiety, health promotion, and self-regulated learning, and (4) pain that is reported to stop performance is most often linked to the upper arm/elbow, left and right hands, and the back. The value of such profiling exercises in educational contexts is discussed, with examples of implementation drawn from a UK conservatoire.

Keywords: health profiling; physical fitness; mental health; health promoting behaviors; music education

Having the capacity to assess musicians' skills and abilities is of particular benefit for researchers, musicians, and those involved in musicians' educational and professional development. The knowledge generated through physical and mental profiling exercises can be applied, for instance, as the basis for refining current training approaches, tailoring and implementing novel performance enhancement initiatives, and raising awareness of important issues of musicians' health and wellbeing.

This article highlights the value of skills profiling in educational and professional contexts. Specifically, we profiled music students' fitness for performance through a wide range of self-report and objective physical measures of health and wellbeing. The application of the resulting profile within a conservatoire context is used to illustrate the value of such work to the training of performers.

METHOD

Participants

A total of 91 students (57 female, 34 male; mean age=21.88 years, SD=4.63 years) from the Royal College of Music (RCM, n=59) and the Royal Northern College of Music (RNCM, n=32) took part in the study. The participants represented the following instrumental specialisms: strings (n=42), keyboard (17), woodwind (14), voice (8), brass (8), composition (1), and percussion (1).

Materials

Music students' fitness for performance was profiled through the following self-report measures:

- Questions on musical/personal background (e.g. age, sex, instrument)
- Short Warwick Edinburgh Mental Wellbeing Scale (WEMWBS)
- Frost Multidimensional Perfectionism Scale (Frost MPS)
- Health Promoting Lifestyle Profile (HPLP) II
- Self-efficacy for Musical Learning Scale
- Self-regulation Scale
- Spielberger Trait Anxiety Inventory (TAI)
- Ratings of musculoskeletal health and fatigue

Descriptions of the above measures, including methods for scoring each and their relevant subscales, are provided by Kreutz *et al.* (2008, 2009) and Ginsborg *et al.* (2009).

Procedure

The profiling procedure was divided into three stages. Stage 1 introduced the participant to the profile study, secured written consent, and screened health suitability for the physical assessment. Each participant's height (cm), weight (kg), hand spans (cm), and finger spans (angle) were recorded.

Stage 2 was conducted online using the environment provided by Surveymonkey®, to which the self-report measures above were adapted. The questionnaire was identical at both institutions, and students were able to ask a member of the research team for clarification on the questions presented as necessary.

Stage 3 comprised the physical assessment, conducted by an exercise scientist. The assessment included measures of balance (dominant balance), grip strength (kg), core flexibility (cm), body fat/lean percentages, body fat/lean mass (kg), body mass index (BMI), shoulder flexibility internal and external (dominant balance), and sub-maximal cardiovascular fitness (heart rate recovery, in bpm). Body composition measurements were taken using a bioelectrical impedance meter and sub-maximal fitness by a 3-min step test with bpm measured using a Polar heart rate monitor. Participants were given a printed summary of their results and were fully debriefed.

Data analysis

Preliminary analyses of the data revealed no significant differences between the student cohorts from each institution, except on the spiritual growth subscale of the HPLP II (t_{89}=3.07, p<0.01, where RCM>RNCM) and the Self-regulation Scale (t_{89}=1.99, p=0.05, where RCM>RNCM). For the purposes of this article, the two cohorts have been combined in all analyses.

Here, we focus on the physical measures of fitness, as well as Pearson correlations between physical measures and self-report measures, including ratings of musculoskeletal health and fatigue. Descriptive statistics for each of the measures employed are available from the corresponding author by request.

RESULTS

Descriptive statistics for BMI and sub-maximal cardiovascular fitness—as representative of key profiling measures of physical fitness—are illustrated in Figures 1 and 2, respectively.

Significant correlations between self-reported musculoskeletal health and fatigue, psychological self-report measures, and physical fitness are listed in Table 1. For these analyses, ratings of musculoskeletal health and fatigue were grouped into six categories, following the factor analysis reported by Kreutz *et al.* (2008).

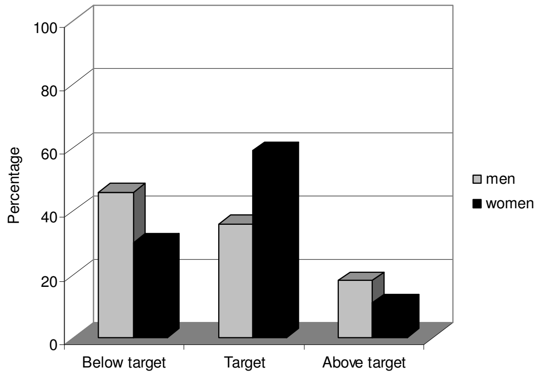

Figure 1. Distribution of BMI for male and female participants (n=89).

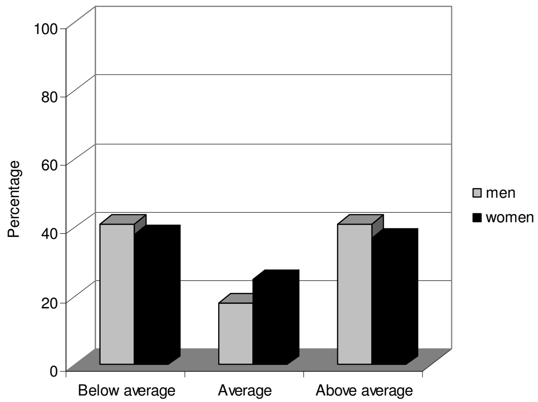

Figure 2. Cardiovascular fitness. Below average includes "below average," "poor," and "very poor." Above average includes "above average," "good," and "excellent" (n=84).

DISCUSSION

The profile arising from these results can be summarized as follows: (1) students tend to fall outside of their target BMI, with more students falling below their target than above it, (2) cardiovascular fitness is most frequently below

Table 1. Significant Pearson correlations ($p<0.05$) between ratings of pain in the elbows, hands, spine, mouth and feelings of fatigue with other self-report measures and BMI, where + indicates a significant positive correlation and - a negative correlation.

	Upper arms/elbows	*Left hand*	*Right hand*	*Spine*	*Mouth*	*Fatigue*
General health rating		-	-			-
Pain stops performance	+	+	+	+		
HPLPII	sm+					sg- sm-
WEMWBS		-				-
Frost MPS				pec+	ps- o-	cmd+ pec+
Self-regulation						-
TAI						+
BMI	-					

Note. sm=HPLPII subscale for stress management, sg=HPLPII subscale for spiritual growth, pec=Frost MPS subscale for parental expectations and criticism, ps=Frost MPS subscale for personal standards, o= Frost MPS subscale for organizational skills, cmd=Frost MPS subscale for concern over mistakes and doubt above actions.

average or average, with under 40% of students achieving above average cardiovascular fitness, (3) student fatigue correlates variously with aspects of perfectionism, trait anxiety, health promotion, and self-regulated learning, and (4) pain that is reported to stop performance is most often linked to the upper arm/elbow, left and right hands, and the back.

Given the physicality of musicians' work, such a trend toward poor fitness is concerning. With the injury and pain problems frequently reported in conservatories—and in light of profiling exercises such as reported here—there is clearly a need for educational programs to address this issue. At the RCM, for example, the profile is used to inform a compulsory seminar series for all incoming undergraduate students, designed to raise awareness of the importance of musicians' fitness and wellbeing. To enable students to follow this up with practical steps, poor fitness demonstrated in the profile is targeted through a fitness awareness scheme, and aspects of student fatigue and injury addressed through "Peak Performance Workshops," introducing students to Alexander technique, yoga, Pilates, and tai chi, among other interventions.

Further work to extend the sample is underway, with new intakes at the RCM and RNCM, and at other UK conservatoires, in order to refine and streamline the profiling procedure. The tools to emerge from this process will be able to inform educators of students' fitness for performance, allowing them to take necessary steps to safeguard students' health and wellbeing.

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Dance science: Scientific investigations into the effect of dance specific fitness training and its impact upon pedagogic practices and dance performance

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Dance training has developed eclectically to serve the different approaches to dance performance and making; however, there is a discrepancy between the physiological demands of training and dance performance. It is no longer acceptable to train dancers without due regard for physiological concerns if they are to be prepared appropriately to meet the demands of current choreographic work. Research over the last two decades has examined the physical fitness status of professional and student dancers', but there is still debate about how fit dancers *should* be. There is a discrepancy in the physical intensity level between training, rehearsal, and performance, and the idea of supplementary fitness training has been debated, albeit untested longitudinally with large groups of dancers. The purpose of this study was to examine the effect of a one-year dance specific fitness program on undergraduate contemporary dance students undertaking full-time vocational training and to observe any impact the findings may make upon dance pedagogic practices. Results from the pre- and post-screening assessments show that, following the intervention, there was a significant decrease ($p<0.05$) in mean heart rates across all five stages of the Dance Aerobic Fitness Test (DAFT), indicating improvement in the dancers' aerobic capabilities. Findings impacted upon the school curriculum, in that the timetable now comprises weekly fitness classes.

Keywords: fitness; dance; physiological; intervention; aerobic

Research over the last two decades has examined the physical fitness status of professional and student dancers (Chatfield *et al.* 1990, Cohen *et al.* 1982, Dahlstrom *et al.* 1996, Novak *et al.* 1978, Rimmer *et al.* 1994), but there is still debate about how fit dancers *should* be. One study (Wanke 2001) assessed the effect of an integrated endurance training program for ballet dancers (n=16) across a ballet season and found positive results. Some studies have suggested a discrepancy in the intensity level between training, rehearsal, and performance (Rist 1994, Wyon and Redding 2005, Redding and Wyon 2001), and the idea of supplementary fitness training has been debated, albeit untested longitudinally with large groups of dancers.

The applicability of laboratory tests and training regimes from sports is questionable (Schantz and Astrand 1984, Redding and Wyon 2003), and it is becoming increasingly necessary to gather relevant data and qualitative observations—physiological and psychological—in order to develop specific methods of promoting and assessing dance fitness. The purpose of this study, longitudinal and experimental in design, was to examine the effect of a one-year dance specific fitness program on undergraduate modern dance students undertaking full-time training.

METHOD

Participants

Screening information from first year students (n=86) provided initial data on a series of physiological tests, including the Dance Aerobic Fitness Test (DAFT; Wyon *et al.* 2003), the Wingate Anaerobic bike Test (WAnT), and the vertical jump height test, which were repeated at the end of the one-year intervention. Students also completed an evaluation questionnaire regarding their personal appreciation of the program. Existing screening information on the previous student cohort (n=85) provided an opportunity to compare physiological changes across the year without the fitness intervention.

Procedure

A weekly 90 minute fitness class was developed across the year according to principles of periodization and specificity (Bompa 1999). The primary aim was for the structure and content to be responsive to curriculum needs and to engage in a dialogue with technique teachers and therapists. Intensity and duration of exercises were considered. The dancers' heart rates were regularly monitored to ensure that the intensity level was appropriate to elicit a training response. Functional fitness training preceded more dance-based movement that increasingly replicated vocabulary from technique classes. For example, plyometric training was introduced, initially using basic parallel foot

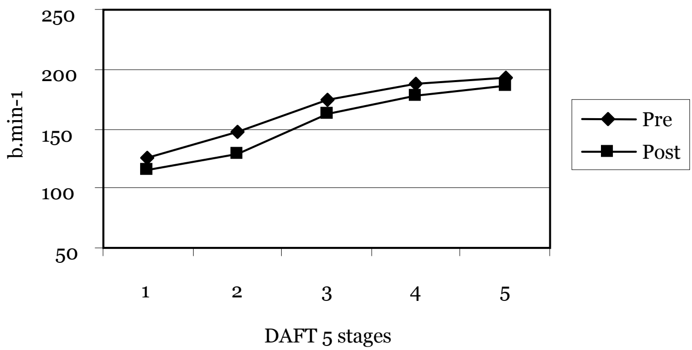

Figure 1. Mean heart rates of dancers undertaking dance specific fitness training before and after the one year intervention.

positions, and later modified to include turned out positions that more closely mimicked the type of jumps seen in dance. Upper body strength exercises gradually progressed to incorporate partner lifting of varying speeds and complexities. During the final phase, a circuit type structure reflected the variety of activity and speed of succession that would be encountered in a dance class.

Data treatment and analysis

All data were entered into SPSS (v.12). Means and standard deviations were calculated for all variables. Dependant t-tests were used to monitor changes in heart rate and jump height data collected from the pre- and post-testing.

RESULTS

Results from the pre- and post-screening assessments show that, following the intervention, there was a significant decrease ($p<0.05$) in mean heart rates across all five stages of the DAFT test (Figure 1), indicating improvement in the dancers' aerobic capabilities. In addition, it appears that this particular group of students displayed lower heart rates at every stage, compared with the group of first year students from the previous year who did not engage in regular fitness training (Table 1).

The females in the intervention group improved their jump height ($p<0.05$), while the males did not. Participant responses to the evaluation

Table 1. Mean heart rates across each stage of the DAFT for three different groups of dance students. There was a significant difference between the two groups at every stage ($p<0.05$).

	Stage 1 *(b.min⁻¹)*	*Stage 2* *(b.min⁻¹)*	*Stage 3* *(b.min⁻¹)*	*Stage 4* *(b.min⁻¹)*
First year students with *no fitness* at end of year 1 (n=38)	122 ±13	153 ±15	179 ±14	190 ±13
First year students post *fitness* end of year 1 (n=50)	115 ±12	129 ±23	162 ±13	177 ±11

questionnaire suggest that the students *are* motivated to participate in their fitness classes. Responses focused on students' increased knowledge with respect to physical preparation for their dance skills training, the importance of application of the theoretical aspects of their fitness course, and the new perspective they have of dancers as athletes as well as creative artists.

DISCUSSION

Results from the DAFT test show that aerobic fitness improved over the one-year period, supporting findings of previous studies (Wanke 2001). When comparing the DAFT heart rate data to that of the dancers who did not participate (from the previous Year 1 cohort), there appears to be an overall reduction at each stage, indicating that it is the fitness training intervention that has contributed to this effect.

Comments from the evaluation questionnaire show that students have gained knowledge and skills that they do not acquire at any other point in their dance training and are capable of applying this knowledge and understanding to their wider physical development. The most frequent physiological self-observed effects were reductions in fatigue, improvement in general energy levels, and improved capacity in dance classes to sustain technique and jumping ability. The importance of warm-up and cool down was commonly cited and the recognition of the relationship between fitness and injury prevention was highlighted. In psychological terms, preliminary analysis of the comments reveals that students have found fitness valuable as a relaxation tool. They explain that they feel more positive and confident in general and find a reduction in stress, tension, and frustration. Reasons include the holistic approach, the absence of competition in the fitness class, and the increased knowledge, awareness, and value of relaxation techniques as an element of fitness. Motivation appears to be increased, although it is still debatable whether this is specific to fitness classes or can be transferred to other areas of training.

This study was the first of its kind in that it assessed the effect of supplementary fitness training in dance across one year. Findings impacted upon the school curriculum. The timetable now comprises weekly fitness classes. The dance-specific fitness team aimed to counteract some possible injury risk factors, such as lack of strength and jumping ability, through the introduction of dance-specific strength work using partnering and plyometric jump training. Also specific short term demands have been addressed. For example, groups of students have followed a prescribed training plan to prepare for a three week historical project, dealing with specific pieces from Limon, Graham, and Cunningham repertory. It is hoped that this dance-specific fitness training will have a more far-reaching effect than functional sports fitness and provide a stimulus for students that can enhance the complete training experience. It is also envisaged that other dance training institutions will consider adopting a similar model so that findings can be shared and more effective training programs for dancers devised.

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Developing evidence-based interventions to enhance performance

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Increasingly, a broader range of training programs and evidence-based interventions are being employed within music education contexts. It is important that these programs are empirically tested to provide an unbiased assessment of their impact and efficacy. This article highlights methods for developing and testing intervention programs. A nine-week musician-specific mental skills training program was developed and delivered to performance students from the Royal College of Music (RCM). Pre- and post-testing involved a battery of questionnaires, public performances, and performance-related tasks. Feedback from these students was collected throughout concerning their views on the relevance and usefulness of the program. In comparison with a control group, this experimental group demonstrated significant changes in their views toward practice activities and specific practicing behaviors. A significant increase in self-efficacy for performing was also found for the experimental group, as was an increase in imagery vividness. These results are further supported by comments from students in the experimental group revealing greater levels of self-awareness and confidence, facilitative views toward and heightened control over anxiety, and healthier perspectives toward music making. Feedback from the participants also provided insight into issues pertaining to content and delivery.

Keywords: evidence-based training; imagery; mental skills; performance science; music education

Training methods within the performing arts have typically been based upon tradition and personal experience. In addition to these, within many areas of performance, a broader range of programs are becoming increasingly employed with the aim of equipping performers with skills necessary for effective performance preparation and career management. However, some of these programs are developed and implemented with little empirical support for their efficacy. In dance, for instance, educators are being encouraged to review and assess how training is provided (Kimmerle and Côte-Laurence 2003). From the viewpoint of researchers, performers, and those who train performers, it is important that these programs be subjected to empirical testing in order to provide an unbiased assessment of how they can be employed to enhance performance, not to mention a level of quality assurance regarding their efficacy.

This paper highlights methods for empirically developing and testing intervention programs with a focus on evidence-based outcomes. In particular, a musician-specific mental skills training program is evaluated qualitatively and quantitatively in terms of its potential to enhance learning and performing skills.

METHOD

Participants

Twenty-three undergraduate and postgraduate performance students were recruited from the RCM. Of these, 14 were assigned to an experimental group while 9 formed a control group. Ages ranged from 20-28 years (mean=22.3, median=22.0, SD=2.2). In terms of the participants' year of study, 4 were year 1 undergraduates, 6 were in year 2, 5 were in year 3, 3 were in year 4, and 5 were postgraduates. For their instrument groupings, 7 were pianists, 4 were vocalists, 7 were string players, and 5 were woodwind or brass players.

Materials

A battery of quantitative and qualitative methods was employed to assess the training program. Quantitative measures addressed the participants' practice attitudes and behaviors (adapted from an interview schedule on self-regulated learning by Zimmerman 1986), assessing how important the participants felt it was to engage in a variety of self-regulated learning behaviors as well as how often they actually employed the different types of learning behaviors. The participants were also asked to self-rate their proficiency on a selection of musical skills. In addition, imagery ability was assessed using the randomized short version of Betts Questionnaire upon Mental Imagery (Betts QMI, Sheehan 1967). Personality characteristics were assessed, including self-efficacy for performing, in reference to both a live performance and a hypothetical performance. The Revised Competitive State Anxiety Inventory (CSAI-2R, Cox *et al.* 2003) was employed to measure self-confidence and state anxiety prior to performing, while trait anxiety was measured using the trait anxiety index from the Spielberger State-Trait Anxiety Inventory (TAI, Spielberger *et al.* 1970). Lastly, each participant gave a 15-minute public performance comprising two contrasting pieces of their choice in order to measure performance ability.

Qualitative methods involved feedback from the experimental group collected during and following the training phase concerning students' views on the relevance and usefulness of the program, focus groups conducted with the experimental group following the training and final testing phase, and case notes kept by the first author throughout the project.

Procedure

Participants from both the experimental and control groups first attended a session during which they completed most of the questionnaires. Following this, each participant performed their chosen pieces in a public performance. Immediately prior to performing, the participants completed the self-efficacy for performing questionnaire and the CSAI-2R. The performances were videoed and assessed for quality by two external adjudicators. Upon completion of the first round of testing, a musician-specific mental skills training program was delivered to the experimental group. The topics covered fell in three main categories: (1) motivation and effective practice, (2) relaxation and arousal control, and (3) performance preparation and enhancement. The training phase involved one 60-minute group session and one 30-minute individual session per week for nine weeks. The control group, meanwhile, received no additional training. Following the training phase, the experimental and control groups again completed the questionnaires and public performances, using a procedure identical to the first round of testing. Descriptive statistics for the questionnaires were initially calculated from the two rounds of testing, following which repeated-measures analyses of variance (ANOVAs) were employed to elucidate changes occurring from one testing phase to the next.

RESULTS

Quantitative results

The assessment protocol employed in this study yielded a number of significant findings (see Table 1). In comparison with the control group, the experimental group demonstrated significant changes in their views toward practice activities and in their specific practicing behaviors. This was evidenced by a

Table 1. Significant results from repeated-measures ANOVAs. The mean scores (and standard deviations) for the experimental (EG) and control groups (CG) for both phases of testing are provided, as are the resulting F values.

		Pre-test	*Post-test*	*F*
Self-regulated learning	EC	48.69 (6.21)	48.69 (4.51)	$F_{1,21}$=6.22, p<0.01
	CG	51.18 (6.34)	51.18 (4.90)	
Quantity of practice	EC	4.39 (1.15)	4.39 (1.35)	$F_{1,21}$=9.64, p<0.01
	CG	4.27 (1.35)	4.27 (1.06)	
Technical proficiency	EC	4.81 (0.66)	4.81 (0.73)	$F_{1,21}$=5.59, p<0.01
	CG	5.18 (0.75)	5.18 (0.83)	
Self-efficacy	EC	41.94 (5.09)	41.94 (5.03)	$F_{1,21}$=6.88, p<0.01
	CG	45.00 (6.18)	45.00 (6.24)	
Betts QMI: Total	EC	105.44 (26.13)	105.44 (26.22)	$F_{1,21}$=9.26, p<0.01
	CG	78.36 (16.63)	78.36 (21.92)	
Betts QMI: Sensations	EC	16.00 (6.09)	16.00 (4.80)	$F_{1,21}$=5.66, p<0.01
	CG	11.09 (3.18)	11.09 (3.89)	
Betts QMI: Touch	EC	15.63 (4.65)	15.63 (5.43)	$F_{1,21}$=6.75, p<0.01
	CG	10.64 (4.06)	10.64 (4.51)	

significant increase in the experimental group's scores on the self-regulated learning questionnaire compared with the control group. The increase in practicing behaviors over the control group also emerged on the musical skills items of "quantity of practice" and "technical proficiency." Increased practice effectiveness appeared to enhance the experimental group's self-efficacy as well, as demonstrated by their significant increase beyond that of the control group. The experimental group's imagery ability also increased significantly over the control group's, specifically within the total score from the Betts QMI, along with the scores for the subcomponents of touch and interoceptive sensations.

Qualitative feedback

The results in Table 1 were further supported by comments from the participants revealing that, as a result of taking part in the training program, they were experiencing improved practice efficiency, greater levels of self-awareness and confidence when performing, facilitative views toward and a heightened sense of control over anxiety, and healthier perspectives toward music making.

Feedback from the participants also provided insight into issues pertaining to the content and delivery of the program. The participants felt that the training program could have been strengthened with the inclusion of more case studies and less information on research findings, more examples of practical application, and a greater use of class discussion and activities to facilitate learning from one another.

The case notes, as well as information derived from the follow-up focus group, suggest that people may respond to a training program individually, particularly in terms of their willingness to engage with some of the content areas. Given this, prior to program implementation, it would seem instructive to develop a sense of participants' willingness to engage in change so that the program could best be designed and delivered based on the participants' wants and needs.

DISCUSSION

While evidence-based training programs are commonplace within sport, similar empirical backing is largely lacking for many programs within the performing arts. Partly due to this, there is still little scientific evidence to indicate the range of benefits performers stand to gain from such programs, as well as the most efficacious means of providing training and education. The mixture of quantitative and qualitative investigation employed in the present study provides one means of addressing these questions.

In addition, a few issues arose as a result of the employment of this particular assessment protocol that are worth noting. Quantitative results derived from questionnaires could potentially be somewhat misleading given that the questionnaires employed may not be adequately sensitive, or even appropriate, to pick up changes. This could account for the fact that while anxiety intensity scores did not change significantly in the present investigation, the experimental group participants reported frequently how their perceptions toward anxiety had changed. Moreover, while assessment of performance quality is often important to many within performers' training, using it as a dependent measure to gauge program effectiveness could be challenging, particularly given how slowly performance quality improves and the somewhat subjective methods available for measuring improvement. When employing new training methods and techniques, changes may be slow to occur. This refers to both the participants' willingness to engage in new methods, as well as their abilities to engage with the methods presented. This should be borne in mind by those implementing new interventions and training programs.

In the present investigation, the importance of employing a mixed-methods approach to generate a more complete understanding of the effects of a training program was reaffirmed. Through the knowledge gained, this study aims to impact on performers' training and education and, subsequently, on their performance experiences. In doing so, it contributes to the growing body of evidence-based research supporting novel programs for enhancing performance.

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How can neuroscience help performers?

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Many neuroscientists are interested in musicians and in the neurobiology of music perception and performance. This interest is usually motivated by the attractiveness of the topic (music as an art) and by the enormous effects of music on brain networks and brain morphology, demonstrating the powerful mechanisms of brain plasticity in the short- and long-term range. Therefore, most neuroscientists consider music as an excellent paradigm to study brain mechanisms related to sensorimotor or perceptive learning. However, it remains open as to whether the growing body of research in this area has been made fertile for musicians, for example with respect to improvement of practice or teaching strategies. We report new results of brain imaging studies focusing on sensorimotor integration while novices learn to play the piano. Interestingly, auditory-sensorimotor integration can be established in less than 20 mins of piano practice, demonstrating the dynamics of brain plasticity in this specific task. Implications include the usefulness of pure auditory stimulation for the acquisition of skilled finger movements. Furthermore, we review recently published work on error monitoring in skilled pianists. This research demonstrates that errors are already "identified" by the brain 50 ms prior to their actual execution. We discuss this finding with respect to practical consequences concerning error avoidance. Based on these studies, we demonstrate the utility of some neuroscience research for musicians, particularly when the researchers themselves are trained musicians and work diligently to translate their findings from one discipline to the other.

Keywords: neuroscience; auditory-sensorimotor integration; pianists; focal dystonia; translational science

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Thematic session:
Expression and interpretation I

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Expressive timing: Martha Argerich plays Chopin's Prelude op. 28/4 in E minor

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This paper scrutinizes the temporal organization of Martha Argerich's interpretation of Chopin's Prelude op. 28/4 in E minor, recorded in 1975 for Deutsche Grammophon (DG 415 836-2). It proposes a method for extracting the timing of the attacks from the audio signal, it visualizes the data of bars 1-4, and maps Argerich's timing to Chopin's composition in a process of "inverse interpretation."

Keywords: microtiming; interpretation; piano; Martha Argerich; Frédéric Chopin

When Western art music is performed, microrhythmic organization often differs considerably from the notated rhythm of the score; these deviations can be referred to as "expressive timing" (Clarke 1999) and have been studied intensely in empirical rhythm research (see Pfleiderer 2006 for an overview). There has been a considerable amount of research concerning performance invariants in time organization; most of it analyzed performances of classical/romantic piano music on recordings. Several studies present evidence that performers tend to slow down at the end of a melodic phrase (e.g. Repp 1998, Clarke 1999) and that melody voices anticipate accompanying voices by a few milliseconds ("melody lead," e.g. Palmer 1989, Goebl 2001). Most conclusions endorse a general assumption in music performance research that expressive timing relates closely to structural features of a composition (e.g. Clarke 1988, Palmer 1996).

Against this background of invariant performance behavior, we would like to analyze one particular recording as an individual response to a composition: between 22-25 October 1975, Martha Argerich recorded Frédéric Chopin's Preludes op. 28 in Munich for Deutsche Grammophon (catalogue number DG 415 836-2). Our analysis in this paper concentrates on the temporal organization of the E minor Prelude op. 28/4, bars 1-4 (although measurements for the whole piece have been made). It divides the fabric of the Prelude into two rhythmic layers: the solo voice in the right hand and the sequence of accompanying chords in the left hand each have their own rhythmic structure (see Figure 2) and are analyzed separately. Finally, the timing phenomena are related to the score in a speculative process of "inverse interpretation": inspired by Timmers *et al.* (2000), we assume that there is a great number of possible ways to analyze the structure of a composition. We do not analyze the compositional structure first, and map it to the performance data later, but the other way around. We inspect the timing data and try to separate expected phenomena from Argerich's individual approach. Then, the score of the piece is analyzed in order to find the properties that are highlighted by Argerich's interpretation. This analysis is done strictly from a listener's point of view: we are not trying to reconstruct Argerich's thoughts or intentions. But we do try to articulate which sense or meaning we—as listeners—might discover in Argerich's interpretation of Chopin's piece.

MAIN CONTRIBUTION

Method

Our method to secure tone onset times seeks to meet two requirements: it must allow us to differentiate tone onsets in two separate rhythmic layers (solo voice and accompaniment), and the accuracy of the measurements must be within 10 ms. Our approach implies two steps. First, we marked the onsets roughly in a sonogram (window size=4410 samples, hop size=441 samples); this places the timing in a range of ±20 ms near the attack time. Since the notes of the accompaniment chords are not necessarily struck at the same time, only the onset of the loudest note of each chord was measured. In a second step we adjusted the measurements with the help of filters and two loudness measurements: a narrow bandpass filter (bandwith=100 Hz) was employed to isolate the fundamental tone (or, if necessary, one of the first partials) of a note; the delay caused by the filtering was compensated. Then, the behavior of two loudness measurements was interpreted in order to detect the precise timing of the onset. It was set to the moment when a fast peak level (window size=1 ms) overshoots an RMS level (27 ms) which reacts early but slowly to an energy surge. First tests with monophonic piano examples suggest that this method places the timing markers within a range of 2-12 ms after the physical onset; more systematic tests need yet to be conducted in order to evaluate this (rather conservative) estimate. All measurements and the visualizations of timing data in Figure 2 were made with the Lucerne Audio Recording Analyzer (software freely available at www.hslu.ch/lara).

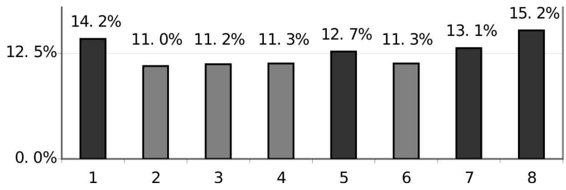

Figure 1. Average distribution of bar duration on the 8 eighth notes in the accompaniment in % (calculated with timing data from bars 1-11 and 13-22).

Analysis

In bars 1-11 and 13-22, the accompaniment of Chopin's Prelude op. 28/4 consists of a rhythmically uniform sequence of chords, pulsating in eighth notes. Argerich plays these eighth notes with flexible rhythm; nevertheless, a general bar profile is discernible.

Figure 1 shows the mean distribution of bar durations among the 8 eighth notes of a bar throughout the whole piece (in % of bar duration). Two ritardando zones can be identified: one strong ritardando spans over the bar line, from eighth note 7 (13.1% of bar time) and the longest 8 (15.2%) to 1 (14.2%). We would like to call this formation "bar line ritardando." Another, much more subtle lengthening concerns eighth note 5 (12.7%). We call this the "mid-bar ritardando." Besides the performance invariants reported in the research literature (slowing down on phrase endings, melody lead), this average bar profile can serve us as a background for identifying Argerich's individual reactions to particular configurations within the composition.

Figure 2 presents Argerich's rhythmic disposition of bars 1-4 alongside the respective excerpt of the score. The rhythm diagram just above the score (L for "left hand") represents the timing of the accompaniment: every vertical line on the horizontal timeline marks the timing of a detected onset. The width (and consequently the height) of the squares represent the inter-onset-intervals (IOI) on different metrical levels of the score. The smallest squares denote IOIs between neighboring eighth notes, the biggest squares denote IOIs between successive downbeats—i.e. they represent bar durations. All IOIs are given as a tiny numerical value (in ms) in the upper part of each square. The top rhythm diagram in Figure 2 (R for "right hand") represents the timing of the solo melody: the smaller squares stand for the anacrusis, the dotted half notes, and the quarter notes, respectively. The biggest squares visualize bar durations analogous to the lower diagram. Both diagrams (R+L) are adjusted horizontally to the same timeline. The numbers between the

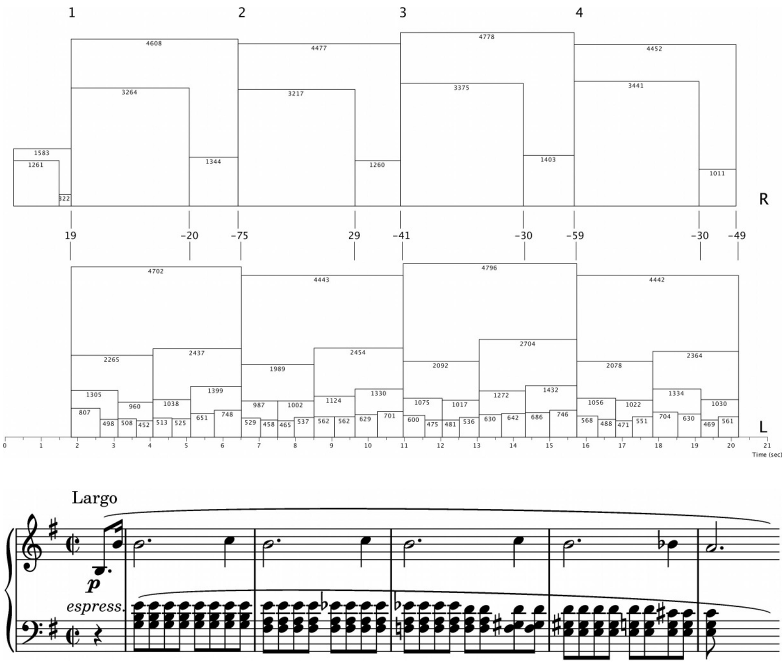

Figure 2. Rhythm diagram and score (according to G. Henle edition, 1968), bars 1-4.

diagrams represent differences between onsets in the right and the left hand, which—according to the score—occupy the same metric position. Most of the time, Argerich plays the solo voice's onsets earlier than the accompaniment's: in bars 1-4, the melody leads in seven of nine instances (78%), the average melody lead is 28 ms.

Argerich takes up the slow tempo of the anacrusis in the accompaniment. In bar 1, she starts with a quite long first eighth note (807 ms) which takes 17.2% of bar duration; then she speeds up. No mid-bar ritardando is discernible in bar 1, but the bar line ritardando (eighth notes 7 and 8) is distinct. In bar 2, Argerich starts fast but slows down considerably in the second half of the bar. This tendency is even stronger in bar 3: the first half of bar 3 is fast (28.7 bpm) and takes only 43.6% of bar duration (2092 ms), whereas the second half is considerably slower (22.2 bpm) and lasts for 56.4% of bar duration (2704 ms).

Which properties in the score might trigger the rhythmic phenomena of bars 1-3? Our attempt at inverse interpretation focuses on the repetitive pattern of the solo voice: the piece receives a first impulse from the octave leap of the anacrusis. Then the solo melody seems to be stuck in repetition—the motif C5-B4 is repeated three times in an identical way. With her fine sense of dramaturgy, Argerich seems to make a new effort to gain some speed with every new bar (hence the faster first halves), but this effort is lost as the bar progresses, the tension relaxes and the music seems to stagnate.

The situation changes completely in bar 4: the bar line ritardando is absent, but the mid-bar ritardando appears for the first time and very distinctively on bar 4, eighth note 5 (704 ms, 15.8%). Why is that? At the end of bar 4, the solo melody progresses from the repeated melodic pattern C5-B4—it descends one tone to B*b*4-A4. Following the research literature, we would expect the tempo to slow down at the end of bar 4, which is the end of the first 4-bar period. But the contrary is the case: after the mid-bar ritardando of bar 4, Argerich speeds up again. This development makes sense, if we take into account that the quarter notes of the melody are most likely heard as anacruses to the dotted half notes on the downbeats. The B*b*4 quarter note in the solo melody at the end of bar 4, thus, does not belong to the first 4-bar period but to the next formal entity. With the pronounced mid-bar ritardando of bar 4, Argerich slows down at the end of the first period just before this anacrustic B*b*4, and then gathers speed for the second period: the melodic anacrusis to bar 5 gives a new impulse to the piece, and the rhythm of the accompaniment supports this impulse. Compared with bars 3 (25.1 bpm) and 4 (27.0 bpm), bar 5 speeds up considerably (31.8 bpm).

IMPLICATIONS

Using time measurements, we described the microrhythmic fabric of the first 4-bar passage in Martha Argerich's 1975 recording of Chopin's Prelude op. 28/4. The specificity of her rhythmic interpretation was established against the background of rhythm performance invariants (as reported in the research literature) and an averaged profile of the eighth note lengths in her recording. Then, in a process of inverse interpretation, we have tried to figure out constellations in the score that might have triggered Argerich's specific approach. This procedure casts an analytical light on the composition through the lens of a concrete performance. It is no news that we can learn a great deal about structural features of a composition by listening to an eminent performer. Inverse interpretation attempts to transfer some of this intuitive knowledge into the explicit domain of music performance studies.

Acknowledgments

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Controlling the pacing of retards and accelerandos in piano performance: A roller coaster solution?

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Performers of a musical work generally well understand how to control steady tempos carried by the musical beat. More problematic for the performer, however, is controlling the graduated pacing of flexible tempos such as retards and accelerandos that depart from, yet link, the established tempos. According to Epstein (1995), the pacing of retards and accelerandos in performance is among the least accomplished events in our concert halls; indeed it is often left to chance. In this article, I propose that the performer may control the pacing of the ascent and descent of the melodic curves which characterize *Bruyères*, a prelude from *Book 2* for piano by Debussy, by using a subtle application of retards and accelerandos following the principle of the roller coaster. However, the retards and accelerandos, like the roller coaster, also require some means of support. I shall suggest too that Debussy's deployment of cadences is intended to give support to that pacing. But how may the performer achieve this?

Keywords: piano performance; accelerations; retards; cubic curve; roller coaster

There are few systematic studies on either retards or accelerations. While Sundberg and Verillo (1980) have dealt with the retard as a gesture during the closure of a work, perhaps more relevantly Epstein (1995) has proposed in an empirical study that retards or accelerations may be best performed if they fit within a mathematical equation known as the cubic curve. However, this is a pilot study that does not investigate how retards and accelerations, which are inverse forms of each other, may be paced smoothly one to the other. Kinetic and potential energy—which are exemplified in the pacing of the retardations and accelerations of the roller coaster—may provide, in part, a simpler solution, as will certain aspects of the "rethink" which has taken place in recent years in musical academic circles, notably Berry (1989) and Rink (2002) who have looked afresh at the relationship between performance and analysis. These changes have made possible the informal analysis at the end of this article, which seeks to demonstrate that the graduated pacing of the ascent and descent of the melodic curves in *Bruyères* requires a subtle application of retards and accelerations following the principle of the roller coaster. Informal tools of analysis such as découpage, diagrams, and historical evidence are used to support this approach.

MAIN CONTRIBUTION

The cubic curve

Retards and accelerations are governed by the principle of graduated change in the pacing of motion. As such, they do not proceed toward "ad hoc goal tempos" but rather link tempos that are already predetermined. Describing the retard/acceleration process, Epstein (1995) states that:

> The initial tempo from which the change starts, the number of steps though which the change must move, a related tempo to be achieved at the end of the time series: these elements set the temporal framework within which an retard/acceleration must be shaped (Epstein 1995, p. 418).

He suggests, also, that the cubic curve, while mathematically complex, can describe an act of timing such as the retard and acceleration which not only "feels natural and seemingly effortless to effect, but is compatible with our own musical intuitions" (Epstein 1995; see Figure 1 below). From this mathematical concept, Epstein extrapolates the idea that the shape of the curve could represent a "possible timing trajectory in the moulding of a retard and accelerando" (p. 419).

In this pilot study, Epstein transferred performances of retards by Szell and Stravinsky and accelerations by Karajan and Herrara de la Fuente onto an analog audio tape and timed the "durations of their successive beats with the tape measure technique" (p. 417). This enabled him to assemble a "highly correlated model" of a retard and accelerando performance from which he observed that their trajectory fitted within the model of the cubic curve with striking similarity. This, he suggests, means that they all had a good comprehension of the "boundary tempos" that frame the "timing path" of their retards and accelerations. Finally, a computer programme revealed that the

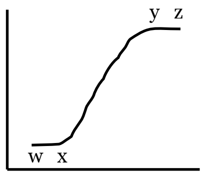

Figure 1. A reproduction of Epstein's (1995) diagram which shows: first, two horizontal lines between w-x and y-z. These lines represent the steady, or predetermined, tempos. Second, an s-shaped ascending curve links the horizontal line w and x to the horizontal line at the uppermost point of the curve marked y and z.

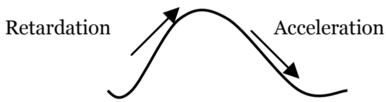

Figure 2. A general representation of the curve of a roller coaster. The arrow on the left shows the path of the retard of the roller coaster as it ascends toward the peak of the curve. The arrow on the right shows the path of acceleration of the roller coaster as it descends on the downward side of the curve.

retards and accelerandos measured in the study consistently fitted within the cubic curve model with less than 7% variance. Epstein concluded that the "cubic model does about as well as it is possible to do" (p. 423).

The roller coaster

Since the time constraints on a performer's life may discourage the study of the models described above in detail, it may be more effective for him or her to observe the similarities between the shape of a melodic curve in *Bruyères* and the path of the roller coaster as it rises and falls (this being closely related to the cubic curve). The energy of the roller coaster, during its fall, is transformed from potential energy to kinetic energy (energy in motion) and, during its rise, from kinetic energy to potential energy (stored energy). Thus, during the ascent of the roller coaster there is a retardation as it draws toward the top of the curve, and an acceleration as it descends on the other side of the curve (see Figure 2).

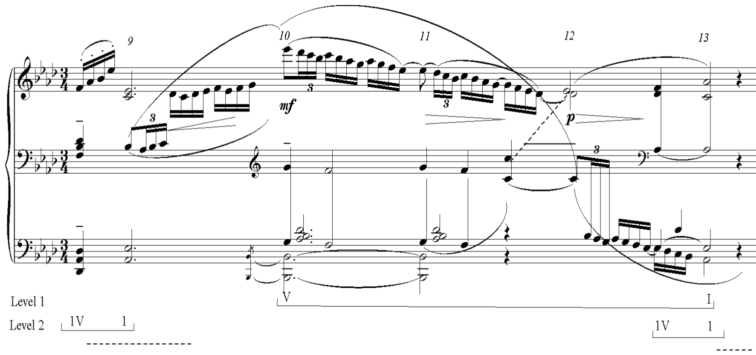

Figure 3. An informal analysis of bars 9-13 of *Bruyères* by Debussy. (1) Above the score, the contour of the melodic curve is highlighted with a black line to expose it more clearly, (2) level 1 shows the prolonged cadential memory device, (3) level 2 shows the deployment of the cadences irregulières at an intermediate level of hearing, (4) the dotted lines on both sides below level 2 are an approximation of the area of the predetermined tempo, 66 to the quarter note.

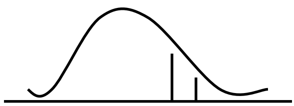

Figure 4. The curve represents the path of the roller coaster as it ascends and descends. The vertical lines below represent the hypothetical cadential points of support.

The analysis

This informal analysis seeks to expose elements that will support the pacing of the ascent and descent of the melodic curves in *Bruyères*. Since the aim is to apply a subtle application of retards and accelerations following the principle of the roller coaster, it will, first, expose the shape of the melodic curve between bars 9-13, since "curves not angles are the very nature of this composition" (Schmitz 1950, p. 172), and second, demonstrate that the role of the perfect cadence and the *cadences irregulières* support the pacing of the curve. *Découpage* and a diagram will be employed as part of the analytical process. For example, in bars 9-13, the vertical bar lines have been removed to expose a complete melodic curve. Its contour is highlighted above with a black line (see Figure 3) to reveal the similarity of the rise and fall of the musical curve with the ascending and descending path of the roller coaster. Thus, just as the energy of the roller coaster is transformed from kinetic to potential energy as it draws toward the peak of the curve, bars 9-10 may be performed with a subtle departure from the predetermined tempo of approx 66 to the quarter note, and a retardation applied toward the E*b* at the top of the melodic curve.

In the same way in which the roller coaster uses kinetic energy during its descent of the curve to "fuel the rest of the ride" (Epstein 1995, p. 27), performers may plan their descent of the curve with a graduated accelerative pacing through bars 10-13 and gradually rejoin the predetermined tempo of 66 to the quarter note smoothly in bar 13.

However, the pacing of the ritardando and accelerando, like the roller coaster, needs some means of support or stability. This article suggests that this is provided by Debussy's deployment of a hierarchical arrangement of cadential points (see Figure 4).

At level 1 (see bars 10-13, Figure 3), the function of the perfect cadence may be seen as a prolonged cadential memory device which serves to maintain a sense of unity in a work that otherwise might be heard as a series of fragmentary and isolated melodic curves. The dominant chord of the cadence is placed under the highest point of the melodic curve on the first beat of bar 10, and it does not resolve onto the tonic, A*b* major, until the first beat of bar 13. This, alongside the added energy of the accacciatura in the base, contributes stability to the pacing of the retardation, pushing the music up and forward to the top of the melodic curve like the car on the roller coaster. The positioning of the tonic chord A*b* on the first beat of bar 13 enhances the sense of closure as the car descends to the end of the melodic curve.

At level 2 (see Figure 3), the *cadences irregulières* are identifiable by the harmonic progression using the subdominant with an added sixth, which then resolves onto the tonic. These may be seen first between the third beat of bar 8 and the first beat of bar 9 (see Figure 3) and similarly between bars 12 and 13. In both instances, their function is to support the pacing of a subtle retard toward the end of the descent of the melodic curve.

Conclusion

The similarity of the melodic curves in *Bruyères* with the roller coaster's track and the degree of slope and corresponding retardation and acceleration with its "coefficient of friction at all points along the way" (Epstein 1995, p.27), which in this case is supported by two different types of cadences, is clear to see. If the performer plans and controls this recurring accumulation and release of tension, which together affect the pacing of the retardation and acceleration during the ascent and descent of the melodic curve, this will, as Epstein points out "lead the car to its designated end, its motion controlled throughout" (1995, p. 27). If not, the pacing of the ascent and descent of the melodic curve, like the car of the roller coaster, may be spent too soon and the intended musical effect, which is to control a graduated pacing of the ascent and descent of the melodic curve from the predetermined tempo of approximately 66 to the quarter note, to the same related tempo at the downward end of curve may be dissipated.

IMPLICATIONS

Future research may consider associating the graduated pacing of retards and accelerandos in piano performance with the kinetics of body movements. For example, bodily movements may be organized to reduce any angular movements in performance by planning ideal trajectories of bodily motion that take into account the demands of the musical score.

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Maintaining skill across the life span: Magaloff's entire Chopin at age 77

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The study is based on a corpus containing the entire works of Chopin performed by Nikita Magaloff at the age of 77, precisely measured and fully annotated with score information. On this data, we test a model of successful aging including selection, optimization, and compensation hypotheses (SOC). We identify performance errors, compare Magaloff's etudes with recordings by 14 other renowned pianists, and investigate specific age effects in a selected nocturne in 14 different recordings.

Keywords: performance errors; symbolic data; SOC model; aging virtuosity; piano performance

Many renowned pianists perform with great success up to old ages (e.g. Backhaus played his last concert at 85, Horowitz at 84, Arrau at 88). The demands posed by performing publicly are enormous (motor skills, memory, physical endurance, stress factors; see Williamon 2004). Theories of human life-span development identify three factors to be mainly responsible for "successful aging": selection, optimization, and compensation (SOC model, Baltes and Baltes 1990). Applied to piano performance this would imply that older pianists play a smaller repertoire (selection), practice these few pieces more (optimization), and hide technical deficiencies by reducing the tempo of fast passages while maintaining tempo contrasts between fast and slow passages (compensation) (Vitouch 2005).

In this study, we examine a unique corpus of Chopin performances by Nikita Magaloff, recorded on stage at age 77. We test whether Magaloff actually used strategies identified in the SOC model to master this unprecedented project. First, we assess his performance by quantifying performance errors. Second, we analyze recordings of the etudes by other renowned pianists to test whether Magaloff's performance tempi were slower than those of the others. Finally, we examine whether tempo contrasts are maintained when fast sections are performed slower at older ages by analyzing recordings of the *Nocturne Op.15 No.1 (Andante cantabile)*, which contains a fast, technically demanding middle section *(con fuoco)*.

METHOD

Materials

In Spring 1989, Magaloff performed the entire work of Chopin for solo piano that was published during Chopin's lifetime (Op.1-64) in six public appearances at the Vienna Konzerthaus. These concerts were recorded with a Bösendorfer computer-controlled grand piano that provides a huge set of symbolic performance data with highest precision—156 pieces over 320,000 performed notes; about 10 hours of performed music.

To put Magaloff's etudes performances into context, recordings of the etudes by the following performers were also analyzed (a total of 289 performances): Arrau (recorded 1956), Ashkenazy (1975), Backhaus (1928), Biret (1990), Cortot (1934), Gavrilov (1985), Giusiano (2006), Harasiewicz (1961), Lortie (1986), Lugansky (1999), Magaloff (1975), Magaloff (1989), Pollini (1972), Schirmer (2003), Shaboyan (2007), and Sokolov (1985).

The 14 recordings of the *Nocturne Op.15 No.1* were by Argerich (1965), Arrau (1978), Ashkenazy (1985), Barenboim (1981), Harasiewicz (1961), Horowitz (1957), Leonskaja (1992), Maisenberg (1995), Magaloff (1975), Perahia (1994), Pires (96), Pollini (68), Richter (68), and Rubinstein (1965).

Procedure

To make Magaloff's performances accessible for analysis, the entire Chopin scores were scanned (946 pages) and subsequently converted into a digital format (musicXML) using a commercial optical music recognition software and custom-made post-correction steps. The data from Magaloff's performances were then semi-automatically matched to the symbolic scores, building a huge corpus with precise performance information for all score notes and vice-versa. Based on the alignment, performance errors were categorized as insertion, deletion, or substitution errors. We extracted basic tempo values (see Note) of Magaloff's performances of the etudes Op.10 and Op.25 in order to compare them with recordings by the other famous pianists. These audio recordings were semi-automatically beat-tracked using the software *Beatroot* (Dixon 2007) to determine the expressive timing at the beat level; tempo values were then extracted as before.

Table 1. Error % by piece category and error type (i.e. insertion, deletion, substitution).

	Ins.	*Del.*	*Sub.*		*Ins.*	*Del.*	*Sub.*
Rondi	1.86	2.40	2.50	Polonaises	5.74	4.09	1.54
Sonatas	4.20	3.63	1.82	Preludes	3.38	2.97	1.56
Mazurkas	2.44	3.41	1.00	Impromptus	1.36	2.12	0.89
Nocturnes	2.22	2.46	0.99	Scherzi	6.15	2.97	1.63
Etudes	3.90	3.94	1.33	Ballades	5.00	2.33	1.23
Waltzes	2.48	3.53	1.26	Pieces	4.36	3.49	2.27

RESULTS

Performance errors

Overall, Magaloff's data contained 3.73% insertion, 3.28% deletion, and 1.52% substitution errors. This is slightly higher than Repp's (1996) account for other pianists (1.48%, 0.98%, and 0.21%, respectively), but comparing the particular piece used by Repp (Op.28/15), the error percentages were similar. With a percentage higher than 5%, the scherzi, ballades, and polonaises stand out in terms of insertion errors (see Table 1). The *Allegro de Concert* Op.20 in the category "pieces" shows an exceptionally high insertion percentage (6.77%). With an insertion percentage below 2.3%, the nocturnes, rondi, and impromptus constitute the low-insertion categories. The impromptus are also the category with the lowest percentage of deletion errors (2.12%), while the etudes and polonaises exhibit the highest percentage of deletions.

Performance tempo of etudes

Table 2 shows the tempo modes obtained for all pianists. Each performance is named by the first two letters of the pianist, followed by the pianist's age at the time of the recording. For the sake of comparison the metronome indications from the Henle Edition (Zimmermann 1983) were added (HEN). In 12 of the 18 pieces, Magaloff's tempo (MA) is within a 10% range of the Henle indications. Three pieces are more than 5% slower and three pieces more than 5% faster compared with the metronome markings. Compared with the performances of 14 other recordings (including an earlier performance by Magaloff in 1975) Magaloff's performances of the Op.10 etudes are on average 1.2% slower than the average over all other recordings. The Op.25 etudes are on average about 5.6% slower than the average performance.

Comparing Magaloff's recordings at the age of 63 and 77, the tempi vary to a surprising degree, but no systematic tempo decrease in the latter can be

Table 2. Tempo modes of different pianist for selected pieces from Op.10 and Op.25. Entries are named by the first two letters of the pianists' name and age at recording.

Op.10/1		*Op.10/2*		*Op.10/4*		*Op.10/10*		*Op.10/12*		*Op.25/1*	
BI49	157	BI49	129	HA29	157	BI49	426	PO30	64	HA29	77
HA29	159	**MA77**	139	BI49	157	BA44	450	LO27	64	AS38	84
SH32	163	SH32	140	AR53	161	**MA63**	467	**MA63**	65	LO27	91
CO56	164	HEN	144	SC31	165	SC31	471	SC31	66	LU27	93
MA63	165	HA29	145	**MA63**	166	HEN	480	LU27	66	SO35	94
SC31	169	**MA63**	145	SH32	169	SH32	480	AS38	66	GA30	102
AS38	170	CO56	149	LO27	169	AR53	483	HA29	68	**MA63**	102
MA77	170	AR53	152	PO30	169	LU27	487	BA44	71	BI49	103
HEN	176	SC31	152	**MA77**	170	HA29	505	SH32	71	HEN	104
PO30	178	PO30	152	GI33	174	GA30	508	**MA77**	72	**MA77**	104
LO27	179	LO27	156	AS38	174	AS38	512	BI49	74	AR53	104
BA44	179	AS38	157	CO56	175	PO30	513	CO56	75	GI33	105
LU27	180	LU27	159	HEN	176	LO27	529	HEN	76	BA44	109
GA30	190	GI33	165	LU27	179	CO56	542	GI33	77	PO30	111
GI33	191	GA30	173	BA44	191	**MA77**	550	GA30	87	CO57	118
AR53	196	BA44	176	GA30	197	GI33	574	AR53	88		

Op.25/6		*Op.25/8*		*Op.25/9*		*Op.25/10*		*Op.25/10*		*Op.25/12*	
HEN	69	BI49	64	BI49	94	**MA77**	64-90- 65	HA29	51	HA29	58
MA63	70	HA29	66	HA29	104	BI49	64-106-68	BI49	53	**MA77**	62
BI49	71	HEN	69	AR53	107	LO27	67-86- 70	**MA63**	58	**MA63**	69
AR53	71	GA30	69	**MA77**	107	BA44	71- 112- 70	GI33	59	AS38	70
CO57	73	**MA63**	69	LU27	107	AR53	71- 96- 68	**MA77**	60	LO27	73
PO30	74	AR53	70	CO57	110	AS38	71- 84- 70	LO27	61	CO57	73
BA44	74	LO27	71	HEN	112	**MA63**	71- 100-70	CO57	61	BI49	74
MA77	75	**MA77**	71	PO30	113	CO57	71- 127- 71	AS38	62	GI33	74
AS38	75	CO57	73	**MA63**	115	HEN	72-126- 72	LU27	63	SO35	76
HA29	75	GI33	73	GI33	117	PO30	72-104-74	PO30	63	LU27	76
LO27	77	AS38	73	LO27	118	GI33	74-129-73	AR53	63	PO30	76
GI33	78	PO30	76	GA30	120	HA29	74-112- 76	SO35	66	AR53	77
LU27	83	LU27	77	AS38	125	LU27	75-96- 71	HEN	69	HEN	80
GA30	84	BA44	78	SO35	125	SO35	83-86- 87	BA44	69	BA44	82
SO35	85	SO35	81	BA44	131	GA30	86-117- 81	GA30	71	GA30	83

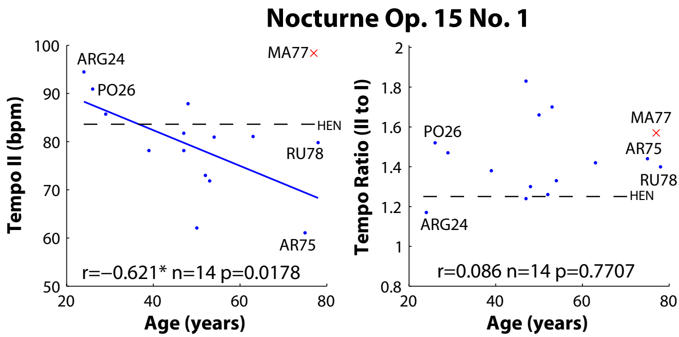

Figure 1. Nocturne Op.15 No.1 by 14 pianists and Magaloff: basic tempo of middle section (left) and tempo ratio between middle and first section (right) against performer's age. Dashed lines indicate given tempo (left) or tempo ratio (right) by Henle edition.

found. On the contrary, in 12 pieces out of 18, the recording at age 77 is faster, sometimes to a considerable degree (up to 17% in Op.10 No.10). On the whole, no significant correlation of age and tempo could be established.

Age effects and tempo contrast in a nocturne

For an exemplary piece containing tempo contrasts, we examined the tempo values in performances of the *Nocturne Op.15 No.1* by 14 other pianists. We found a significant correlation between the performance tempo of the middle section and the age of the performer (the older, the slower; see Figure 1). However, the tempo ratios between the contrasting sections of the piece showed no overall age effect, confirming Vitouch's (2005) interpretation of the SOC model. Age seemed to have no effect on Magaloff's nocturne; he played faster than the youngest of the performers while keeping a comparable tempo ratio. The same tendency could be found in Op.25 No.10; however, the negative correlation was not significant.

DISCUSSION

Based on the fact that Magaloff performed the entire piano works by Chopin, we can refute the selection part of the SOC model. Due to missing information about his practice regime before and during the performance period, we cannot make a statement about optimization processes. Magaloff's tempi do not point to compensation processes, which were indeed found with other famous pianists. However, his relatively high error rates may indicate that

Magaloff aimed at realizing his musical ideas of Chopin's work rather than at error-free performances. In sum, Magaloff's data does not seem to corroborate the SOC model. This study is the first of its kind to examine a huge corpus of symbolic performance data of the entire work of a composer and to put it into context of a substantial number of other recordings.

Note

A basic tempo value was estimated by the mode value, the most frequent bin of an interbeat interval histogram with a bin size of 4% of the mean inter-beat interval.

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Thematic session: Expertise development

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Strategies for achieving performing excellence of twentieth and twenty-first century art song

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Strategies professional singers use in the selection and preparation of twentieth and twenty-first century art song were gathered from an international study carried out by email during 2006-07. These strategies were applied in the preparation of 34 Australian art songs for a recital in 2008 by three professional singers in a practice-led research project involving the author. The 84 resulting performance and learning strategies from the professional singers' study are discussed in relation to the literature and their application by the three singers who strove for performance excellence in their preparation and performance of a recital of these Australian art songs. The application of how these strategies can ultimately benefit singers and vocal teachers learning and performing twentieth and twenty-first century art song is discussed, along with the categorization of the strategies with reference to the literature.

Keywords: practice strategies; learning strategies; art song; practice-led research; performing excellence

The challenges singers face in relation to performance excellence of twentieth and twenty-first century art song are seldom discussed in the literature. Singers perform with a partner—an accompanist—and must together interpret the text of the song they perform (Fine and Ginsborg 2007). The demands modern composers have placed on performers involve challenges in rhythm, new vocal techniques, and often new notation approaches in scores, to name but a few (Mabry 2002). While each performer will rely to a certain extent on their intuition and innate musical talent (Rink 2002), various skills involving the preparation of the music can be learned and may go towards enhancing the singer's path in achieving perceived excellence.

Within the scope of practice (Hallam 1997) and learning strategies (Nielsen 1999), a performer has the possibility to develop and maintain their skills in many areas. Skills such as sight-reading/sight-singing (i.e. being able to sing notation) is one many singers struggle to master despite its importance (Killian and Henry 2005). The skill of memorizing the words and melody together was found to be effective for singers (Ginsborg and Sloboda 2007), with the formal structure of a song providing the basic framework for memory. Communicating emotion through both psychological and physiological means is essential for a singer, with strategies involving both speech and singing (Sundberg *et al.* 1994).

Other strategies musicians use in their pursuit of performance excellence (Williamon 2004) include the areas of analysis, practice (Jørgensen 2004), imagery (Emmons and Thomas 1998), rehearsal, memory (Barry and Hallam 2002), self regulation (McPherson and Zimmerman 2002), technique, goals, organization, and time management (Jørgensen 2004).

This paper presents the findings of (1) a study investigating strategy use by professional singers of the selection and preparation of twentieth and twenty-first century art song and (2) the practical application of those strategies in the preparation and performance of twentieth and twenty-first century Australian art song.

METHOD

Participants and data collection procedures

Data were collected from two sources, the first being a group of n=14 professional singers from America (2), Australia (7), Canada (1), New Zealand (3), and Spain (1) in a study from 2006-07. Six were male, seven female, and their voice types were soprano (6), mezzo soprano (2), tenor (4), baritone (1), and bass/baritone (1). The professional singers completed a series of three email questionnaires, the first of which sought responses about the selection and subsequent preparation of twentieth and twenty-first century art song repertoire from a program for a recent performance. The second email questionnaire sought information on learning and preparing one twentieth and twenty-first century art song contained in the submitted program. Participants were requested to send a score of the song, which they could annotate to illustrate their answers. Specific and generic questions (relating to *any* twentieth and twenty-first century art song) about learning strategies, procedures (i.e. order of learning), and the use of vocal techniques and challenges were asked in the third and final email questionnaire. The resulting qualitative data was categorized into a list of either performance or learning strategies. The draft list of strategies (n=50) was informed by a list of strategies drawn from the initial literature review, combined, and made available to three professional singers to apply as they prepared a recital of Australian art songs.

The second source of data collection came from three professional Australian singers in a project that involved the author (a soprano), a mezzo, and a baritone who all applied the collected strategies in their preparations for a 2008 recital of 34 Australian art songs. The recital was recorded and the singers and accompanists were interviewed following the performance. This practice-led research project (Aggett 2008) required the three singers to record their practice sessions and keep and reflect on practice diaries, choosing and adopting appropriate strategies as a means of improving their performances. Their new strategies resulted in further expansion to the existing list of strategies.

Materials

The 34 songs for the recital were chosen as a result of an extensive search of all the Australian art songs in the Australian Music Centre (submitted from 2005-09) and other sources including the Mitchell (Sydney, New South Wales) and National (Canberra, Australian Capital Territory) libraries, in an attempt to select a repertoire of songs suitable for all voice types and addressing a range of pedagogical aspects.

RESULTS

Eighty-four strategies drawn from the literature review and first group of participants were categorized and coded as being musical (M), performance (P), or contextual (C) according to themes evident in the literature. Many of these strategies can be viewed as performance (self-regulatory) strategies for the singer and/or learning strategies (for a teacher or singer). Performance strategies (n=55) included overall strategies to help prepare a piece (10), pitch strategies (12), rhythm strategies (5), textual strategies (7), vocal techniques (7), and ensemble and accompaniment strategies (7). Learning strategies (n=29) included general strategies (14), order of learning (8), pitch strategies (1), aural strategies (1), and strategies for preparing a whole song cycle or program (4).

The second group of participants adopted n=118 performance strategies—42 musical, 49 performance, and 27 contextual; a total of n=43 learning strategies were adopted, with 21 being musical, 11 performance, and 11 contextual, with singers introducing 13 new strategies to the list (see Table 1).

Table 1. Strategy use in relation to recurring musical (M), performance (P), and contextual (C) themes existing in the literature on and about twentieth and twenty-first century solo vocal music and Australian song. The performance and learning strategies used by professional singers as reported in the study conducted in 2006-07 were sorted into M, P, and C themes, some of which were adopted by the three professional singers in a 2008 recital.

		M	*P*	*C*			*M*	*P*	*C*
Occurrence in literature		163	70	269					
2006-07 prof singers study									
Performance strategies	(PS)	14	41	13	Learning strategies	(LS)	12	14	21
2008 recital: Application of strategies									
Soprano	(PS)	24	29	14		(LS)	4	6	1
Mezzo soprano	(PS)	3	6	5		(LS)	11	-	9
Baritone	(PS)	15	14	8		(LS)	6	5	1
Strategy use total	(PS)	42	49	27		(LS)	21	11	11

DISCUSSION

Most frequently encountered performance strategies in the first study were pitch and overall strategies to learn a song (see Figure 1). Because of the breakdown of tonality in the twentieth and twenty-first centuries, vocal repertoire of this period can be musically challenging, and it is not surprising to note the emphasis on pitch. However, few participants had definite learning approaches to tackle the repertoire, and their responses demonstrated that many had a lack of understanding of current trends in song composition. General strategies were the most frequently employed learning strategies reported by singers; for example, both a mezzo and tenor found it helpful to use a sound file from a composer to help learn a melody when no recording was available. Many of the strategies can be viewed as performance/self-practice strategies for the singer and/or learning strategies for the teacher or singer. The number of composer biographies and articles included in the review of literature consulted explains the high reference to contextual strategies found (see Table 1).

Strategies that second study participants found most useful related to performance rather than learning strategies. From the practice journals, it was apparent each singer had tailored their learning, practice, and strategy use to suit each song, their own personal challenges, and the technical de-

Figure 1. Distribution of performance and learning strategies collected from responses by 14 professional singers in the 2006/7 international study conducted by email questionnaires.

mands specific to the repertoire. Both an ensemble and pitch learning strategy used with the sixth song of Peggy Glanville Hick's *13 Ways of Looking at a Blackbird* involved the accompanist playing the notes of each bar as a block chord to familiarize the singer with the tonality, gradually adding in the rhythm.

The use and application of performance rather than learning strategies, drawn from literature and the experience of professional singers, were found to be effective in striving for performing excellence when preparing twentieth and twenty-first century Australian art song. Categorizing strategies by the themes apparent in the literature and cross-referencing them with the experiences of professional singers can offer singers and singing teachers a way of tackling the challenges offered by twentieth and twenty-first century vocal art song.

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Developing the ability to perform: Investigating the field of higher education and expertise development for learning and performing the double bass

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The aim of the present study was to find out if there were significant differences between the learning student, the supervising professor, and the expert performer working in a symphony orchestra regarding the development of their ability to perform. Survey results demonstrate that all groups showed a secure level of understanding of the concepts of deliberate practice and self-awareness, while those of metacognition were practically unknown. While students reported the most practice of all groups, they rarely record themselves or use computer technology. All participants were highly supported by their parents especially at the time when they decided to become a professional. The instrumental diversity of size, *scordatura*, playing postures or bowing schools was seen as an advantage rather than a disadvantage, overruling statements of previously undertaken research. The study highlights the importance of early pre-professional learning for the university student.

Keywords: double bass; skill; practice; pre-professional learning; expert performance

Over the past decade, researchers have taken numerous approaches to studying how musicians acquire and refine their skills as performers (e.g. Hallam 1997, Jørgensen 2000). While many of these studies have provided new perspectives on instrumental learning (e.g. Hallam 1997), it remains unknown whether the findings found their way back to benefit the population (Bastian 1998). What has been noticed is that the results of studio research only very slowly establish themselves as the "learning to learn" concepts to "professional practice" in higher education (Pertzborn 2007). If these links remain disconnected to instrumental practice, they may not give the student the means to achieve maximum proficiency. However, and also in some way confirmed in this investigation, most double bass students are still advised to study from method books published in the nineteenth century. It seems somehow awkward that more recent method books have excluded an in-depth exploration of the processes of skill acquisition as guidelines to professional instrumental practice.

METHOD

Participants

Fourteen professors (PROF), 82 students (STUD) from 13 universities, 33 double bassists (ORCH) from 7 symphony orchestras representing seven countries in three continents, participated in the DAP survey (see Figure 1). Principals from symphony orchestras collaborated in handing out the questionnaires to their section colleagues, and university professors to their students, as well as sending back the completed questionnaires. The total number of participants was 129; the response rate was 85%.

Materials

Together with the empirical approach adapted to this study, literature was reviewed comprising the areas of (1) the learner and (2) the instrument. The first part focused on practice, expertise, task requirements, and biographical issues. A second part reviewed the history of the double bass, its performer, and their influences on the development of expertise of the instrument and its role in the repertoire. Many of the findings that came out of the historical review—such as the diversity of at least two bow schools, different playing postures and tunings—are still subject to controversial discussion today. These concerns were included in the survey to examine the impact of history and tradition on the present generation. The blueprint of the survey (see Figure 2) was based on a multidimensional learning model to instrumental practice conceived by Hallam (1997).

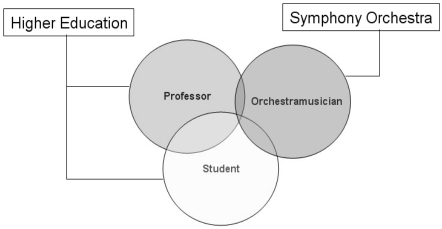

Figure 1. Field of investigation and groups of participants.

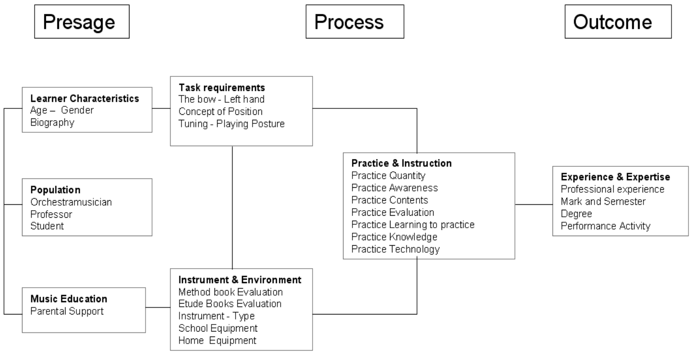

Figure 2. Blueprint of the DAP survey.

Thirty-four questions were organized in presage, process, and outcome factors, assembling a wide range of topics: learner characteristics, population, music education, task requirements, environment and instrument, processes of practice, performance experience and expertise, methods, biographic information, professional experience, health and wellbeing, and lifestyle. Four different types of responding were used: (1) rating from 1-5, (2) multiple choice, (3) selecting between yes/no/rarely, and (4) numeric indication of, for example, "years of playing." Five open-ended questions were used to assemble individual opinions or different views. The surveys were translated to English, German, and Portuguese.

Procedure

The data collected from the survey were processed through the statistical program SPSS 17.0, taking into account the most adequate statistical technique to the involved variables. The data were organized according to the nature of variables, most of them qualitative and descriptive techniques. Principal component analysis was used to reduce the dimensionality and to identify profiles considering biography, education, etc. To compare the results, parametric Analysis of Variance (ANOVA) or non parametric Kruskal Wallis techniques were used. For the other topics, some independent chi-squared tests were performed to evaluate the association between the different groups of PROF, ORCH, and STUD and the correspondent item. The decision rule used to detect significant statistical evidence was a probability (p) value less than 0.05. In addition, the survey provided 204 individual comments to open-ended questions which were assembled for further discussion according to the topics and group of population.

RESULTS

Results from the survey revealed that the double bass is still a male dominated instrument. Male participants were dominant in the group of the PROF (79%), STUD (72%), and ORCH (100%). No female orchestra bassist participated in the survey. The mean age of PROF was 50 years male and 41 years female, ORCH 41 years (only male), and STUD 23 years male and 21 years female. The average age for starting the double bass for all groups was between 14-15 years. However, the starting age ranged from 3-20 years. A high percentage of all groups previously gained experience on other instruments, which they learned for 4-7 years before moving to the double bass at the age of 13-15. The late and most diverse starting age reveals a relative inconsistency when comparing to other instruments such as the violin. These findings confirm those from a similar study undertaken by Langner (2003).

The majority of the ORCH group (52%) practices regularly only when they have important performances, while this is done less by PROF (36%) and STUD (25%). This may be because PROF and STUD have a different time frame to build up repertoire in advance. They may also have more freedom in choosing their repertoire, while the ORCH group normally has to deal with an intense and pre-given performance schedule. Additional comments were made on these issues, which confirm these views. The PROF (78%) and ORCH (76%) reported that they practice between 1-3 hours daily, while this was assumed by 60% of the STUD; 35% of STUD reported practicing 4-6 hours per day. In all groups, between 54-67% of the participants tended to maintain a practice free day through the week. STUD (73%), unlike PROF and ORCH (38%), consider studying *etudes* as a key point of their practice. The landscape of "practice contents" was fairly even and consistent in all groups and showed a high percentage in "learning new repertoire," "maintaining or re-learning already performed material," "maintaining or improving technical issues," and "preparing performance."

PROF obtained the highest scores for factual knowledge of practice issues (80-100%), followed by ORCH (50-85%), and STUD (35-84%), with the exception of the concepts of metacognition. Here, the groups PROF (58%), ORCH (50%), and STUD (64%) reported that they were not familiar with these concepts. This fact may well indicate that concepts of practice are widely known to most of the participants and that topics of instrumental research have the potential to find their way back to the practicing musician. Only a minority of all groups recorded themselves on audio: PROF (43%), ORCH (18%), and STUD (30%). The usage of video was still much lower than the usage of audio: PROF (21%), ORCH (14%), and STUD (7%). The usage of computer software as a practice aid was indicated by PROF (50%), ORCH (26%), and STUD (20%). A much lower score was attained for the usage of MIDI accompaniment: PROF (29%), ORCH (11%), and STUD (25%). These results illustrate a low rate of usage of audio, video, and computer technology in all groups. In the century of almost unlimited access to recording and music technology, one may have expected a higher usage of these media. Listening to CD audio recordings and instructional DVDs received a higher score of appreciation: PROF (57% for DVD, 71% for CD), ORCH (44% for DVD, 59% for CD), and STUD (35% for DVD, 69 % for CD). It is noted that CD recordings received a higher score than DVDs.

Indications on lifestyle revealed that all groups highly enjoyed their profession as a double bassist (95-100%). Nevertheless, ORCH (48%), STUD (27%), and PROF (22%) already thought at some point in their careers about doing something else. The PROF was the most active in performing sports regularly, while the ORCH and the STUD showed less activity in this domain. In addition to this, 43% of the PROF, 32% of the ORCH, and 19% of the STUD reported to have another professional qualification, activity, or expertise.

DISCUSSION

Results of this study revealed a strong relation and influence between teachers and their students. The group of the PROF was the most experienced in all performance domains and had also the highest academic qualification when compared to the ORCH and the STUD. The latter, however, seemed to follow their PROF in being active in all domains, although professional opportunities such as performing in festivals are yet rather more limited for them. Early instrumental learning on the double bass has been identified as one of the potential key factors to a prospective professional career. This has obvious implications in early learning methodologies and in providing adequate instruments for the young learner. The low use of technology, while making such a high investment of practice time to achieve a competitive level of performance, is a second point that needs further investigation. The proposal is that a wider perspective of learning, practice, and self-evaluation in combination with the use of technology as a support for practice and feedback should be taken into account to form efficient venues to move forward on the road to excellence for the double bass. By providing better and more challenging concepts to expertise and (early) instrumental learning, future generations of double bassists may breakdown more rapidly the technical barriers of the instrument and will use the whole range of the instrument as an advantage rather than a limitation.

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Pathways of excellence in science and dance: Lessons learned from a Portuguese case study

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Many researchers are studying the early identification of exceptional individuals, expertise acquisition, personality, and the role of external catalysts, aspiring to explain their influence on the process of talent and expertise development. Researchers seek a deeper understanding of these exceptional individuals, using multiple methodologies and techniques, studying multiple contexts and domains, and focusing on multiple dimensions and constructs associated with excellence. Moreover, much psychological research on excellence takes a predominantly outsider perspective favoring quantitative inquiry, but little is really known about the experiences and personal meanings of exceptional individuals. In this study, we explored the insider perspective of being excellent. Using a case study approach, two dancers and two scientists were interviewed. A theoretically-oriented content analysis grid was constructed to assist data analysis. Overall, participants stressed personal characteristics such as extreme curiosity, persistence, and passion for their work as central features in nurturing and sustaining their motivation for practice, and also as key features of being an excellent performer. Additionally, intensive and hard work, discipline, and strong commitment were emphasized and other personal and contextual dimensions highlighted. Singularities and some reflections that emerged from this study are discussed.

Keywords: excellence; dance; science; performance; qualitative

The interest and curiosity about the lives of exceptional scientists, artists, or athletes has always encouraged researchers to search for the reasons and determinants of being creative and attaining high levels of performance. In science and performing arts, pioneering work by Roe (1946), Bloom (1985), Gardner (1993), and Feist (2006) has inspired many researchers. For instance, Lubinski *et al.* (2001) tracked intellectually precocious youth over 25 years, reaching conclusions about stimulating early educational experiences, mentoring relationships, early development of interests, and strong commitment to career and work as significant attributes in developing exceptional expertise in science. Recently, Feist (2006) conducted and reviewed several studies on personality and development of scientists, arguing for the need of a new "psychology of science" for a complete understanding of scientific thought and behavior. Conversely, research in dance seems to be still developing, focusing essentially on classical and non-professional dancers, and more "negative" topics, such as eating behavior disorders, injury, stress, or physical and biomechanical issues (see Krasnow and Kabanni 1999). Still, some efforts have been developed towards a more complete dance science, with studies focusing on professional and elite performing artists and psychological issues, such as personality profiles, expertise, or motivation (e.g. Hays 2002, Kogan 2002, Ureña 2004).

Moreover, several theoretical models have been developed to explain the process of performing excellence in different domains (see Araújo *et al.* 2007). The theoretical models of Renzulli (2002) or Gagné (2004), explaining talent development, Ericsson's deliberate practice and expert performance approach (Ericsson and Charness 1994), as well as the Berlin school paradigm on the study of wisdom (Baltes and Staudinger 2000) represent some of the strongest approaches that influence current empirical research. Overall, findings suggest that singularity of exceptional individuals seems to emerge from a dynamic combination of contextual and personal factors.

Despite the vast amount of research on excellent performance, several issues remain ambiguous. Definitions of excellence are still vague and multiple criteria are used to identify excellent performance (Weiss *et al.* 2002, Trost 2000, Ureña 2004, Zannotto 2006). Additionally, little is known about the trajectories of excellent individuals from their own thoughts and meanings. Quantitative inquiry has been favored in the study of performance excellence, even if the singularity of successful trajectories and the complexity associated with performing excellence in adulthood is assumed. Nevertheless, qualitative methods are being gradually accepted as a valuable way to investigate singular and complex topics in-depth. Hence, a qualitative case study was conducted aiming to analyze the singularities and commonalities behind talent and success trajectories. In this paper, we present general findings and discuss some lessons learned from this research.

METHOD

Participants

Two female dancers (contemporary dance) and two scientists (life sciences, female and physics, male) were consensually identified by a panel of experts in each specific domain. Participants were all nominated for revealing excellence in performance and being actively engaged in their respective field. The ages of participants were 36, 41, 38, and 43, respectively.

Materials

The interview protocol was created after reviewing relevant literature and interview guides successfully used in previous studies with exceptional individuals in different domains (e.g. Connaughton *et al.* 2007, Kiewra and Creswell 2000). A semi-structured protocol covering the following main areas in a fluid and flexible sequence was used: (1) career path, (2) past achievements and actual performance, (3) expertise acquisition, (4) personal characteristics, (5) role models and significant others, and (6) relationships within each professional community. In addition, participants' academic and professional pathway and productivity were analyzed through their actualized curricula vitae.

Procedure

A nomination strategy was conducted to select participants. Although criticized, this strategy seems to be effective, particularly in domains where objective and rigorous criteria are difficult to establish and "gold standards" do not exist. In addition to peers' recognition, some quantitative criteria were considered (Weiss *et al.* 2002, Urenã, 2004, Zanotto 2006). Criteria to select scientists included: number of publications on refereed journals, number of citations, highly cited papers, awards, members of editorial boards, and grants. Awards, participation on international/European dance companies/projects, and professional certification were the criteria used to select dancers. Identified participants were contacted by email or telephone, study aims were presented, and data anonymity and confidentiality was guaranteed. Subsequent to participants' agreement, interviews were scheduled according to their time and location. Interviews were recorded integrally and transcribed verbatim and sent to participants for verification. A theoretically-oriented content analysis grid was designed to assist data content analysis. Since the interview protocol had a semi-structured and flexible format, themes in the analysis grid had a different organization reflecting that unanticipated issues could arise during interviews. Transcripts were sorted into three main dimensions: (1) contextual factors, (2) personal factors, and (3) answers to a specific question: “what makes you an excellent professional.” Texts were coded and analyzed using Maxqda qualitative analysis software and following the proposals of Schilling (2006) and Mayring (2000) on qualitative content analysis. Some validity procedures were used such as triangulation, member checking, and peer-debriefing (Onwuegbuzie and Leech 2007).

RESULTS

An overview of participants’ productivity through their curricula vitae shows some evidence for their superior performance. The scientists had several publications in refereed journals, some of which are highly cited papers. We found them working within the most influential international research networks and heading research teams with national and international grant funding. The dancers were also distinguished by their creative and outstanding performance. They work with the most creative and renowned Portuguese choreographers and are frequently selected to perform on choreographic projects in Europe.

Interviews’ content analysis highlighted several features confirming some general research findings (e.g. Feist 1996, Lubinski *et al.* 2001, Kogan 2002). Describing some aspects of macro context (social, historical, economical, cultural), all the participants mentioned that, at the time they started to become involved in domain-specific activities, Portuguese society was not sensitive to their domain (dance/research), and opportunities and choices were limited. Nevertheless, participants reveal that, currently, it is possible to find a stimulating and optimal professional environment. Furthermore, participants clearly identified significant people in their lives who provided important socio-emotional support but also an inspiring role in their career choices and opportunities. Transcript analysis also indicates a strong presence of individuality and singularity on participants’ trajectories. Overall, participants stressed personal characteristics such as curiosity, perseverance, openness to new experiences, adaptability, and passion as central in nurturing and sustaining their motivation. Additionally, intensive and hard work, discipline and sustained commitment were considered important factors in performing excellence. Finally, all the participants affirmed their strong concern with society and a sense of social responsibility and also the importance of family and social networks as core life values.

DISCUSSION

In this study, the role of positive emotional states and strong psychological features are clearly associated with performing excellence, in addition to contextual factors. However, we observed a slight difference between artists and scientists, mainly on working strategies and career trajectories. Whereas careers in science are more organized and sequential, trajectories in dance are irregular and unstable. Scientists seem to plan more, following rigid schedules, while dancers have more flexible agendas and engage in multiple activities other than physical training, which seems to contribute to their technical and performance skills (Kogan 2002). Furthermore, this study provided a rich description of individuals' trajectories, showing several important conditions needed to excel in a small and peripheral country such as Portugal. Participants' critical picture of the Portuguese educational and professional system questions its role in the identification and encouragement of potential talents, suggesting the importance of mentorship and awareness of creative, sometimes unconventional, accomplishments. Not withstanding some well known limitations of qualitative case studies, we believe that more qualitative research is needed in order to promote a deeper understanding of performing excellence. A vast amount of research with scientists exists, but contemporary dancers are as yet under studied. Hence, the present case study suggests that scientists and dancers' personal wellbeing, as well as their career development patterns, are interesting topics for further research efforts.

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Diversity and homogeneity in contemporary violin recordings of solo Bach

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Over 20 recent commercial recordings of Bach's solos for violin were studied to examine performance trends of the last 25 years and to test the widely held opinion that style has become fairly homogenous and lacking in individuality. The main trends found were the influence of historically informed practices (e.g. in bowing, fingering, vibrato) and a move toward greater flexibility in phrasing and rhythmic delivery. Both strong and subtle individual differences were observable, but these seem less suitable for quantitative reporting.

Keywords: J. S. Bach; violin; vibrato; performance; recordings

Research into performance styles on sound recordings has been growing steadily in the last decade or so. The standard narrative that has emerged regarding trends over a century of recordings is a claim for a continued "tidying up" of performance (Philip 2004, p. 232). Commentators lament the increased uniformity of interpretations as we move from the early decades of recording to mid-century and beyond (e.g. Day 2000). Yet studies of specific repertoires show just as much individuality in recent as in old recordings (e.g. Ornoy 2008, Repp 1990, 1992, Fabian and Schubert 2008). The contradiction may stem from the fact that investigations tend to focus on earlier recordings. Few published research exists that examines in any systematic way the artistry of contemporary musicians. It is also likely that in solo or chamber music there is more room and need for an individual voice than in works involving large ensembles such as symphonies. Given the growing amount of information available regarding the history of violin playing on record (Katz 2003, Milsom 2003, Fabian 2005, Leech-Wilkinson 2009) and yet a lack of detailed information on current practices, this study aims to provide data to fill this hiatus. To this end, it examines contemporary recorded performances of Bach's *Sonatas and Partitas for Solo Violin* (BWV 1001-1006).

METHOD

Materials

Over 20 commercially available studio and concert recordings of the Bach solos released since 1976 were analyzed. Nine of the violinists play on period instruments, and at least five others are known to have been influenced by the achievements of historically informed performance (HIP) to some extent. Four players made more than one recording of the works during the designated period. Selected performers and dates are listed in Tables 1-3; a full discography is available from the author.

Procedure

Aural analyses of bowing, fingering, and phrasing together with software assisted analyses of vibrato, tempo, and rhythmic flexibility were conducted. The analysis aimed to distinguish between "mainstream" and "period" violinists and examined their techniques and artistic approach. Only general trends and aspects of the quantitative data are reported.

RESULTS

Bowing differed considerably across most violinists; earlier and mainstream players choosing a more seamless bowing (e.g. Perlman, Hahn) while younger players, especially those using period apparatus, a more articulated style with faster note decay. Fingering choices involving lower positions and use of open strings were more common among HIP-inspired players.

Phrasing showed great diversity reflecting the continuum from literalistic to flexible approaches. Of those with multiple recordings, Kremer seems to have changed his interpretation the most: it became much more strongly accented with slower tempi and a narrower and less continuous vibrato. The many different ways the works are delivered can be illustrated by comparing the beginning of the G minor *Adagio*. Ehnes and Kremer play it in a literal manner, while others with greater degree of freedom. Huggett plays the opening chord with emphasis on the low G followed by arpeggiation and then a pause on the high G. Wallfisch and others also arpeggiate but faster, reaching the top G in one gesture. When played chordally, it is broken 2+2.

Vibrato also provided variety. HIP violinists on recordings from after 1995 tended to use less and narrower vibrato. Among mainstream violinists, Bar-

Table 1. Vibrato rate, width, and frequency of use measured on selected notes in different movements and averaged across each selected violinist. (NB. Rate in cycle/second, width in semitones; frequency refers to occurrence of vibrato on the selected pitches.)

Performer, date	*Vibrato rate (c/s)*		*Width (semitones)*		*Frequency of use*
	mean	*SD*	*mean*	*SD*	*%*
Huggett 1995 (HIP)	5.8	0.50	0.2	0.06	46.3
Kuijken 1983 (HIP)	5.9	0.60	0.2	0.07	63.3
Kuijken 2001 (HIP)	5.9	0.80	0.1	0.90	60.0
Luca 1977 (HIP)	6.8	0.10	0.1	0.08	39.5
Podger 1999 (HIP)	6.0	0.70	0.2	0.09	27.0
Schroeder 1985 (HIP)	6.5	0.60	0.2	0.06	55.0
Van Dael 1996 (HIP)	5.5	0.80	0.1	0.04	23.0
Wallfisch 1997 (HIP)	5.8	0.50	0.1	0.14	45.5
Barton-Pine 1999	6.9	0.90	0.2	0.12	62.0
Barton-Pine 2007	6.1	0.90	0.1	0.03	14.0
Hahn 1999	6.6	0.30	0.2	0.10	100.0
Kremer 1980	6.3	0.36	0.3	0.07	91.0
Kremer 2005	6.2	0.80	0.2	0.12	45.3
Mintz 1984	5.9	0.40	0.3	0.04	90.0
Perlman 1987	6.6	1.70	0.3	0.15	76.0
Ricci 1981	6.0	0.50	0.3	0.17	76.0
Szenthelyi 2002	6.4	0.28	0.3	0.10	82.0
Tetzlaff 1994	6.2	1.10	0.2	0.12	64.5
Tetzlaff 2005	6.5	0.43	0.3	0.48	91.0
Tognetti 2005	5.9	0.30	0.1	0.03	36.0
Zehetmair 1983	4.8	0.50	0.4	0.16	14.0

ton-Pine used vibrato the least and Hahn the most. Multiple recordings of violinists indicate a decreasing use of vibrato. Table 1 provides details.

Overall tempo choices showed no clear trend but varied most in fast and fugal movements, as well as in the C major *Adagio*. Table 2 provides an example.

Variety was discovered in relation to ornamentation as well. Luca, Podger, Huggett, Gringolts, and Tognetti added graces and embellishments (e.g. A minor *Andante*, E major *Gavotte*). Their solutions differed radically from each-other both in terms of quantity and type of added ornaments. Rhythmic flexibility was more obvious in the most recent and HIP versions, where the articulation of metrical groups and the inflection of hierarchically important

Table 2. Tempo choices in selected G minor sonata recordings. Mean metronome values were calculated from movement duration. SDs marked as negative indicate variance that is slower than the mean. SD>2 is italicized.

Date, performer	*Adagio*		*Fuga*		*Siciliano*		*Presto*	
	mean	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*
1977 Luca	27.0	1.28	69.0	-0.16	19.0	*-2.61*	65.0	-1.22
1980 Kremer	20.0	-1.16	86.0	*2.31*	27.0	0.26	87.0	1.54
1981 Kuijken	27.0	1.14	70.0	-0.06	24.0	-0.69	75.0	0.11
1983 Zehetmair	28.0	1.33	80.0	1.43	31.0	1.76	81.0	0.82
1984 Mintz	19.0	-1.38	63.0	-1.06	24.0	-0.79	73.0	-0.15
1986 Perlman	20.0	-1.14	69.0	-0.16	26.0	-0.14	80.0	0.62
1993 Tetzlaf	27.0	1.16	69.0	-0.18	29.0	1.01	95.0	*2.52*
1995 Huggett	22.0	-0.65	56.0	*-2.10*	24.0	-0.92	63.0	-1.44
1996 Poulet	23.0	-0.15	77.0	1.03	28.0	0.79	74.0	-0.11
1996 van Dael	27.0	1.01	69.0	-0.25	29.0	0.92	66.0	-1.06
1997 Wallfisch	24.0	0.13	65.0	-0.77	28.0	0.48	66.0	-1.06
1997 Podger	23.0	-0.21	68.0	-0.34	27.0	0.19	72.0	-0.27
1998 Gähler	24.0	0.31	64.0	-0.91	25.0	-0.64	72.0	-0.31
1999 Ehnes	17.0	*-2.06*	67.0	-0.52	27.0	0.08	80.0	0.62
2001 Szenthelyi	28.0	1.43	73.0	0.34	30.0	1.25	67.0	-0.89
2005 Tetzlaff	24.0	0.13	74.0	0.55	25.0	-0.45	83.0	0.98
2005 Kremer	22.0	-0.44	82.0	1.78	26.0	0.02	80.0	0.72
2005 Tognetti	21.0	-0.96	68.0	-0.40	23.0	-1.27	76.0	0.20
2001 Kuijken	25.0	0.55	67.0	-0.49	24.0	-0.69	67.0	-0.95
1999 Barton-Pine	23.0	-0.18	72.0	0.20	28.0	0.72	69.0	-0.74
2004 Barton-Pine	23.0	-0.15	69.0	-0.25	28.0	0.72	75.0	0.06
Mean	*24.0*		*70.0*		*26.0*		*75.0*	

notes created easily detectable rhythmic irregularities. The analysis of dotting ratios revealed under-dotting in the D minor *Corrente* movement. This reflects the view that dotted rhythms within fast triplet motion are to be assimilated into long-short swings. In contrast, ratios in the C major *Adagio* were found to be universally over-dotted (see Table 3).

DISCUSSION

The analyses indicate great diversity in approach, along the continuum from literalistic to flexible. Several mainstream violinists are influenced by current beliefs about HIP. This can be seen in the declining use of vibrato; the more

Table 3. Dotting ratios calculated from IOIs in selected D minor *Corrente* and C major *Adagio* recordings. A ratio of 0.75 indicates literal dotting (3:1).

Performer, date	*Dotting ratio*	
	D minor Corrente	*C major Adagio*
Barton-Pine 1999	0.76	n/a
Barton-Pine 2004	0.74	n/a
Barton-Pine 2007	0.70	0.82
Brooks 2001 (HIP)	0.72	0.88
Ehnes 1999	0.80	0.81
Hahn 1997	0.78	0.81
Huggett 1995 (HIP)	0.69	0.79
Kremer 1980	0.76	0.80
Kremer 2005	0.76	0.85
Kuijken 1983 (HIP)	0.71	0.86
Kuijken 2001 (HIP)	0.71	0.86
Luca 1977 (HIP)	0.74	0.80
Mintz 1984	0.78	0.81
Perlman 1987	0.65	0.80
Podger 1999 (HIP)	0.72	0.77
Poppen 2001 (HIP)	0.76	n/a
Schroeder 1985 (HIP)	0.72	0.78
Szenthelyi 2002	0.74	0.77
Tetzlaff 1994	0.77	0.78
Tetzlaff 2005	0.78	0.82
Tognetti 2005	0.72	0.81
van Dael 1996 (HIP)	0.73	0.81
Wallfisch 1997 (HIP)	0.72	0.85
Zehetmair 1983	0.78	0.85

articulated and “lifted” bowing style, and the use of lower positions and open strings. Multiple recordings of artists, especially those of Kremer, show this tendency clearly. Apart from this broad stylistic fashion no real homogeneity was found. Rather, the examination showed diversity in tempo choices, ornamentation, and approaches to phrasing and expressive flexibilities. These qualitative differences do not lend themselves easily to quantitative reporting and can be better explained through detailed individual comparisons.

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Breathing in classical singing: Linking science and teaching

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This article addresses three issues. Firstly, breathing studies of trained classical singers have found high inter-singer variability, which raises many questions about the nature and role of breathing in singing; these study findings and their implications are discussed from a pedagogical perspective. Secondly, the article examines the resulting limitations inherent in a segmented model that divides voice into respiration, phonation, and articulation and that excludes key components from a narrow concept of a "breathing system." Finally, the article examines how this wider paradigm of singing-breathing inevitably positions breathing at the confluence of technique, emotion, and musical line.

Keywords: singing; breathing; pedagogy; lung volumes; kinematics

When classical singers and singing teachers are asked "what do you need to sing well?" the list almost always starts with "good breathing." Yet, despite hard work on all sides there remains a large gulf between research into breathing for singing and its influence in the teaching studio. There are three main reasons for the lack of interaction. First, singing teachers often find the concepts, techniques, and equipment used in breathing studies to be difficult to access. This lack of familiarity makes it difficult for teachers to interpret and apply research findings in the studio. Second, the scope of what is considered to be "the breathing system" is often too narrow, neglecting the respiratory contribution of elements not immediately associated with respiration. Last, conceptualizing breathing as simply air supply for phonation negates its role as the link between phonation, emotion, and musical line, a role that is crucial to singing and in teaching singing. This has led some pedagogical approaches to reject studies as unrealistic or irrelevant.

The article introduces, from a pedagogical perspective, some of the concepts and methods used in the study of breathing. The first section explains certain assumptions, terminology, and techniques employed in the measurement of breathing generally and with respect to singing. The second section discusses problems that arise when paradigms of breathing employ a narrow definition of what constitutes the "breathing system." The third section explores how a wider paradigm supports a view of breathing more relevant to the role of breathing in singing and more consistent with historical vocal pedagogy. The paper is not intended to be exhaustive or prescriptive but to assist the teacher in accessing findings and exploring paradigms in other disciplines which have implications for the discipline of vocal pedagogy. The paper outlines the major points to be presented in the second and third sections, but particularly takes the opportunity to describe the measurement of lung volumes and chest-wall kinematics to assist the teacher in understanding implications for pedagogy.

MAIN CONTRIBUTION

Breathing studies

This section briefly describes the techniques used in breathing measurement. Interpreting any research requires an understanding of the background concepts and the methods used. Teachers who happily discourse on partials, the singer's formant, and the relationship between the thyroarytenoid and cricothyroid go silent at the mention of recoil, rib-cage volume contribution, or resting expiratory level. There is nothing inherently more complex about respiratory analysis than acoustical analysis, or about the physiology of one part of the human body versus another. The difference is familiarity. Powerful personal computers and cheap (and more recently free) software offer singing teachers the chance to experience firsthand how these relate to their teaching and to the singer standing before them. By contrast, equipment for measuring breathing is currently specialized, cumbersome, and expensive, and few teachers have the opportunity to play, one of the most powerful aids to learning. However, advances in sensor tracking technology, fuelled by the enormous entertainment and virtual reality industries, make it increasingly probable that breathing measurement will become as accessible in the future as acoustic measurement is today. The chance to play with respiratory recording will provide an impressive learning tool but will require that teachers acquire an appreciation of the discipline of respiratory research, just as many have acquired an appreciation of acoustics. Fortunately, a basic understanding of breathing analysis is not difficult to acquire and offers singing teachers access to studies that speak directly to their questions.

Lung volumes

The most common assessment of breathing is lung volume (LV). Key measurements are LV at the start and end of each phrase, with the difference between these being the amount of air used (to normalize comparisons, LV measures are expressed as a percentage of the individual's vital capacity [%VC], measured by having the singer breathe in to full capacity and then exhale as far as possible). On average, singers generally start phrases at 70-80%VC and end phrases at 30-50%VC (Hixon 1991). The individual singer is highly consistent in LV measurements (Thomasson and Sundberg 1999), but singers are very different (Collyer *et al.* 2008, Collyer *et al.* in press). Intra-singer consistency versus inter-singer variability can be seen in Figure 1. The question immediately arises whether a particular LV behavior is associated with better singing, but no study has yet been able to find such a link. The next question, then, is how is LV measured?

Chest-wall kinematics

It is possible to measure LV directly with a spirometer or indirectly by measuring airflow over time. However, these require a mouthpiece (and nose clip) or a mask, which tend to inhibit singing. Konno and Mead (1967) developed an alternative approach which estimated LV change from changes in the surface dimensions of the ribcage and abdomen (known together as the chest wall, and "kinematics" is simply the study of motion). Generally, ribcage (RC) and abdomen (AB) dimensions have been measured by encircling the RC and AB (strain gauges, inductance bands) or by applying sensors which measure the anteroposterior (front-to-back) distance. In brief, changes in RC and AB dimension are recorded while the singer performs various respiratory maneuvers on a spirometer (with mouthpiece and nose clip). Known changes in RC and AB dimension are therefore matched with known changes in LV, so changes in RC and AB can be used to estimate LV when the singer is no longer encumbered by the spirometer. The left panel in Figure 2 shows how LV is the weighted sum of RC and AB, weighted because it takes less change in RC than in AB dimension to move a given LV. The right panel shows a CWK (or volume contribution) plot. The key to understanding these plots is to remember that, since LV change is the *sum* of RC and AB change, changes in LV are at 45° angles, as indicated by the dotted arrows. So, the line A-B moves toward 100%VC and thus is inhalatory; the line also tells us that the inhalation was due almost entirely to an AB increase (see Figure 2, left panel). Line B-C shows that an RC increase and an AB decrease cancelled each other out, so there was no net change in LV; we know this because line B-C is par-

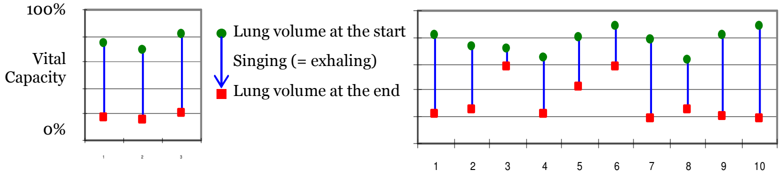

Figure 1. Lung volumes (LV) used in the *messa di voce* on B4. At left: consistency of one singer performing three *messe di voce*. At right: variability amongst 10 female singers. Data are taken from studies published in Collyer *et al.* (2008) and Collyer *et al.* (in press). (See full color version at www.performancescience.org.)

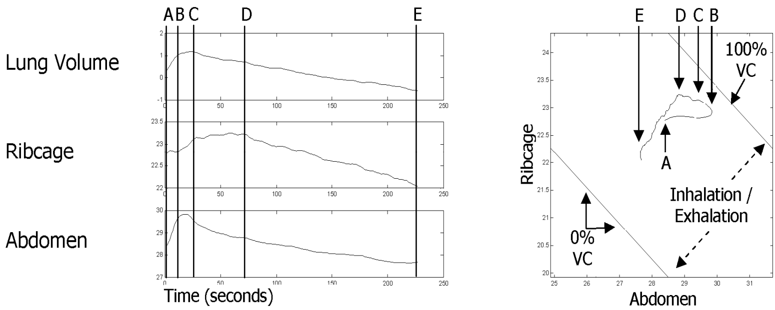

Figure 2. Relationship between LV estimation and chest-wall kinematics (CWK). See main text for description.

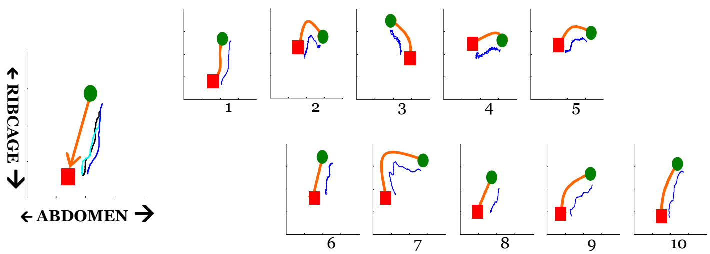

Figure 3. CWK plots for the LV changes shown in Figure 1. (See full color version at www.performancescience.org.)

allel to the 100%VC line. Line C-D-E follows the singer performing a *messa di voce*. Note that at first (C-D) this singer expands the RC (paradoxical behavior), but greater AB decrease gives *net* exhalation and then RC also decreases (D-E).

CWK plots have provided a great deal of information about singers' behavior. The prephonatory adjustment (B-C) is very common (Thorpe *et al.* 2001). So too are paradoxical movements (where RC or AB dimension decreases during inhalation or increases during singing). But the most striking feature is that, while a trained singer shows a highly consistent CWK pattern on the same task, singers are very different from each other. Figure 3 shows the CWK plots underlying the LV changes in Figure 1.

What is the "breathing system"?

The second section of the paper addresses the definition of a "breathing system." Voice is often conceptualized as consisting of three isolated stages: respiration, phonation, and articulation. This segmented model is inconsistent with human anatomy and physiology because it models the larynx as an independently functioning entity rather than as an intrinsic and inseparable part of the respiratory system at all stages of development. For example, the role of the larynx in modulating airflow for singing derives from its role in modulating airflow for respiratory needs, which in turn originates with modulation of lung fluid efflux by the larynx, which is essential for lung development in the womb (Harding *et al.* 1986). Even when protecting the airway during swallowing, a role often considered to be the larynx's primary function, the larynx also assumes an expiratory modulation role to assist aspiration (Cedborg *et al.* 2009). The conference presentation considers the limitations of the segmented model, which requires that laryngeal adjustments can occur independently of respiratory adjustments.

Breathing, emotion, and musical line

The final section of the paper extends this wider "breathing system" model to incorporate emotional influences of and on breathing and then to relate these to the nature of musical line. This pivotal role of breathing as the intermediary between phonation, emotion, and music—which is at the heart of historical pedagogy's reverence for breathing—cannot be sustained under a segmented or larynx-driven paradigm. The conference presentation discusses how a wider concept of the nature of breathing is consistent with the nature of singing at all levels: the technical, the interpretative, and the human.

IMPLICATIONS

LV and CWK data raise many questions for the teacher. What determines a singer's breathing pattern? How susceptible to training is breathing? What represents an improvement for a singer? How does the teacher match training with singer? In the conference presentation, findings of the studies are presented from a pedagogical perspective, including the implications of study limitations such as technical constraints.

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Synchronization of motion and timing in clarinet performance

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We examined the effect of expressive intent on timing and movement in clarinet performance. Clarinetists' performances were recorded with motion capture while they performed with three expressive intents: expressive (normal) performance, exaggerated performance, and inexpressive performance. Acoustic measures (intensity, pitch height, duration) were compared with ancillary gestures (bell movement). The more expressive performances contained larger expressive timing measures and bell movement. Clarinetists marked phrase boundaries with increases in both expressive timing and clarinet motion. Neither pitch height nor sound intensity accounted for bell movements beyond expressive timing. These findings suggest that ancillary bell gestures are rule-governed and correlate with some acoustic features of musical expression.

Keywords: expressive timing; clarinet performance; motion capture; movement analysis; ancillary gestures

How do performing musicians express a range of musical intentions? Patterns of expressive timing have been linked to performers' expressive intentions (Palmer 1989), and various auditory cues provide sufficient information for listeners to distinguish between levels of expressive intent (Kendall and Carterette 1990). Visual cues resulting from pianists' head and upper torso movements have been shown to be more effective than auditory cues in conveying performers' intended expressivity, suggesting that movement best conveys expression (Davidson 1995). In piano performance (on which most research is conducted), expressive movement is limited to the hands and the upper torso/head region (Davidson 2007); a larger variety of movements may be found in the performance of wind instruments, including the clarinet

(Wanderley 2002). Limited research to date combines acoustic and movement features of expressive performance. The current study examines the effect of expressive intent on both timing and movement in clarinet performance.

Expressive rubato timing in music performance is characterized by increased tone durations as performers approach cadences or phrase endings (Gabrielsson 1987, Palmer 1989), and additional lengthening of tones notated with long durations and shortening of tones notated with shorter durations (Sundberg *et al.* 1991). Inexpressive performances tend to exhibit less range of rubato timing than expressive performances (Gabrielsson 1987, Palmer 1989). These studies, however, did not investigate performers' movements or their relation to musical intent.

Wanderley (2002) analyzed clarinetists' movement gestures while they performed the same music in expressive and inexpressive ways. Following Delalande's (1988) classification of musicians' ancillary gestures as those visible body movements that are not directly linked to sound production, Wanderley (2002) recorded the ancillary movements of the clarinet bell with a motion tracker system. Surprisingly, clarinetists' vertical and horizontal bell movements were highly consistent across their repeated expressive performances. However, Wanderley's instructions to clarinetists to move the clarinet as little as possible in the inexpressive condition precluded comparisons of expressive timing with movement.

The current study examines the relationship of clarinetists' ancillary movements to their expressive goals by combining Palmer's (1989) expressive performance conditions with Wanderley's (2002) measures of bell motion in clarinet performance. Skilled clarinetists performed the same musical piece under three different expressive instructions: normal expressive, exaggerated, and inexpressive performance. No instructions were given concerning movement. We tested the hypotheses that increased expressive intent results in both increased variation in timing (Palmer 1989) and larger amplitudes of ancillary movement (Davidson 2007, Wanderley *et al.* 2005).

METHOD

Participants

Eight adult clarinetists from the Montreal community participated in this study (with 8-20 years of performing experience, mean=12 years).

Materials

The first eight measures of Mozart's *Clarinet Concerto in A Major* (K. 622), second movement, were used. The excerpt (Figure 1) was chosen for its high expressive content and the fact that it is well known. All clarinetists performed on an A clarinet. All clarinetists were familiar with the excerpt before participating. An active motion capture system (NDI Optotrak Certus) measured the clarinetists' movements at a 250 Hz sampling rate. Markers were placed on each fingernail tip of the clarinetists' hands and on the clarinet: one marker on the barrel (below the mouthpiece), one centered just above the bell, and two on the bell. These markers provided information about the orientation of the clarinet. An AKG C414 B-XLS standing microphone, as well as a microphone integrated into the clarinet barrel, recorded the audio at 44.1 kHz. The clarinet movements are reported only up to the notated ornament in measure seven, which permitted a variety of temporal interpretations and was therefore excluded.

Procedure

The clarinetists were instructed to perform the melody as they would in a normal concert setting (normal), with an exaggerated version of their interpretation (exaggerated), and with a flat and inexpressive interpretation (inexpressive). The orientation of the clarinet was computed from the marker data in spherical coordinates, eliminating translational position differences that arise between participants of different heights and standing positions. Clarinet elevation (vertical rotation) was measured as degrees of rotation around the mouthpiece marker, relative to a rest position perpendicular to the floor. Tone onsets were detected by identifying large negative peaks in the first derivative of sound intensity, taken from the integrated barrel microphone. Audio and motion data were smoothed using *functional data analysis* (Ramsay and Silverman 2005) and registered by tone onsets.

RESULTS

Figure 1 shows the mean clarinet elevation in each expressive condition; positive values indicate the bell was raised relative to the mouthpiece. A functional Analysis of Variance (ANOVA) on the continuous elevation data indicated significantly lower elevations at the beginnings of phrases as clarinetists performed more expressively (significant regions are shown in horizontal lines at the bottom of Figure 1). Overall, clarinetists were more variable

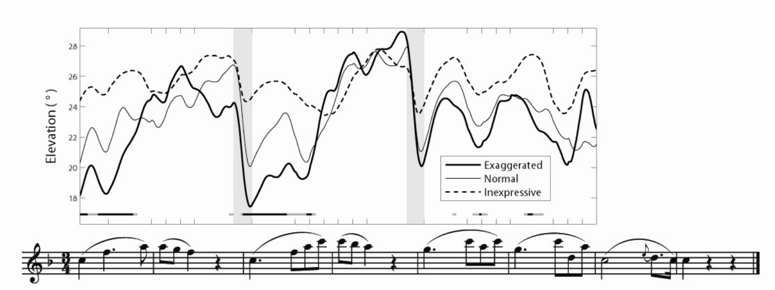

Figure 1. Mean clarinet bell elevation (degrees) in each expressive condition. Horizontal lines indicate significance regions (grey and black indicate p<0.05 and p<0.01, respectively); vertical shaded bars indicate locations of rests at phrase boundaries.

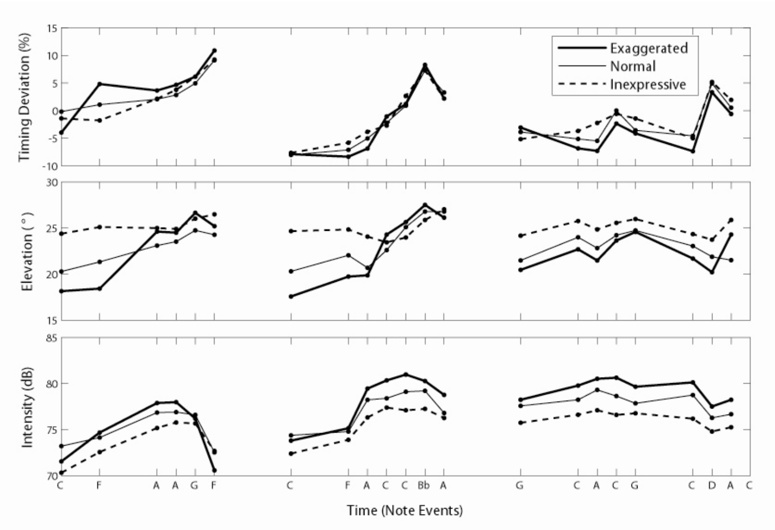

Figure 2. Mean timing deviation, bell elevation, and intensity (from standing mic) for each expressive condition. Gaps indicate locations of ends of phrases.

in clarinet elevation (measured by standard deviation) from inexpressive to exaggerated conditions ($F_{2,14}$=33.04, p<0.01).

Next we measured expressive timing, in terms of the difference between observed and expected interonset intervals (in %) relative to the notated durations in the score ([observed-expected]/expected); positive values indicate lengthened tones. Figure 2 shows clarinetists' mean expressive timing deviations, which indicated slowing from the beginnings to the ends of each phrase. Furthermore, the variability of timing deviations (measured in standard deviation) increased with expressive intent ($F_{2,14}=5.3$, $p<0.01$). Figure 2 (bottom) shows the peak intensity for each tone, which reflected the phrase structure, but in a different pattern (inverted U-shape) than that of the elevation and timing deviation measures.

To examine whether the ancillary gestures were related to the acoustic features of performance, regression analyses were conducted to predict the bell elevations for each tone from expressive factors: timing deviations, sound intensity (correlated with loudness), and sounded pitch (as measured by modal frequency). Individual correlations among variables indicated that sound intensity and pitch correlated with each other (mean $r=0.82$, $p<0.01$). In addition, sounded pitch correlated with elevation in expressive performances (mean $r=0.51$, $p<0.05$); however, only expressive timing predicted elevation significantly when other acoustic features were controlled in each expressive condition [semipartial correlations: standardized regression coefficient (β) for timing=0.65 in exaggerated condition, $p<0.01$; $\beta=0.58$, $p<0.01$ in expressive condition; $\beta=0.44$, $p=0.06$ in inexpressive condition].

DISCUSSION

Expressive timing and clarinet bell motion increased across each phrase with clarinetists' expressive intent: performers used more bell motion and more expressive timing when performing with greater expressive intent. Clarinetists may use the bell's elevation to help shape phrases, by physically representing change in musical features such as tension/relaxation. Together with previous findings that documented performers' reduced expressive timing when musicians were asked to perform without moving (Wanderley *et al.* 2005), these findings suggest a bi-directional relationship between expression and movement in performance. The clarinet elevations and the expressive use of rubato increased from phrase beginnings to endings. Clarinet tone intensities instead showed an inverted U-shape throughout each phrase.

This study extended several findings on expressive performance to the study of ancillary gestures in a wind instrument that permits considerable degrees of motion. Our findings suggest that ancillary bell gestures are rule-governed; they correlate with some but not all acoustic features of musical expression, and in particular with phrase structure. Future research may derive musical variables from performers' movements by creating a taxonomy of gestures that correspond to specific musical intentions.

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Thematic session: Memory and performance

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Memory for tactus and musical tempo: The effects of expertise and speed on keeping time

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The ability to keep time and remember speeds is important in musical performance. Eight musicians and eight non-musicians heard a metronomic beat at three musical speeds—35, 110, and 185 beats per minute (bpm)—and clapped in time to it as accurately as possible. They were then asked to recall the three speeds by clapping alone. After another set of trials clapping to the metronome, they recalled the three speeds once again. Results showed that the participants tended to clap too slowly for the 110 bpm and 185 bpm tempi and that the medium speed was less accurately remembered than the slow or fast. There was no effect of musical experience, but there was a trend of better recall of speed on the second than the first recall trial.

Keywords: tactus; absolute; tempo; memory; clapping

One important aspect of much musical performance is the ability to keep a beat or tactus going generally at a fairly steady rate, expressive variations in tempo aside. In larger groups a conductor will often act as an external time-keeper by dictating a self-paced beat, trying to make it as steady and constant as possible. It is the responsibility of all players to follow the conductor's beat and play at the same tempo. Their behavior can be seen as a form of sensorimotor synchronization (SMS), where they synchronize their motor behavior, whatever that may be, to the conductor's visual beat. Thus both the conductor's internally paced beat and the players' synchronization behavior are forms of rhythmic time keeping. Research on SMS and self-pacing has shown that there are a number of factors that affect the accuracy and variability of the beat, and also that there are upper and lower tempo limits (e.g. Repp 2005, London 2004, Aschersleben 2002).

Keeping in time is clearly relevant to musical performance, and responding regularly (e.g. tapping or clapping) is a commonly used method of measuring SMS ability. The asynchrony between the given beat and the participant's response indicates their accuracy. Previous research has suggested this SMS accuracy is affected by various factors, including the tempo of the tactus and the participant's musical expertise (Repp 2005). Research when the beat disappears but the participant has to keep tapping at the same tempo has also been conducted. This is called continuation tapping, and typically appears to show an approximately 12 s period of maintained control (Chen *et al.* 2002).

Another important skill in performing music in most cultures is the ability to set and control the tempo: too fast and the piece may be unplayable and detail glossed over; too slow and perceptual and structural coherence and performers' breathing (if relevant) may suffer. Conductors and unconducted performers (often soloists) must be able to start a piece at the right tempo, and better performances tend to show less evidence of tempo drift or unplanned corrections or fluctuations in speed. Although there is much evidence concerning absolute pitch (AP), the ability to recall at will a pitch from long term memory (e.g. Ward 1999), there is less on "absolute tempo" (AT), the ability to remember a particular beat speed (i.e. tactus) and recall it when required for performance.

Previous research has tested tempo recall for pieces in long term memory. Levitin and Cook (1996) had participants sing popular songs with which they were familiar, and 72% of the productions were within 8% of the original tempo. Trainor *et al.* (2004) also showed that infants preferred a familiar piece provided the tempo was not changed by more than 25%, suggesting a long-term tempo memory, though probably less accurate than that of adults.

The aims were, therefore, twofold. First, we investigated the effect of musical expertise on people's accuracy for carrying a tactus and remembering a tempo in the absence of a specific piece of music, both measured by clapping in time. It was hypothesized that expert musicians would be more accurate both in their tapping accuracy and in their long term memory for tempo than non-musicians. Secondly, we investigated the effect of different speeds of a given tactus on tapping in time and, in particular, on tempo recall.

METHOD

Participants

There were 16 participants, split into two equal groups of expert musicians (professional, semi-professional, and student) and those whose professional life did not involve music. The musicians (5 M, 3 F) were aged between 20 and 48 years (mean=30.8). Some were specialists either in conducting or in percussion playing. Non-musicians (6 M, 2 F) were aged between 23 and 74 years (mean=49.9), and had no musical training beyond school, though two had choral singing experience, and one was a self-taught drummer.

Materials

Metronomic recordings of three different tempi: quarter note=35 bpm corresponding to interstimulus interval (ISI) of 1714 ms, quarter note=110 bpm corresponding to ISI of 545 ms, and quarter note=185 bpm corresponding to ISI of 324 ms, were made on a MacBook 4.1 (2.1 GHz processor) in the software *Finale*, using the sound of a woodblock. This was transferred to a CD, along with instructions, and the recordings were played to participants in various testing locations. Attention was given to minimizing ambient sound and to avoiding the presence of aural or visual rhythmic stimuli in the room. Participants' productions together with the metronomic stimuli were recorded on the same MacBook computer and converted to AIFF format files. These were then analyzed using the software program *Praat* (version 5.1.04) to measure times between claps (Boersma and Weenink 2009).

Procedure

There were two tasks. First, participants were asked to clap, synchronizing as closely as possible with a recorded beat (the beats on the recording disappeared and reappeared, see below). In the second task, participants were asked to reproduce from memory the speeds of the original recording. The three speeds of 35, 110, and 185 bpm ("slow," "medium," and "fast," respectively) were chosen so as not to be related to each other by any simple proportion. Tempo order was counterbalanced between participants.

In the first section of each test, participants were asked to listen to the recording of beats, to join in after hearing the first four beats, and to continue clapping until told to stop. Some beats on the metronomic stimulus were absent and the participants were informed of this but asked to continue clapping nonetheless. In all tests, there were 8 beats present, 4 absent, 4 present, 4 absent, 8 present, 8 absent, 8 present, and 8 absent. Thus, clapping regularity in both the presence of a beat (SMS) and its absence (continuation) were tested. Participants performed the above test at the three speeds and then repeated them in the same order. A gap of about 30 s was left between tests. They were then asked to fill in a questionnaire covering age, gender, and musical experience. Approximately 4 mins were given for this.

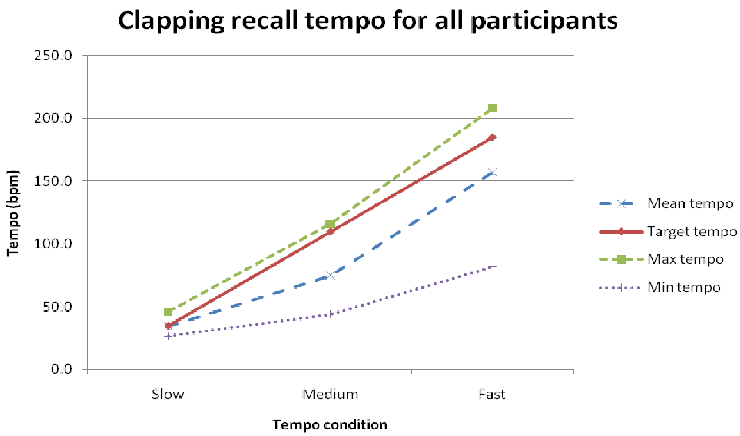

Figure 1. Mean, minimum, and maximum recorded clapping tempi (bpm) as a function of the given tempo. The target tempo is shown by the solid line. (See full color version at www.performancescience.org.)

Next, participants' memory for the three speeds was tested. They were asked to clap at the slow, medium, and fast speed, in the same order they had already been tested on, both beginning and ending when indicated. A total of about 32 claps were recorded for each trial. After the recall test of each speed, the first test (clapping with the recorded beats) was repeated, followed, after a 1 min pause, by the test of memory once again. A complete testing session took approximately half an hour per participant.

RESULTS

The present article focuses on the participants' tempo memory data. Overall, participants were fairly good at recalling the slow tempo but tended to underestimate both the medium and fast tempi (i.e. clapping too slowly) quite substantially (see Figure 1). However, their recall for these tempi was generally better on the second recall trial, underestimating less (see Table 1). When the musicians and non-musicians were analyzed separately, the musicians were generally found to recall the medium and fast tempos more accurately than the non-musicians, underestimating the speeds less (see Table 2). A 3-way Analysis of Variance (ANOVA) with tempo, trial, and musical experience as factors was conducted on the mean error as a percentage of the target tempo.

Table 1. Clapping tempo (bpm) in the recall tests (SD in brackets.)

Tempo	*Target tempo*	*Recall 1*	*Recall 2*
Slow	35	34.7 (4.86)	38.5 (13.36)
Medium	110	75.0 (23.06)	87.8 (28.52)
Fast	185	156.9 (35.02)	166.0 (23.75)

Table 2. Clapping recall tempo (bpm) as a function of musical training (SD in brackets).

Target tempo	*Musicians*		*Non-musicians*	
	Recall 1	*Recall 2*	*Recall 1*	*Recall 2*
Slow (35)	32.0 (3.24)	32.9 (3.02)	37.0 (5.01)	43.5 (17.05)
Medium (110)	74.5 (24.91)	97.5 (34.43)	75.4 (24.85)	80.5 (15.86)
Fast (185)	165.9 (21.46)	175.0 (22.95)	146.7 (45.90)	157.1 (23.75)

Tempo was highly significant ($F_{2,22}=10.96$, $p<0.01$): Bonferroni post-hoc tests showed that the medium tempo was recalled significantly more poorly than either the slow or fast tempi (as can be seen from the mean and target tempo lines in Figure 1). Trial showed a non-significant trend ($F_{1,22}=4.14$, $p<0.07$), in that the tempo error was smaller in the second trial than the first. Musical experience was not found to be a significant factor.

DISCUSSION

Overall there was large variation in remembered tempo, particularly showing underestimation (see Figure 1), but the slow and fast tempi were recalled better than the medium tempo, at least in terms of percentage errors. It is unclear why fast speeds were better remembered than the medium speed, although future tests may study the relevance of remembering fewer tempi in a test. However, musical experience was not found to affect tempo recall, there being no difference between the two groups. This may be because three of the non-musicians in fact had some musical experience (see “Participants”), diluting the difference between groups. Tempo memory was generally better on the second trial, after the participants had carried out more SMS/continuation tasks. The continuation claps can be thought of as testing short-term memory, with in effect immediate feedback, so this was not surprising.

In future research, we intend to ask participants to clap to tempi identified by name (e.g. “quick march” and “slow dirge”) or bpm (e.g. quarter note=

65 or 140), rather than the terms “slow,” “medium,” and “fast”. We will vary the number of tempi included in tests and accurately control the time elapsing before participants are required to reproduce a tempo from memory. We also intend to include distracter tasks, which may affect mental rehearsal, and compare the use of a beat pad with clapping, to reveal the relevance of the “choreographic” element of clapping.

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Moving backwards and forwards in time: Recalling dance from long-term memory

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Recalling complex non-verbal motor sequences, such as contemporary dance, provides insights into cues and associates in long-term memory (LTM). Four dancers recalled material that they had not performed for between 3-31 years; they initially recalled the material in silence, although the material had been associated with particular musical excerpts. Eight exercises were recalled either immediately or after an unfilled delay and using self-motion or a mannequin. Recall was greater when immediate rather than delayed; self- versus mannequin-motion had little impact on the length of material recalled. Qualitative data indicated that music and dancer movement were important cues to LTM, transitions were sometimes forgotten, and images associated with movement recall were kinesthetic, verbal, visual, and auditory. The results suggest an interplay of procedural and declarative knowledge and activation of multimodal images.

Keywords: movement; dance; procedural memory; declarative memory; non-verbal behavior

At once non-verbal, communicative, and expressive, contemporary dance is also visual, spatial, temporal, auditory, kinesthetic, affective, and dynamic. This study investigates four dancers' use of cues and associations when recalling complex dance sequences from LTM after intervals from 3-31 years.

Retrieval cues and associates in long-term memory

Jazz and classical musicians use knowledge of formal musical structure to aid retrieval (Chaffin and Imreh 2002, Noice *et al.* 2008). Motor cues aid actors' recall of text and contextual cues significantly aid retrieval (Noice and Noice 1997, 2002). Music prompts increased recall for prose and verse, and the recall of such material tends to begin and end at breath pause locations (Rubin 1997).

In contemporary dance, there is no set repertoire of steps or verbal associates. Contemporary dance and choreographic traditions are passed on not in words but by showing and doing (Grove 2005). In the absence of notation and scores the dancers are dynamic archives of works that they have rehearsed and performed. Smyth and Pendleton (1994) proposed that movement involving configuration of body parts is encoded kinesthetically. Overby (1990) has suggested that, while novice dancers prefer a visual mode of thought, experienced dancers are inclined to use both verbal and visual modes of thinking.

Margaret Barr dance-drama

Margaret Barr had a choreographic career that spanned more than 60 years and three continents. Barr described her work as *dance-drama* because she was interested in both the inherent drama of the body in motion and its ability to create and sustain the human drama of her primarily narrative based works. Barr's technique classes were a series of set studies performed to the driving rhythms of Carl Orff's *Carmina Burana*. This choreographed material explored a broad range of movement dynamics including the elegant simplicity of her lyrical studies to the extremes of strong, direct, thrusting sequences. Throughout her classes great attention was given to the rhythm of the breath cycle as the dancer moved. For Margaret the dramatic moment in a breath cycle was the "breath pause"—the moment of stasis between the inhalation of breath and its exhalation.

Long term recall of dance: Choosing a method of investigation

The opportunity to observe four mature dancers recalling movement material that they have not performed for between 3-31 years is unique and challenging. There is a need to exercise some experimental control by systematically manipulating potentially informative key variables although variables such as dancer age, years of exposure, years since previous recall/performance, current dance involvement, and body flexibility were out of our control. Cues to recall were brought under partial experimental control with the dancers asked to recall a specific dance exercise prompted initially by its verbal label, and to recall using either their own body or a small mannequin, either immediately or after a 20 s delay. Delayed rather than immediate recall gives time for mental rehearsal and visual and/or motor imagery that should enhance recall. The body versus mannequin conditions permitted the investigation of procedural recall in the form of self-motion versus motion of another figure without use of words. We anticipated greater recall using self-motion.

METHOD

Participants

Four female dancers who had all trained with the same choreographer volunteered for the study (mean age=55.38 years, SD=10.13, range=44.0-68.5). Two had performed the choreographer's dance material within the past three years, whereas the oldest participant had not performed it for 22 years (dancer 2, C) and the second youngest participant for 31 years (dancer 3, F).

Materials and procedure

The eight exercises to be recalled were: *Headwork Series*, *Simple Arms*, *Complex Arms*, *Egyptian*, *Spiral*, *Thursday night class "Lyric": Assyrian Bull*, *Figure 8 Arm Rolls*, and *The Falls*. Each had a descriptive label and was associated with a particular piece of recorded music. Participants recalled four exercises using their own body and four using the mannequin, either immediately or 20 s after the label had been given. The mannequin was a 30 cm wooden artist's doll as used in life drawing and art. A questionnaire asked: (1) "would you describe how you felt performing under each of these conditions: (a) immediate body, (b) immediate doll, (c) delayed body, (d) delayed doll?", (2) "how do you feel that music, others in room, social, and emotional factors affected recall of this movement material from your long-term memory?".

RESULTS

The duration of recalled material performed by individual participants was calculated as a proportion of the music excerpt duration. Quantitative recall data have been calculated from the 3 participants who had not performed the material for 3 years (dancer 1), 22 years (dancer 2) or 31 years (dancer 3). Table 1 shows the duration (in seconds) of material recalled by exercise and by recall condition. The proportion of recalled material duration as a function of the musical (veridical) excerpt is also shown. In Table 2, proportion of recall duration is presented according to recall condition. It was hypothesized that recall is greater in the delayed than in the immediate recall condition. However, the mean proportions indicate the reverse with proportion recall of

Table 1. Duration of recall by dancer and seven exercises showing raw scores (in seconds) and as proportions of the duration of the associated musical excerpt. (Proportions shown in brackets; 0 refers to zero recall.)

	Headwork Series *199 s*	*Simple Arms* *50 s*	*Complex Arms* *50 s*	*Egyptian* *150 s*
Dancer 1 (K)	68.00 (0.34)	34.00 (0.68)	45.00 (0.90)	27.00 (0.18)
Dancer 2 (C)	29.00 (0.15)	78.00 (1.00)	31.00 (0.62)	54.00 (0.36)
Dancer 3 (F)	23.00 (0.12)	36.00 (0.72)	34.00 (0.68)	10.00 (0.06)
Mean	40.00 (0.20)	49.33 (0.80)	36.66 (0.73)	30.33 (0.21)
cont.	*Spiral* *50 s*	*Fig. 8 Arm Rolls* *135 s*	*The Falls* *50 s*	
Dancer 1 (K)	36.00 (0.72)	30.00 (0.22)	53.00 (1.00)	
Dancer 2 (C)	25.00 (0.50)	0	27.00 (0.54)	
Dancer 3 (F)	67.00 (1.00)	15.00 (0.11)	42.00 (0.84)	
Mean	42.66 (0.74)	15.00 (0.11)	40.66 (0.79)	

0.55 (SD=0.38) in the immediate recall condition and 0.44 (SD=0.31) in the delayed recall condition. There was no difference between proportion recall duration when the dancer's own body was used (mean=0.50, SD=0.29) compared with when the mannequin was used for recall (mean=0.49, SD=0.40).

Dancers reflected on their recall of each exercise and completed a short written questionnaire. Their responses are organized below according to independent variables, cues, memory associates, and images.

Recall using the mannequin: "immediate doll condition required thinking as I moved it, i.e. feeling it in my own body as I moved the doll" (K), "doll totally unable to move—disjointed—results lacking flow and staccato positioning which [is] what all/most dancers try to avoid" (C), "could not visualize movement on the doll. Perhaps a real body would have triggered more memory" (F).

Immediate versus delayed conditions: "immediate and delayed body didn't make much difference more that it immediately came to mind or not" (S). W commented that having time to rehearse the exercises in the delayed recall condition led to some confusion, while F wrote that in the delayed body recall condition she "had a lot of trouble remembering anything first without moving."

Table 2. Mean duration recall proportions collapsed across seven exercises and three dancers and shown as a function of recall condition. (SD shown in brackets.)

Recall condition	*Immediate body*	*Immediate mannequin*	*Delayed body*	*Delayed mannequin*
Mean proportion	0.53 (0.35)	0.56 (0.40)	0.47 (0.24)	0.41 (0.39)

Auditory imagery: During different exercises (*Headwork*, *Simple Arms*, *Spiral*), all four dancers noted that during recall an inner voice was active: "forward, back, bring wrist forward, bring wrist back" (W), "forward, back, forward, back, side, side, then around" (K), "forward and right, up and over" (C). All commented on their recall of Barr's voice as they performed the exercises and the rich intonation and drama of her voice in their imagery.

All dancers commented on the importance of music. For W, recalling *Spiral* "music is such a key; it tells you there's nine swings," and more generally "absence of music meant that I had to 'hum' the music to myself as I was dancing/recalling," "the music for me is essential to conveying the 'right' sequence." C commented that she did not think she knew some exercises without the music; the music rather than a label would trigger recall. For F, the rhythm of the music was important. For K, the music timed the movement, "lack of the music made remembering more difficult."

What is forgotten? Two of the four dancers reported forgetting a transition: at the opening of *Spiral* (W), forgetting how to get up after a particular phrase (F), and finishing an exercise suddenly having forgotten the middle section (F). This pattern is consistent with schema theory "junction errors" and "switches"—a kind of structural performance cue (Chaffin *et al.* 2002).

DISCUSSION

For an artform such as contemporary dance, where formal notation is more the exception than the rule, dancers' brains and bodies are repositories of works of art that have been learned and memorized. The present study demonstrates that multi-modal cues elicit and accompany long-term memory for movement. Music, with its inherent sequential and temporal order, is a provocative and effective cue. Imagery is not only visual and verbal but also kinesthetic and auditory. Transitions between movement sequences may be susceptible to forgetting, especially in the absence of sequential cues from music. The dancer's opportunity to move is important for dance recollection. Future studies might focus on the learning and memorization of new material. Interference paradigms could also be used effectively to shed light on the nature of the memory code.

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Memory span in dance: Influence of age and experience

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The retention and recovery of movements are capacities that characterize and determine the life of dancers and dance students. The application of certain memory strategies is necessary and leads to an improvement in motor performance. Usually, the lowest levels of retention are associated with younger dancers when their performances are compared with the oldest and more experienced in dance. We aim in this study to evaluate capacity of the short-term motor memory of children and adults, with and without experience in dance, when asked to reproduce immediately (after presentation) sequences of movements. Results show that experience is crucial when comparing the maximal number of actions and sequences recalled in the correct order. For these same variables, children show lower results than adults, but these differences are not significant when we compare children with experience with adults without experience.

Keywords: motor memory; memory span; retention capacity; experience in dance; motor actions

The quantification of the capacity to retain information is a topic of interest since the 1950s, especially after the famous Miller's article of 1956. The first studies used exclusively words (Longstaff 1998), but after the end of the century, motor memory started to be studied as movements were used as stimuli. In the research of learning and motor control, motor memory is one of the crucial topics of study.

In dance, the capacity to memorize is very important, particularly in its artistic dimension which is very selective and in which professionals have to perform huge sequences of motor actions, sometimes for more than an hour. As actors have to retain/memorize a text, dancers are distinguished in many cases for their good ability to memorize long passages of movement.

The amount of information and the time available for its retention are two important aspects when we talk about memorization. According to several authors (Marteniuk 1976, Perlmutter and Hall 1992, Weiss 1995) Miller's work has established a referential: the short-term memory has an overall capacity of 7±2 items. The recovery of more information is dependent on the use of the long-term memory.

The short-term memory increases considerably with age, so the capacity to memorize is generally lower in children when compared with adults. This difference is due to the lack of knowledge and strategies of memory that children present (Ille and Cadopi 1999). As children grow older they acquire a repertoire of strategies that will help to solve problems: from age seven they begin to use strategies of rehearsal/memorization spontaneously, and until age eleven, a rapid increase in the number and quality of strategies is evident (Bouffard and Dun 1993, Weiss and Klint 1987). The acquisition of the *labeling*, *repetition,* and *cluster* strategies increases progressively up to eleven years old, and during the next two years children acquire other strategies.

One problem that arises when studying motor memory is how to measure it—that is, to find an appropriate unit of measurement to quantify this capacity. It may be easier to identify the number of words in a spoken or written discourse than the number of movements of a person who is dancing. The tests that are used to measure the capacity of short-term memory are called memory span. This type of testing identifies the longest sequence of non-related items that can be recalled immediately in the same order as they were presented.

The measure established by Miller (7±2 chunks of information to the short term memory capacity) means that the amount of information per chunk varies. This leads the author to conclude that capacity of short-term memory is a matter of organization of material to remember in units of meaningful information, so that maximum information is retained (Marteniuk 1976). But can the amount of recalled words be applied to, or similar to, the ability to remember movements?

According to Bavelier *et al.* (2006) the capacity of the short-term memory depends on the nature of the information, for example 7±2 items for language and 4±1 for visual-spatial items. Furthermore, the ability to organize information into chunks seems to depend more on familiarity and experience that the individual has with the skill or knowledge area, than their pre-existing capacity to store more information in memory (Rose 1997). This study tries to identify the largest number of motor actions that subjects with and without experience in dance are able to recall after the presentation of various sequences of motor actions in dance. We wanted to compare children with adults, so participants were organized in four groups: children and adults with and without experience.

METHOD

Participants

The "children" group consisted of 10 female subjects with experience in dance and 6 female subjects without experience in dance. They were randomly chosen from the following criteria: age, experience, and availability. Both groups have an average age of 11 years. We considered that subjects have experience in dance when they dance for more than a year in a regular, formal, and systematic way, as is the case in vocational teaching. Children with experience had on average 6 years of experience, with 3 hours per day. The "adult" group consisted of 12 female subjects, 6 with experience in dance, and 6 without experience, mostly university students. They had on average 12 years of experience with 3 hours per day.

Materials

In the present study we have applied the *memory span test*. This is a test of presentation/reproduction of items (motor actions) in which subjects are classified/categorized by the number of items that they can identify and recall in the correct order (Bouffard and Dunn 1993). The material to be reproduced by subjects (motor actions and movement phrases), developed by the authors, was created for this study taking into account the degree of difficulty of the motor actions and movement phrases. We aimed to use sequences of motor actions *without complexity,* considering that a task with more relationships between the parts that compose it is more complex than a task with fewer relationships. For example, a jump with a rotation during the aerial phase is more complex than a vertical jump from two to two feet.

We created twelve sequences of non-related motor actions and eleven sequences of related motor actions. The transition between each sequence is characterized by adding a motor action. Structure units were taken to be the motor actions of the classification of movement in dance presented by Rodrigues (1999). The motor actions were our unit of measurement: posture, balance, gesture, turns, steps, displacement, jumps, and falls.

Procedure

The memory span test was done individually; only the participant and the researcher, responsible for projecting the images and recording the participant performance, were in the studio. The test started with the projection of the first group of non-related motor actions. The subject observed the sequence twice and then was asked to repeat it immediately once. The test followed the same procedure until the last sequence (12 motor actions). Subjects were asked to reproduce exactly what they saw, maintaining the overall form and also keeping the order of the presented movements. Subjects were not allowed to reproduce/rehearse the film during its projection. After a break of 10-15 minutes the second test was applied. The procedure was the same as the first, but this time subjects were asked to recall eleven movement phrases (related motor actions) of 2-12 actions per phrase.

RESULTS

The two types of sequences of our study (non-related and related motor actions) were studied according to the following variables: maximum number of motor actions recalled in the correct order, number of sequences recalled in the correct order, number of sequences recalled independently of order, total actions recalled in the correct order, and total actions recalled independently of order.

The m*aximum number of motor actions recalled in the correct order* ranges from 2-11 and seems to be the most interesting variable in quantifying the number of actions per sequence either in future studies or in learning applications. The results range from 3.50 actions in the children group without experience, to 8.00 actions in the group of adults with experience. The other two groups realized almost 5.00 actions sequentially in the correct order. For this variable, the approximate values obtained for the group of children with experience and the group of adults with no experience is consistent.

The *number of sequences recalled in the correct order* ranges from 0-5, with values of 3.67 actions for adults with experience, and 2.00 actions in adults with no experience. This variable focuses on the sequence; the number of actions executed correctly before the first error. This means that there were some subjects (2 adults without experience and 1 child with experience) who failed the first sequence of 2 related motor actions and that there were some (2 adults and 1 child with experience) who continued accurately until the fifth motor action sequence, after having also correctly completed the earlier sequences. In this variable, children with experience presented results slightly higher than adults with no experience.

The results obtained from the analysis of the *number of sequences recalled independently of order*—that is 12 and 11 sequences (related and unrelated, respectively)—consider all of the sequences that were executed without error because one subject can correctly complete 4 actions, not complete 5 actions, and correctly complete 6 actions, etc. For this variable, the values are between 1 and 6 activities, with averages ranging from 1.17 for children with no experience to 4.17 for adults with experience. The other two groups have similar values with a slight advantage for children with experience (3.20-2.20 actions) compared with adults without experience (3.17-2.17 actions).

The *total of actions recalled in the correct order* varies from 15.58% in children without experience to 76.62% in adults with experience, which is the equivalent to 12 and 59 actions from the 77 actions presented by the model. The average values range from 33.76%-69.26%, with the highest values belonging to adults with experience and the lowest to children with no experience. Analysis of the *total of actions recalled independently of order* showed mean values generally higher than the values of the previous variable, with values ranging from 34.19%-70.30%. To study further the age and experience independent variables—and because of sample size and according the type of dependent variables—we used the nonparametric Mann-Whitney-Wilcoxon or the t-Student test. To compare the related and non-related data we used the Wilcoxon test and, for the paired data, the t-Student test. We considered a result significant if $p \leq 0.05$.

DISCUSSION

The results indicate that there are significant differences when comparing the groups with respect to experience. The n*umber of sequences recalled in the correct order* depends on this factor as it appears in all possible comparisons and cross-comparisons. The other four variables in the study also appear often, which reinforces the idea that years of practice in a particular activity influence the ability to recall movement, which despite being generic (not specific to a particular dance technique) have dance as frame of reference of the motor repertoire. With regard to age, it is confirmed that for the variables under study (which appear to have consensus in the literature) children are less able than adults to memorize movements; this disadvantage is more apparent if the sequences are particularly long (more than 5 motor actions), common in many situations of dance learning. When we associated age and experience, we found an aspect that seems worthy of development in future study: that the group of children with experience have similar or sometimes slightly higher scores than the group of adults without experience. This, and the size of the sample for different age groups, should be considered in future studies.

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Graduate award paper

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Fast feedforward error-detection mechanisms in highly skilled music performance

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Expert performance in music or sport requires the ability to monitor on-going behavior, detect errors *in advance*, and modify the performance accordingly. In this context, errors have dramatic consequences, such as playing the wrong note in a piano concert or mis-hitting a smash during a tennis match. Detection and correction of errors in advance is possible due to the fast functioning of the self-monitoring system. Surprisingly, only sparse evidence about error monitoring has been published in the music domain. Consequently, the present study investigated the electrophysiological correlates of predictive (feedforward) error detection and action control during piano performance. Pianists had to retrieve memorized music pieces at a fast tempo in the presence or absence of auditory feedback. Only wrong pitches were considered as erroneous actions. The main outcome was a negative component elicited around 70 ms prior to errors in the event-related potentials and which is generated by the anterior cingulate cortex (ACC). This component was independent of the auditory feedback and was assumed to reflect error detection processes. Moreover, an interaction between the ACC and the lateral prefrontal cortex predicted corrective mechanisms. The findings presented here shed new light on the neural mechanisms of feedforward motor control.

Keywords: ACC; EEG; errors; motor control; performance monitoring

Playing tennis, performing a piece of music from memory, and even leaping in a rhythmic gymnastics exercise are all complex multimodal tasks which rely on predictive (feedforward) mechanisms acquired through extensive training. All these refined sensory-motor tasks depend on time-based sequential behaviors and, as such, require accurate preparation in advance of the events planned for production (Lashey 1951, Schmidt 1975, Pfordresher and Palmer 2006). Moreover, the performance of complex overlearned motor programs requires the perfect tuning of the action-monitoring system to the extent that potential errors, which might otherwise interact with the goals, must be predicted in advance (Bernstein 1967, Wolpert *et al.* 1995). Overlearned motor tasks thus present an ideal paradigm for the study of brain activity associated with feedforward mechanisms of error detection. However, in the context of expert performance, there is sparse information concerning the neural mechanisms responsible for predictive error detection processes.

A seminal finding in the context of the human action-monitoring system was a negative deflection in the event-related potentials (ERPs) of the electroencephalogram (EEG), termed error-related negativity (ERN), which peaks about 70 ms after the incorrect key press in reaction-time tasks (Falkenstein *et al.* 1990). The neural generators of the ERN have been located in the anterior cingulate cortex (ACC; Dehaene *et al.* 1994). The ERN has been hypothesized to reflect the error signal of a feedforward control mechanism (Holroyd and Coles 2002, Bernstein 1967). Thus, during goal-oriented behavior, the ACC is assumed to monitor the ongoing performance and signal the need for higher control in erroneous trials (Miller 2000). Further, the ACC is hypothesized to interact with lateral prefrontal areas (lPFC), which in turn implement performance adjustments (Botvinick *et al.* 2001, Ridderinkhof *et al.* 2004). Surprisingly, no specific data about this interaction have been reported during the monitoring of skilled overlearned performance. The aims of the present study were the following:

- To investigate with EEG the neural correlates of *error-monitoring* in humans by using piano performance as an example of a complex multimodal task.
- To study the interplay between auditory and sensory-motor information in the processes triggered by an erroneous action—namely, a *wrong pitch*.
- To test whether the ACC and lPFC interact by means of phase synchronization in the feedforward mechanisms acting in advance of overt errors.

METHOD

Participants

Eighteen healthy pianists (10 males, 8 females; age range=20-29 years, mean=22 years), who were students at or had graduated from the Hanover University of Music and Drama, participated in this study. All participants were professional pianists. Seventeen of the participants were right handed and one was left handed, according to the Edinburgh inventory (Oldfield 1971). All participants reported normal hearing.

Materials

The stimuli were six sequences extracted from the right-hand parts of the Preludes V, VI, and X of the *Well Tempered Clavier* (Book I) by J. S. Bach and the *Piano Sonata* No. 52 in E Flat Major by J. Haydn. These pieces were chosen because their parts for the right hand contain mostly single pitches of the same value (duration)—i.e. sixteenth notes. The number of notes per sequence was approximately 200. The tempo for each piece was selected so that the interonset interval (IOI, the time between onsets of two subsequent notes) was 125 ms (8 tons/s) in all cases. Participants were instructed to rehearse and memorize them before the experimental session.

Procedure

Participants had to perform the memorized pieces on a MIDI digital piano (Wersi Digital Piano CT2, Halsenbach, Germany) in a synchronization-continuation paradigm (see Herrojo Ruiz *et al.* 2009 for more details). The keyboard and the right hand of the participant were covered with a board to prevent participants from visually tracking hand and finger movements. Playing the correct notes and maintaining accurate timing were stressed.

The experimental design consisted of two conditions—audiomotor (AM), motor (M)—comprising 60 randomized trials (around 12,000 notes) each. Both in AM and M, participants played the musical stimuli 1-6 from memory. The only difference between both conditions was that the volume of the MIDI keyboard was set to zero in M, thus cancelling out the auditory feedback.

During the performance, continuous EEG signals were recorded from 35 electrodes placed on the subjects' scalps according to the extended 10-20 system referenced to linked mastoids. Data were sampled at 500 Hz; the upper cutoff was 100 Hz (software by NeuroScan, Inc., Herndon, Virginia, USA).

Visual trigger stimuli, note onsets, and metronome beats were automatically documented with markers in the continuous EEG file. Performance was also recorded as MIDI files using a standard MIDI sequencer program.

Data analysis

An error-detection algorithm was developed in MatLab®, which compared each MIDI performance with the pitch contents of a template (the score).

Only isolated pitch errors and correct notes, which were preceded and followed by three correct notes, were included in the analysis. Two additional constraints were set to all pre-selected errors and correct notes in order to assure their temporal precision and to avoid overlapping of brain responses: first, the time interval between MIDI note on and off was not accepted above 150 ms. Second, the minimal and maximal IOI prior to and after the error were set to 100 and 300 ms.

We performed the following types of analysis of the EEG signal: first, the standard time averaging technique was executed to analyze the ERPs of the brain responses triggered by actions leading to pitch errors (wrong note was played) as compared with actions leading to correct pitches. ERPs were derived by averaging the raw epochs for each subject and condition and the result was baseline-corrected (from 300 to 150 ms prior to the keystroke). Second, we analyzed the bivariate (pair-wise) phase synchronization between EEG signals (Lachaux *et al.* 1999, Varela *et al.* 2001), as a measure of the functional interaction and integration between the underlying neural populations. This latter investigation focused on the electrodes F3-FCz and F4-FCz, as a measure of the synchronization between areas located over the lPFC and mPFC. To rule out an alternative explanation of volume conduction effects, the bivariate synchronization index was additionally calculated between C3-FCz and C4-FCz: these pairs have a similar distance as pairs F3-FCz and F4-FCz, but a more posterior location; however, there are no a priori hypotheses that posit a role of these brain regions in cognitive control. Three frequency ranges were analyzed: (1) the theta band (4-8 Hz), based upon its modulation of the ERN (Luu *et al.* 2004, Cavanagh *et al.* 2009), (2) the alpha band (8-13 Hz), as an indicator of attention-deficits and precursor of forthcoming mistakes in monotonous tasks (Mazaheri *et al.* 2009), and (3) the beta band (13-30 Hz), due to its sensitivity to movement-related changes in humans (Pfurtscheller *et al.* 1997).

All statistical tests were performed by means of nonparametric univariate permutation tests and multivariate synchronized permutations (Good 2005).

RESULTS

Performance data

The selection of isolated erroneous notes yielded a value of 80 (SD 30) in AM and of 80 (SD 20) in M. In AM, the mean IOI was 121 ms (8 ms), whereas in M the mean IOI was 123 ms (8 ms). The difference in mean IOI or number of errors was not significant ($p>0.05$). These results confirmed that pianists successfully performed the sequences with timing very close to the right IOI.

Moreover, these data indicated that pianists played with a similar timing and error rate with or without auditory feedback.

Interestingly, the loudness (assessed by MIDI velocity) of errors was significantly reduced as compared with the loudness of the corresponding correct notes in the same position on the musical score, both in AM (mean=-7, SD=4, p=0.01) and in M (mean=-5, SD=4, p=0.01). The reduction in loudness was similar in both conditions (p>0.05). These results indicated that a corrective response had already been initiated by the time the subjects pressed the erroneous key. Finally, a pre- and post-error slowing was observed both in AM and M [pre-error slowing of 190 ms (SD=60) in AM and 170 ms (SD=60) in M; post-error slowing of 240 ms (SD=60) in AM and 200 ms (SD=60) in M].

Error signal preceding errors

The comparison between the waveforms of errors minus correct notes, both in AM and in M, revealed a negative event-related potential triggered 70 ms *before* the onset of errors. This negative component resembled the ERN and was termed *pre-error negativity* (pre-ERN, see Figure 1A and 1B). Also, we observed a final positive deflection between 240 and 280 ms (AM) and between 180 and 220 ms (M), resembling the Pe. The Pe was larger in AM. The maximum of the pre-ERN was localized across frontocentral positions (Fz, FCz, Cz) of the scalp in both conditions. Likewise, the topographic maxima of the Pe in AM and M were localized across frontocentral electrode positions. By means of multivariate statistical analysis, we established that the ERP waveforms of the mesial frontocentral electrodes between errors and correct notes differed depending on the task condition from 220 to 260 ms (significant interaction of the factors event type × condition, p=0.008). A post hoc univariate permutation test across subjects in AM revealed a significant enhanced negativity, the pre-ERN, between -70 and -20 ms before errors as compared with correct notes (p=0.007) and a significant Pe (p=0.008) between 240 and 280 ms. A similar result was obtained in M between -50 and 0 ms for the pre-ERN (p=0.008) and between 180 and 220 ms for the Pe. The comparison between ERPs in AM and M revealed a significantly larger Pe in AM between 250 and 280 ms (p=0.008). However, the pre-ERN did not differ between conditions (p=0.3).

The source of activity generating the pre-ERN was localized by sLORETA in the Brodmann area (BA) 32 of the rostral ACC (Figure 1C). Similarly, the neural generators of the of the brain activity associated with the Pe were localized by sLORETA in the BA 24 of the rostral ACC (Figure 1D).

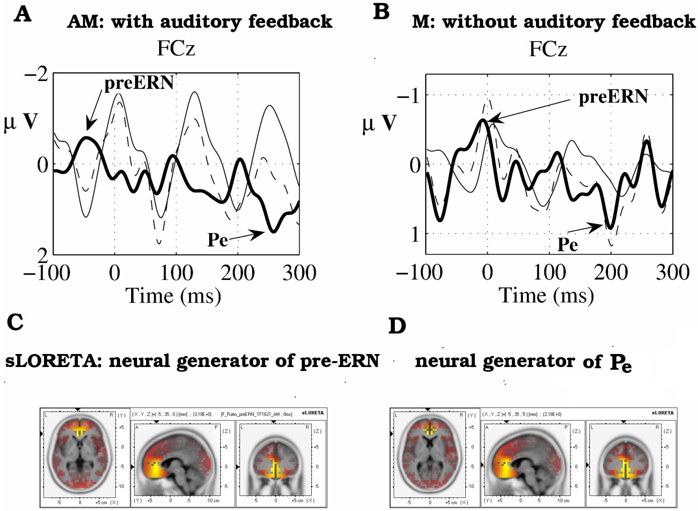

Figure 1. Note-onset ERPs depicted at electrode location FCz for erroneous notes (dashed line), for correct notes (solid line), and for the difference (errors minus correct notes, bold line) in the presence (A) and absence of auditory feedback (B). Note the increased negativity just before the commission of the errors (pre-ERN, arrow) and the large positivity after errors (Pe, arrow) in both conditions. Note the different scaling in y-axes (C) sLORETA localized the source of activity associated with the pre-ERN in AM and M in the BA 32 of the rostral ACC. (D) The neural generator for the Pe in AM and M was localized by sLORETA in the BA 24 of the rostral ACC. (See full color version at www.performancescience.org.)

In summary, the pre-ERN was independent of the auditory feedback. However, the auditory information did modulate the processing of the errors after their execution, as reflected in a larger Pe in AM.

Phase synchronization as feedforward control mechanism

The lower beta band (13-15 Hz) phase coupling between FCz and F4 increased robustly from -100 to 0 ms before overt errors compared with overt correct notes (p=0.001, permutation test, Figure 2). Similar statistical tests were run on the pairs F3-FCz, C4-FCz and C3-FCz, but no significant effects were found. These findings give evidence of an increased right-lateralized phase interaction between FCz and F4 preceding errors, which could be related to

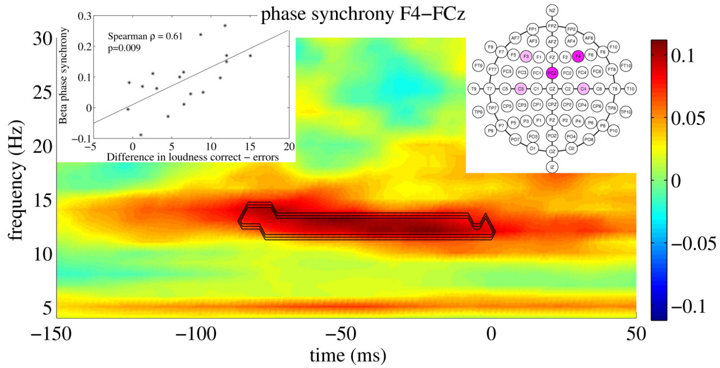

Figure 2. Difference between erroneous and correct trials in the grand-averaged phase synchrony between channels F4 and FCz. An increase in bivariate phase synchrony can be observed starting 100 ms prior to the note onset and due to more phase coupling for error trials. Significant differences are marked by the black contour (p=0.001). The left panel illustrates the results of the correlation analysis. The right panel depicts the electrodes (dark pink) FCz and F4, in addition to electrodes F3, C3 and C4 (light pink). (See full color version at www.performancescience.org.)

the feedforward mechanisms of error detection and correction. To investigate the latter, we assessed the modulations by the F4-FCz phase coupling of the corrective mechanisms by a regression analysis between the beta phase coupling and the decrease in loudness of errors. The phase synchrony index averaged in the time-frequency window -100-0 ms x 13-15 Hz was highly significantly correlated with the reduction in the loudness of errors (Spearman's rho=0.62, p=0.001). Such positive correlation suggests that in subjects with a higher F4-FCz phase coupling there was a better correction mechanism that results in the reduction of the loudness of errors.

DISCUSSION

In the present study, the main finding was a negative event-related potential triggered 70 ms *before* the onset of errors, the pre-ERN. The pre-ERN signaled error detection in advance and was generated by the rostral ACC. Furthermore, this component was independent of the auditory feedback and had a correlate at the behavioral level: the loudness of pitch errors was reduced. This behavioral finding suggests that a corrective response had already been initiated by the instant of pressing the erroneous key.

Furthermore, the auditory information did modulate the processing of the errors after their execution, as reflected in a larger Pe around 250-280 ms in AM, generated by the rostral ACC. Based on the evidence that associates the rostral ACC with emotional processing (Luu *et al.* 2003), the previous result might indicate an enhanced emotional evaluation of the errors with auditory feedback.

Finally, in searching for a feedforward mechanism that might detect the upcoming wrong note in advance and try to cancel the associated sensory consequences, we found that the beta band phase synchrony between F4 and FCz increased 100 ms before errors. This measurement positively correlated with the reduction in loudness of errors. Thus, the degree of increased pre-error bivariate synchronization between this pair of electrodes—with F4 representing the lPFC and FCz representing the ACC—was associated with more efficient correction mechanisms.

The present results demonstrate that the pitch accuracy and temporal precision required in the production of fast complex musical sequences is possible in part by the perfect functioning of feedforward mechanisms in highly skilled pianists. Internal forward models can predict the next state of a system from its current state and motor command (Bernstein 1967, Wolpert *et al.* 1995). Further, they compare the actual motor outflow (efference copy) with the motor command. In case of a mismatch, an error signal is triggered to cancel the undesired sensory effects of the movement (reafference) and a corrective response is initiated. This model is supported by the present results. In our paradigm, (1) the reported pre-ERN may be the neural correlate of this error signal, and (2) the auditory feedback plays a fundamental role in the emotional evaluation of errors. In addition, (3) the feedforward *control signal*, which indicates the need of a corrective response and/or posterior behavioral adjustments, is indexed by the pre-error increase in beta phase synchrony between FCz and F4. Finally, (4) the corrective response triggered to cancel the undesired sensory effects of the wrong movement leads to the observed decrease in the loudness of errors and to the pre-error slowing (~190 ms).

The evidence for our hypothesis that the auditory feedback does not mediate the detection of the pitch errors prior to the execution in piano performance is in agreement with previous studies. Lashley (1951) postulated that auditory feedback could not control for the fast motor sequences of piano performance at a high tempo. This statement was further strengthened by the study of Finney and Palmer (2003), which demonstrated that the presence or absence of auditory feedback in the retrieval of memorized music sequences did not affect the error rate. Performance of rapid movements must thus be prepared in advance (Schmidt 1975, Pfordresher and Palmer 2006). We believe that this outcome is characteristic not only of skilled piano performance but also of other skilled time-based sequential sensory-motor behaviors, such as those used in sports, dance, or speech. These behaviors share as common aspect the preparation in advance of the events planned for production, possible through extensive training. Consequently, these behaviors rely rather on forward predictive mechanisms than on the slow sensory and proprioceptive loops (Wolpert *et al.* 1995).

Optimization in performance might be achieved by the interaction between the action-monitoring and the cognitive control systems (Botvinick *et al.* 2001). According to this view, the action-monitoring system supervises ongoing performance and signals the need for adjustments, which are in turn implemented by the cognitive control system. Most of the previous investigations have located the neural activity associated with action-monitoring processes in the ACC, whereas the control system is ascribed to the lateral PFC (Botvinick *et al.* 2001). However, a different theory posits that neural activity in the ACC might mediate both monitoring and control mechanisms (Rushworth *et al.* 2004). Our results are in line with the former model, in which the ACC monitors ongoing performance to detect unfavorable upcoming actions and interacts with the lPFC, so that this brain region can implement the behavioral adjustments. To the best of our knowledge, out results are the first to demonstrate that around 100 ms before errors are committed, increased beta phase synchronization between electrode regions located over the ACC and lPFC is associated with better corrective mechanisms. As a consequence, it seems plausible that feedforward control mechanisms are triggered already 100 ms before errors are committed.

In summary, our findings provide compelling evidence for the hypothesis that fast predictive mechanisms are required for the optimal execution of preprogrammed temporal and spatial movement patterns that characterize piano performance (Catalan *et al.* 1998). The present results can be generalized to expert performance in sports, music, and dance.

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A balanced approach to excellence: Life-skill intervention and elite performance

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To become an elite performer in the modern world, individuals must discipline themselves to train and practice for many years. Usually they need to dedicate most of every day in pursuit of their dreams. More and more countries have been developing systems to identify this talent very early in life and are finding new ways to nurture it. The challenge faced by most elite performers is how to manage this intense focus and still build a resilience and capacity to meet the many transitions and demands required in both elite performance and life. These skills are more often than not under developed as a result of the myopic environment typically created for the elite performer. One of the most challenging transitions often faced is retirement. The basis of much research in this area has been undertaken in sport (Alison and Meyer 1988, Baillie 1993, Blann and Zaichkowsky 1989, Blinde and Greendorfer 1985, Lerch 1984, Lavallee *et al.* 1997). Other performance environments such as dance and music have also captured the interest of researchers (Davidson and Burland 2006, Burland and Davidson 2004, Patton and Ryan 2000, Saposnek 1995, Patton and McMahon 1999, Wallach 1988). This growing body of literature has led to some performance environments introducing early intervention programs to broaden the life-skills of the performer. The belief is that this will protect them from the uncertainty and anxiety about their futures and will result in fewer traumas when they have to deal with the transition from elite performance.

Keywords: transitions; life-skills; athlete identity; athlete foreclosure; self identity

RETIREMENT AS A TRANSITION

Social gerontological models of aging and thanatological models of death and dying have been used by researchers to better understand career termination from elite sport (Atchley 1991, Lerch 1984, McPherson 1980, Rosenberg 1981, Freidman and Havighurst 1947, Rose 1962, Kuypers and Bergston 1973). These approaches can also be applied to a range of other elite performance environments, including the arts, dance, music, and acting industries.

The social gerontological perspective takes into account the following theories: Activity Theory, Disengagement Theory, Subculture Theory, Continuity Theory, Social Breakdown Theory, and Social Exchange Theory. Some of these will be discussed below.

Activity Theory (Friedman and Havighurst 1954; Havighurst and Albrecht 1953) maintains that as various activities are lost, the individual establishes new roles, and the maintenance of these contributes positively to self concept and life satisfaction. An important difficulty with this theory when relating to elite performance, according to Baillie and Danish (1992), is that it may not always be possible to duplicate the type of environment created within the elite performance context.

Disengagement Theory (Cumming and Henry 1961) was developed as a response to Activity Theory and suggests that the ageing process sees individuals mutually agreeing to withdraw from society and thereby providing them with the opportunity to enjoy life in the period after paid employment. This theory proposes that it is a function of both the individual and society that naturally occurs. When attempting to draw parallels with the elite performance environment, this concept is a difficult one as it assumes that the withdrawal is mutually agreeable between both parties, and this may not always be the case.

Continuity Theory represents a refinement of Activity Theory (Atchley 1977) and posits that, although activities and habits might alter or be replaced by others throughout our lives, these may not always provide the same meaningful experience. If individuals are capable of retaining the continuity of meaning in their activities, retirement is said to be less traumatic (Anderson 1999). In relating this theory to elite performance the challenge will be to find meaning in other activities when for so long many elite performers have characterized their lives around one specialized activity.

Additional theories worthy of consideration in the present context are Social Breakdown Theory (Kuypers and Bergston 1973) and Exchange Theory (Dowd 1975). Kuypers and Bergston proposed that with any role loss, such as retirement, the individual might become the recipient of negative external labels, leading to a breakdown in their social framework. Therefore, any major role loss is seen to have significant potential to impact adversely on self image. In order to limit the downward spiral that often results, they argued that a social reconstruction is typically needed.

Exchange Theory (Homans 1961) illustrated that retirement can be a positive experience if social activities and networks are considered and possibly redefined. He believed that if an individual can continue to maintain valued social networks then retirement should be an easier process. Rosenberg (1981) has suggested that this theory is the most applicable to elite sport as it is often the inability of an athlete to create these new networks that contributes to a difficult adjustment.

Social Breakdown and Exchange Theories appear to be most useful in the elite performance context as individuals who retire from these environments often require a social reconstruction of themselves. Application of these theories to date has demonstrated useful parallels (Rosenberg 1981), but further work is required. Continuity, Activity and Disengagement Theories may also have some relevance, but again, more applied research in the elite performance setting is needed to understand their true value.

The Thanatological Models studied the process of death and dying. Introduced by Park (1912) these theories may also have implications for retirement from elite performance and incorporate Social Death (Kalish 1966), Social Awareness (Lerch 1984), and the stages of death (Kubler-Ross 1969, 2005).

Social Death assumes that individuals experience a loss of social functioning which results in those around them retreating from the relationship as though they have already died (Lerch 1984). This is sometimes observed in the elite performance environment when individuals feel a sense of isolation and ostracism prior to their retirement or when they sustain a career ending injury.

Why this may occur can be explained through Social Awareness Theory, which proposes that individuals have different levels of awareness: closed, suspected, mutual, and open. In closed awareness, terminally ill patients may not be aware of their impending death whilst those around may know. The reasons for this could include the doctors not informing the person and the person's non-acceptance of the inevitable outcome. When applying this to elite performance and in particular sport, it can be seen when an athlete does not know that retirement is sometimes imminent because the coach, management, and even team mates have not discussed it with them.

The concept of suspected awareness exists when a dying patient believes or suspects that death is a matter of time, and they engage others to either confirm or deny their suspicions. In the elite performance environment, many performers will pick up on changes in the way they are being treated and seek to determine whether they are about to be retired.

Mutual awareness is when all parties are aware of the impending death and everyone involved behaves as if nothing is going to happen. In elite performance, the individual's career transition would not be discussed, but it is possible that they may sense a degree of isolation but cannot explain why.

Open awareness exists when all parties acknowledge that the patient is dying, and this provides everyone with a chance to discuss their feelings and thus gives the patient a greater sense of control. In terms of elite performance, individuals can begin to plan their post performance career. According to Rosenberg (1984), the most common awareness models seen in the sporting environments are closed and suspected.

Kubler-Ross (1969) created a psychological reactions model in an attempt to understand terminally ill patients. The stages of dying, as described by Kubler-Ross, include denial, isolation, anger, bargaining, depression, and acceptance. These psychological reactions have been used widely to describe retirement from elite sport (see Figure1).

The initial stages of denial and isolation see the elite performer refusing to acknowledge the decision that retirement is approaching. The anger stage may see the performer becoming quite disturbed about the situation. Bargaining will result in creating personal debates and negotiation in an attempt to stay connected to the impending loss. Depression will see the performer distressed and over anxious about the situation. Finally, the performer will acknowledge and accept the situation and be able to transition.

Coakley (1983) challenged the use of gerontological concepts and assumptions that retirement from sport is an inevitable source of stress. He indicated that the problem is not retirement *per se,* but the personal and social characteristics of the individual that affect the ability to adjust to changed circumstances.

The personal attributes of the elite performer and how much their self identity is connected to the performance environment will have an impact on the quality of the transition.

The time taken and the ability to transition through these stages, known as the grieving process, will depend upon whether the decision was a voluntary (own choice) or an involuntary one (e.g. injury or deselection). The athlete retiring by choice may go through the grieving process more quickly and with greater ease than athletes who have retirement forced upon them (Fortunato and Morris 1995).

These sentiments are also shared by Oglivie and Taylor, (1993) who believed that an elite athlete's adjustment to retirement will be smoother if the retirement is voluntary. In other words, the athlete makes the choice, is prepared for life after sport, measures identity on more than just sport, and has good relationships and a broad social support network.

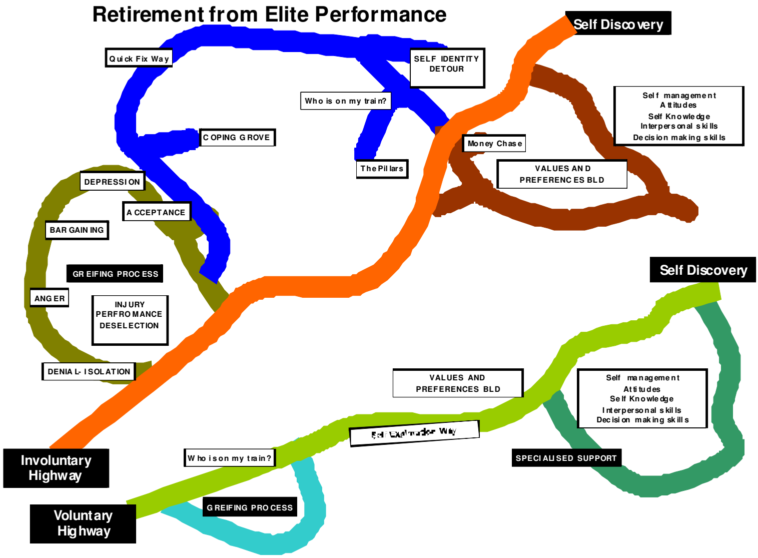

Figure 1. The process of dealing with both voluntary and involuntary retirement from elite performance. (See full color version at www.performancescience.org.)

Kleber and Brock (1992) found that adjustment difficulties might well be explained by how the athlete perceives the level to which sport has constricted their development. What the athlete believes could be reflected in several ways. They might see that engagement in sport prevented serious orientation toward a career and life beyond. It is also possible that sport may have promoted degrees of self-detachment and desensitization to the wider world, thereby leaving the athlete with heightened feelings of vulnerability as retirement approaches (Anderson 1999).

Whether or not the decision to retire from elite performance is voluntary or involuntary, qualitative analysis reveals that performers are frequently disadvantaged by a failure to plan for life outside the performance environment (McPherson 1980). If young performers can be socialized to perceive the value of planning for retirement during their elite performance careers, they might minimize or even avoid the trauma that is currently being experienced by many individuals as cited in research and anecdotal reports (Danish *et al.* 1991).

Retirement from elite performance is a process rather than a single step. It often requires a change in how the performer views themselves and those around them. Clearly each performer would deal with retirement in a very individual manner.

Most elite performers do not prepare for retirement and lack the resources to deal with it, especially when their performance aspirations are not met, and generally experience some form of trauma as a result. Some researchers (Baillie and Danish 1992, Fortunato 1996) believed that these difficulties can be explained through understanding the concept of athlete identity.

The elite performer is often blind to the fact that their career can be brief, curtailed, or even unexpectedly terminated due to a wide variety of circumstances. It is therefore important that an early intervention plan is established. The implementation of such a plan may result in a less stressful time both emotionally, psychologically, and financially, both during and after their involvement in elite performance.

Brewer *et al.* (1993) proposed that if an athlete measures their identity on their sporting performance alone they will have difficulties in dealing with the many transitions associated with both sport and life. Saposnek (1995) believed that dancers experience similar challenges as a result of their early and enduring identification with their field.

One potential outcome of focusing on a particular element of life is that the performer can be distracted from giving due attention to matters peripheral and external to the elite environment. Importantly, this may lead them to foreclose on other aspects of their personal development.

Organizations responsible for elite performers should be encouraging them to develop skills outside of their performance arenas. This will help them minimize the risk of being left with feelings of insecurity and uncertainty in their current and future lives. A course of action that equips them to deal with a range of transitions they will face is a crucial element of both professional and personal development.

THE NEED FOR LIFE-SKILL PROGRAMS

One way of supporting the performer is through the introduction of life-skill programs which aim to up-skill the performer to deal with the many transitions that they are expected to face in both life and elite performance.

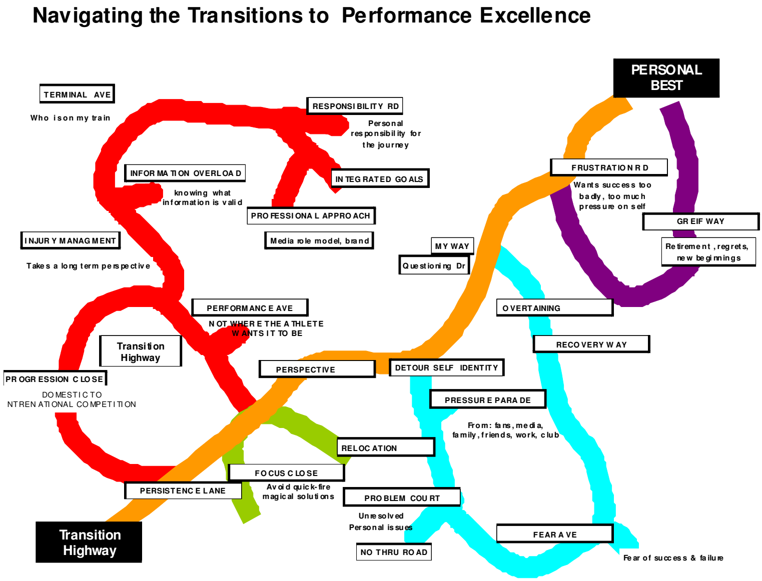

Figure 2. Transitions in elite performance. (See full color version at www.performance science.org.)

More specifically, these transitions are defined as events resulting in changes in assumptions about oneself and the world and which require a corresponding change in behavior and relationships (Schlossberg 1981). Figure 2 outlines most of the common transitions that elite performers will face at some stage. Each transition requires a range of skills that must be learned if the individual is going to sustain and meet their performance and personal objectives.

Transitions are either voluntary or involuntary in nature and performers need to develop a variety of skills so that they can successfully move through the various transitions and issues they confront.

The ability to move through and cope with each of the above transitions, which at times can be multi-phased, will depend on how well the situation can be normalized. To be able to do this requires an awareness of both self and the performance environment. The performer should therefore be encouraged to learn early in their careers about the real performance environment within which they will be expected to function. Such knowledge and take up of early intervention programs that enable them to be better prepared are highly recommended.

The quality of the adjustment to the many transitions will often be dependent upon the following: individual characteristics, socio-economic environment, type and nature of the transition, developmental issues, athlete identity, and identity foreclosure.

The pressure placed on the performer to focus solely on their performance often means that when they need to deal with a transition they only have the capacity to draw on a limited set of experiences. As many performers begin their journeys at a young age, unless a broader perspective on life is developed, their true potential as an elite performer may never be realized.

Developing life-skills during the performance journey enables the athlete to take control of the important aspects of life and provides an even more intense ability to focus on the performance dreams. As well the transition into retirement from elite performance is often smoother. This perspective is still not fully understood by many coaches, teachers, and administrators, despite the ongoing resources spent on helping performers who are unable to progress through the transition process.

Developing the self in a holistic manner creates a stronger base from which to operate and enables the performer to draw on a broader range of skills to cope with the transitions. This integrated approach is essential in order to provide the right attitude, knowledge, and skills. The pillars that make up the self may include performance goals, personal development, family, friends, professional development, and social connections.

The performer should be encouraged to set goals in all areas of life and know what their personal strengths and weaknesses are both within and outside their performance environment. It is also important that they seek, and can interpret feedback from a range of sources, including coaches, teachers, umpires, media, spectators, team members, opponents, officials, family, friends, peers, and supporters.

The performer needs to understand that being assertive and developing effective interpersonal communication skills in both their performance arena and life will give them a greater capacity to influence their environment.

Effective time management is a skill that is often not picked up by performers early enough in their careers. This can be quite common as most of their time is structured and managed for them. In the modern environment, performers need to embrace technology to better manage the often competing demands.

Creating confidence in personal presentation and public interaction can also assist the performer to deal with the public and to take full advantage of what this can offer.

Managing personal income, financial planning, and budgeting can also help the performer take full advantage of their financial situations and ensure that their future has been planned for adequately.

Many performers may be fit ,but few can claim to also be healthy. Personal health and fitness knowledge is important so that they can sustain their commitment to performance for as long as possible. Nutrition, recovery, performance psychology, injury prevention, drugs, and an understanding of the human body will give important knowledge that can sometimes be the difference between success and failure.

THE ELITE PERFORMANCE ENVIRONMENT

Organizations responsible for elite performance should create an environment early that educates elite performers, and those aspiring to be at the elite level, about what to expect. They should also drive a culture throughout the environment that promotes a balanced approach to excellence. This is a critical factor in assisting the performer to process and adjust to transitions such as retirement, injury, and poor performance and many others mentioned above.

These organizations should foster an open door policy enabling informal contact to be maintained after the performer retires and, where possible, utilize their skills to assist others.

Organizational policy, practice, and culture must support the introduction and implementation of an elite performer's life-skill program. The program should be created on the basis of identified need, be flexible enough to ensure that it is individualized, incorporated into the overall assessment of performance, and is thoroughly consistent with the balanced approach concept.

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Poster session

International Symposium on Performance Science
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Memory consolidation in musicians: The effects of sleep, interference, and recall on musicians' performance of a keyboard melody

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Procedural memory consolidation has been shown to enhance a variety of perceptual and motor skills during sleep, but only recently has this effect been investigated in trained musicians performing music. I tested the extent to which a music performance skill improves over a night of sleep and whether the consolidation process is inhibited when musicians learn two melodies in juxtaposition during a single training session. Fifty-five participants learned to perform either one or two 13-note piano melodies during an evening training session and were retested on the target melody the following morning. Participants showed evidence of overnight performance gains in performance speed and accuracy; however, learning a second, similar melody seemed to block these overnight gains in the melody learned first. These results indicate that experienced learners performing a familiar type of task, and one that includes auditory processing demands, benefit from overnight consolidation of procedural memories but that these benefits may be inhibited when musicians learn similar, competing tasks in juxtaposition.

Keywords: memory; music; consolidation; motor skills; sleep

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Health and wellbeing education in British conservatoires

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Musicians' health and wellbeing is rapidly becoming an essential component within the training of aspiring musicians all over the world. At the forefront of tackling these issues are educational institutions, with conservatoires in particular leading the way in creating educational programs that promote the ideal of a sustainable technique and lifestyle for the professional musicians of the future. Strategic frameworks for health and wellbeing education are beginning to develop in other countries as national strategies. However, development in British music schools is not so cohesive, and each institution takes a different approach to the delivery of their health and wellbeing provision. This project investigates current health and wellbeing education programs on offer in British conservatoires and presents the students' view of this area of their education. In this investigation, a wide range of health and wellbeing activities were revealed, with conservatoires showing support to students through a variety of activities, from practical classes to research opportunities. However, despite this extensive range of services, a high proportion of students revealed that they felt their institution was not providing adequate support for their health and wellbeing, stating that they would like a more proactive approach.

Keywords: health and wellbeing; education; music students; injury prevention; conservatoires

Health and wellbeing is rapidly becoming a major consideration for professional musicians who are looking toward avoiding injury, prolonging their careers, and performing to the best of their abilities. Studies with particular instrumental groups of college level students have shown high incidences of injury, with between 30% and 50% of students being affected at some point in their education (Guptill *et al.* 2000). Musicians' health and wellbeing has therefore become a topic for growth and development within educational institutions and is rapidly becoming an essential component within the training of aspiring practical musicians all over the world. Educational programmes that promote the ideal of a sustainable technique and healthy lifestyle for the professional musician of the future are beginning to become integrated into education programs, aiming to raise awareness among students and staff alike. This project examines health and wellbeing provisions and their associated resources currently provided to students in British conservatoires, including how, where, and with what emphasis education in such matters lies. Issues relating to student injury, including treatment pathways and recovery support, are also explored. This is completed through a series of case studies with individual conservatoires and a questionnaire study with conservatoire students.

METHOD

Participants

The study was carried out across seven UK conservatoires, with members of staff from each institution aiding with data collection. The study also questioned a total of 46 student participants from UK conservatoires: 26 male and 20 female participants, with a mean age of 22 years. The students were from both undergraduate and postgraduate courses and played cello, clarinet, flute, horn, oboe, percussion, piano (including two accompanists), saxophone (classical and jazz), trumpet, trombone, tuba, violin, and voice. Twenty-seven participants had experienced an injury, 19 had not, and 15 were currently dealing with an injury.

Materials

Case-studies were compiled on seven British conservatoires, giving a detailed picture of health and wellbeing provisions, each being approached on an individual basis and various departments being asked to describe the health and wellbeing activities taking place.

A self-reporting questionnaire was used to gain an insight into the thoughts and feelings of conservatoire students toward their experiences of health and wellbeing provisions. The questionnaire explored topics such as individual experiences of injury, experiences of health and wellbeing education within their own institution, and the importance of health and wellbeing as a topic.

Procedure

Each institution was approached on an individual basis and case studies were completed with the cooperation of staff members. Since the personal data of students was handled in a variety of different ways, procedure for finding participants and completing the questionnaire was carried out through a variety of methods. Some questionnaires were filled out over the telephone with the researcher taking notes, while others were completed by hand or via email.

RESULTS

This investigation revealed a wide variety of activities, some of which are described below, with conservatoires providing support to students on many levels. One-off workshops were found to be the most common form of health and wellbeing activity, giving students insight into issues ranging from injury prevention to performance anxiety and from hearing health awareness to how to create a healthier lifestyle. Specialist departmental workshops were noted by 45% of students as being particularly successful, and one student commented that "there are fortnightly classes for accompanists where our specific issues can be addressed; I find this really useful." In three conservatoires, workshops have developed into a regular series of classes.

Three institutions present health and wellbeing issues as a first-year project. As well as addressing practical skills, these classes also focus on academic knowledge, developing professional skills, and addressing performance-practice issues. One participant commented: "I had health and wellbeing education when I was in the first year, but I've forgotten everything they've said and I know others have too." Only 43% of participants recognized that health and wellbeing was part of their curriculum.

In four conservatoires, health and wellbeing issues were also found to be raised as a part of larger projects, such as outreach projects and teacher training programs. Conservatoire students are increasingly given the opportunity to pursue academic study of the subject further, with five conservatoires noting an increase in the amount of students choosing health and wellbeing as a topic for dissertation projects. Masters modules and doctoral study in the area is also developing within conservatoires.

Conservatoires also showed diverse support for those who become injured, with a wide range of services for psychological and physical wellbeing, including counseling and physiotherapy and access to information, support, funding, and treatment. However, only 35% of students suggested that they had taken advantage of this. All seven conservatoires provide resources to support health and wellbeing education, which includes literature, journals, and web-based support. In three conservatoires, internet homepages provide comprehensive information on health and wellbeing activities, while in four conservatoires intranet sites contain notes, recordings, or videos from lectures and workshops. One student commented: “I think it’s good that there is so much information on the intranet, and it would be good if all the stuff we learned about was up there so you could look at it again.” However, when students were asked if they were aware of who was responsible for health issues within their institution, 43% could name a point of contact.

When asked if they felt that their institutions were doing enough for their health and wellbeing, only 22% responded “yes.” However, 93% of students questioned stated that health and wellbeing was important to them, commenting: “if you haven’t got your health, you haven’t got your career,” “when you are healthy you find performing easier and can play to a higher standard,” and “awareness of health and wellbeing is essential in order to be able to perform to your best abilities.”

DISCUSSION

This investigation has shown that conservatoires provide a wide range of health and wellbeing information to their students through both timetabled provision but also through less formal individual education. Although a wide variety of activities and support for health and wellbeing issues were found to be offered to students, the level, content, and delivery of this provision varied greatly between institutions. Each conservatoire uses the resources and facilities readily available to them and maximizes the use of local specialists and passionate members of staff as driving forces to their work. The services available are therefore reliant on these resources and are influenced by other issues such as timetabling, funding, student support, and logistics. This reveals that, as yet, there is no united front within British conservatoires in disseminating information on health and wellbeing issues to students. This investigation has revealed that students do not feel that they are getting the full benefit of health and wellbeing provisions within their institutions, provoking the questions of whether or not the topic should become an integral part of a curriculum, the extent to which conservatoires should take a proactive role in preventing injury, and the importance of science in a musical setting.

Creating a set of coherent and organized goals for health and wellbeing education would offer both students and staff a more structured approach to an essential topic. Ensuring that students have adequate training in how injuries may be prevented, how they might detect the onset of injury, where they go for treatment of an injury, and how they are supported back to recovery is essential. Having consistency in comprehensive education and injury support would allow students to study in an environment comparatively free of concern over injury and leave their institutions with a set of skills central in a professional career.

Students have expressed within this study their belief in the importance of education in health and wellbeing matters. Students have also stressed the importance of raising awareness of topics relating to injury, including both the prevention and treatment of playing-related disorders. For this kind of information to be successfully interpreted by music students, the role of the one-to-one teacher should be carefully evaluated. Although creating effective learning plans within the curriculum may be very beneficial, it is one-to-one teachers who have the most influence on the practical usage of techniques. Without the involvement of these teachers in health and wellbeing education, the topic may struggle to be translated into useable, practical techniques.

Acknowledgments

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Evidence of noise-induced hearing loss among orchestral musicians

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An assessment of hearing thresholds among student orchestral musicians was carried out at the UCL Ear Institute in conjunction with the Royal College of Music (RCM). Audiogram data taken from 162 students (86 F, 76 M; mean age=23.7 years, SD=4.8) showed a statistically significant notch at 6 kHz in the left ear, indicative of noise-induced hearing loss (NIHL), but no significant notch was found in the right. Noise exposure asymmetry did not appear to account for notch asymmetry as trombone and trumpet players showed evidence of the same left notch trend as lateralized instruments such as violin and viola players. The earliest audiometric indicator of impending NIHL for musicians may be a developing hearing threshold notch at 6 kHz in the left ear.

Keywords: noise exposure; hearing damage; musical performance; orchestral musicians; music students

Both musicians and non-musicians are susceptible to work-related hearing damage from sound, but unlike other professions, the sound musicians create is not a by-product of their work—it is their product. This distinction makes musicians a difficult special case when it comes to determining what noise regulations should apply to them. Although studies have detailed noise-exposure for many professions including musicians (e.g. Taylor *et al.* 1965), relatively little is known about how the “noise” of music affects student musicians’ hearing (for reviews, see Royster *et al.* 1991; Fearn 1976, 1993; Lee *et al.* 2005).

In this article, we report our measurements of hearing thresholds in a large cohort of young orchestral musicians.

METHOD

Participants

One hundred and sixty-two RCM students (86 F, 76 M; mean age=23.7 years, SD=4.8) participated in the audiogram study over two years, from 2007 to 2009.

Procedure

Participants completed a consent form and then went through standard clinical audiometric testing. They were subsequently asked to respond to a survey detailing their noise exposure.

Audiogram measurements were made with participants comfortably seated in a soundproof room. A recently calibrated (June 2006, June 2007, and June 2008) Kamplex KC 50 audiometer with TDH-39 earphones were used for the standard audiometric frequencies 125, 250, 500, 1k, 2k, 4k, 6k, and 8 kHz; high frequency headphones were used to measure 10k, 12.5k, and 16 kHz. A manual Hughson-Westlake procedure was used with 5 dB resolution for most subjects, but some were done with finer (3 or 1 dB) resolution around areas of particular interest.

Audiogram corrections

Audiogram data were age-corrected using ISO 7029:2000 in order to remove age effects and leave only noise-related effects (in this case, the removal of age effects did not have an impact on the qualitative results, as the cohort was all young musicians of similar age, range=19-36 years). Accounting for age effects above 8 kHz is not supported by the standard, so for 10, 12, 12.5 and 16 kHz age effects were first estimated by extrapolating the mathematical coefficients used in the ISO standard linearly and then calculating and removing those extrapolated effects of age.

Audiometer calibrations were initially carried out according to ISO 389, but since Lutman and Qasem (1998) reported that this calibration procedure—specifically the pairing of the THD39 or TDH 39P headphone with the specified IEC 303 coupler—creates a resonance that can artificially increase thresholds at 6 kHz, we re-calibrated the audiometer using an IEC 318 coupler. We indeed did discover an artifact that would have increased thresholds at 6 kHz by 3.4 dB in the right and 2.4 dB in the left. This artifact was removed from the data retrospectively. We compared our corrected data with an independent data set taken from students from the Royal Academy of Music (RAM) using headphones that do not have any known artifacts and found

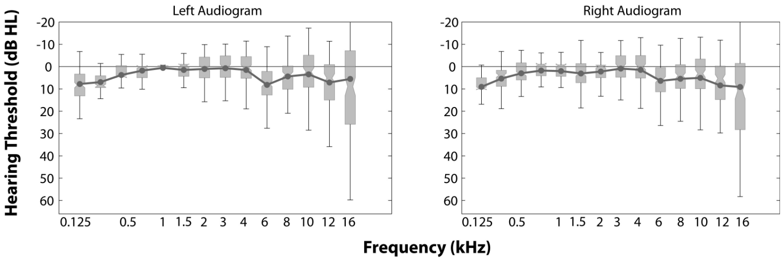

Figure 1. Summary of hearing threshold levels (dB HL) from audiograms taken from RCM students. Boxes extend from lower quartile to upper quartile with median hearing level demarked as the center of a notch; whiskers show extent of the contiguous data (minus outliers). The average of the data is plotted as a thick line. Notches in the interquartile boxes display the variability of the median between samples. The width of a notch is computed so that box plots whose notches do not overlap have different medians at the $p<0.05$ significance level. The 6 kHz threshold notch for the left ear was statistically significant. No significant notch was found for the right ear.

the two sets agreed in all statistical aspects, indicating that our correction was successful. (The RAM data will be presented in conjunction with these data in a subsequent paper.)

RESULTS

Audiogram data (Figure 1) from the young musician group showed a statistically significant threshold notch at 6 kHz in the left ear, indicative of noise-induced hearing loss. A Wilcox signed rank test showed the median threshold at 6 kHz was statistically higher than the median from either the 4 or 8 kHz tests ($Z=-6.37$, $p<0.001$, and $Z=-4.52$, $p<0.001$). Further, paired t-tests indicated that the mean threshold at 6 kHz was significantly higher than thresholds taken at 4 kHz or 8 kHz ($p<0.001$ for both). The right also showed that the 6 kHz threshold departed significantly from 4 kHz, but there was no significant difference between 6 and 8 kHz thresholds and therefore no significant notch.

A comparison of two subgroups, trumpet/trombone players versus violin/viola players, was carried out to see whether noise exposure asymmetry—with violin and viola players assumed to get more exposure in their left ears—could account for the asymmetry we saw in the overall audiogram data. We found, however, that both the trumpet/trombone subgroup and the violin/viola subgroup showed the same trends as the entire group data (cf. Fig-

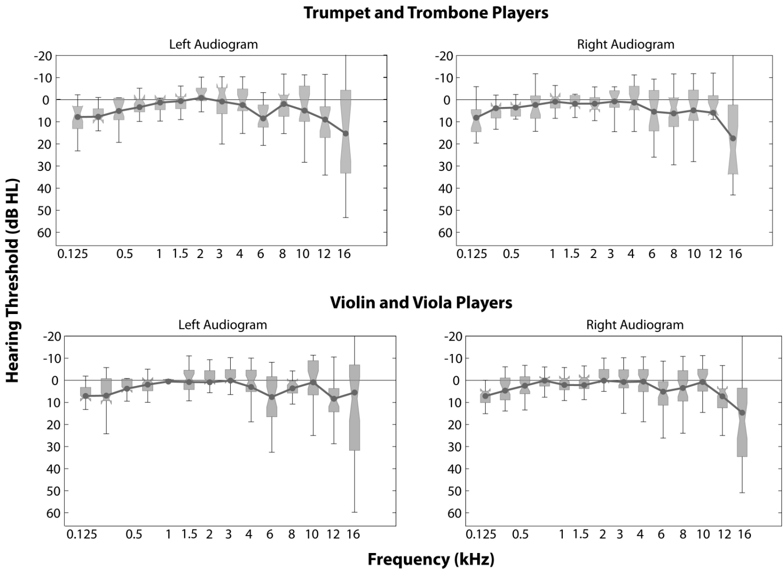

Figure 2. Summary of hearing threshold levels (dB HL) from audiograms taken from 20 trumpet/trombone players (top panel) and 37 violin/viola players (bottom panel), demonstrating that trumpet/trombone players exhibited notches at 6 kHz preferentially in the left ear. Boxes extend from lower quartile to upper quartile with median hearing level demarked as the center of a notch; whiskers show extent of the contiguous data (minus outliers). The average of the data is plotted as a thick line. Notches in the interquartile boxes are centered at the median and display the variability of the median between samples. The width of a notch is computed so that box plots whose notches do not overlap have different medians at the $p<0.05$ significance level.

Table 1. Average hearing threshold levels (dB HL) for 4, 6, and 8 kHz from audiograms from (1) the entire musician group, (2) 20 trumpet/trombone players, and (3) 37 violin/viola payers. All groups show similar trends, with higher thresholds in the left ear at 6 kHz and perhaps higher thresholds in the right ear at 8 kHz. These factors combine to form a more visible notch in left-ear audiogram traces, such as those in Figures 1 and 2.

	Left ear			*Right ear*		
	4 kHz	*6 kHz*	*8 kHz*	*4 kHz*	*6 kHz*	*8 kHz*
All musicians	1.32±0.63	8.02±0.74	4.25±0.75	1.46±0.72	6.41±0.82	5.48±0.92
Violin/viola	3.05±1.39	7.56±1.81	3.63±1.11	0.57±1.20	5.14±1.33	3.44±1.48
Trumpet/trombone	2.57±2.16	8.63±2.43	2.08±1.81	1.98±2.31	6.03±2.31	6.80±2.37

ures 1 and 2), with the left ear being more likely to display a "notch" at 6 kHz. The notch was more likely to be salient in the left because: (1) hearing threshold levels at 6 kHz were generally higher (but not statistically higher, $p=0.15$ in paired t-test) in the left than in the right and (2) hearing threshold levels at 8 kHz were generally higher (but not statistically significantly higher, $p=0.29$ in a paired t-test) in the right ear (see Table 1).

DISCUSSION

Our audiogram data reveal a statistically significant notch in the left ear at 6 kHz across the group of young musicians—a potential hallmark of noise-induced hearing loss—but interestingly, no such notch appeared for the right ear data. We initially suspected that this asymmetry, clearly apparent across the whole group, may have been caused by a subgroup of violin/viola players who receive higher levels of sound in their left ears. However, data for this group alone did not show a preponderance of the asymmetry. An established body of literature suggests that there may be differences in the physiological susceptibility of left and right ears to NIHL (Watson 1967). Exactly what type of differences could account for the asymmetry is still a source of speculation. For example, it is possible that olivocochlear efferents are stronger on the left side or that there is a difference in the middle ear reflex between the two ears (Nageris *et al.* 2007). It is also interesting to note that many reports indicate that TEOAEs appear to be stronger in the right than in the left ear in infants (Keefe *et al.* 2008). It should be noted that in many of these studies the right ear is tested first, which could account for the asymmetry by producing an efferent response prior to the subsequent left ear test.

In conclusion, the earliest audiometric indicator of impending NIHL for musicians may be a developing notch at 6 kHz in the left ear.

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Strategies for the pianist to enhance the artistic quality of piano recording

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The dream of every pianist is to perform in an environment that enables a work to unfold naturally and effortlessly. This, however, does not happen often. Much less so in a studio environment where, compared with the regular concert setting, we have to consider additional sets of issues related to the process of recording in order to achieve a recorded result that meets as closely as possible the player's artistic intentions. This paper suggests some of the strategies that proved to be effective in enhancing the artistic quality of a piano recording.

Keywords: piano performance; piano recording; music interpretation; artistic quality; classical music

When performing, pianists can listen and evaluate only from their position at the keyboard. As for any further assessment and feedback, one can listen to a recording after the event. But how faithful is it?

Pianists are often surprised on hearing a playback of their performances. They frequently remark that the recording does not necessarily match their perception of certain aspects of their interpretation. Vladimir Ashkenazy once remarked in an interview:

> In a recording studio, the difference is what finally gets onto tape, depending on the properties of the acoustics and given piano. What happens very often is that what you hear on a playback is not exactly what you thought you played, so you have to adjust. Then in the process of re-recording, you have to have the results that will have the meaning that you have inside you (Noyle 1987, p. 10).

It is also commonly recognized that an interpretation that proves successful in a concert performance does not always have equal success in a recording studio. Claudio Arrau put it this way:

> Things that work in performance are sometimes not good on records and vice versa. Recording has its own laws—that's why I am not very much for the recording of live performances (Dubal 1997, p. 7).

From the pianist's point of view, the dry acoustics often found in studios, the nature of the piano, the lack of audience, and the recording set up are all factors that impact upon the way a recorded performance is perceived. Although the set of issues surrounding each performance in a recording session is very complex, we have to learn to deal with them. But how can we adjust our technical and musical approaches in order to create a recording that represents a faithful image of our interpretative ideals?

This paper explores some of the factors that influence the quality of the artistic product achieved in a recording studio. It considers technical, musical, and conceptual adjustments that a pianist can make in order to achieve a recorded performance that represents a faithful image of his or her interpretative ideals. Due to space limitations, only three case studies will be presented. These have been selected either because they are unlikely to be encountered in a regular concert performance or because they are intriguing with respect to the ways in which recording equipment processes certain details of interpretation.

METHOD

Participants

The project is being conducted with the assistance of Kevin Roper, Senior Music Producer with the Australian Broadcasting Corporation (ABC) in Adelaide. The pianist was Marija Bajalica.

Materials

Recordings used for this research were made at the studios of the ABC in Adelaide. The piano used was a Steinway Grand, model D, which was one year old at the time of the first recording.

Procedure

The investigative method consists of professionally produced studio recordings and a series of home recordings. The chain of recordings begins with a studio recording followed by a number of home recordings prior to a second studio recording. Each is used as a reference point for the next recording of the same work. Recordings are evaluated against the following variables: tempo, timing, agogics, dynamic range, articulation, pedaling, and voicing. Evaluations identify the extent to which the recorded material speaks truly to a desired interpretation. Once the evaluation has been made, strategies are developed and implemented in preparation for the next recording session. The home recordings have proved to be useful in facilitating a quicker and better result during the studio sessions. Specifically, they have assisted in resolving matters of tempo and tempo relationships. We noticed that certain types of articulation (such as a specific way of creating legato) or particular approaches to pedaling work for recording regardless of acoustics or the nature of the instrument. This gives the pianist a clearer picture of what to do while working on repertoire and preparing for a studio recording. It induces greater confidence and a better chance of creating a successful recorded product in a shorter period of time.

RESULTS

The first case study is the *Allegro* from Mozart's *Sonata in B flat KV570*. The theme in the lower voice in Figure 1 is broad and flowing and needs to be crafted into a single thought.

The first recording revealed inconsistencies in sound quality within this phrase (specifically in bars 102 and 106). The sudden disjunction in tone between the D eighth notes and B quarter note in the lower voice made it sound as if the theme was being performed on two different instruments.

To achieve the desired unity of expression, it was necessary to suppress the multiple personalities found in this particular register of the instrument. In order to achieve this, an unusually "lazy" legato was used, providing more time to blend and disguise the different tonal characters. Since no pedal is used in this section and microphones were positioned reasonably close to the strings, there was a concern that longer overlapping of the fingers would become noticeable on the recording, yielding distasteful and stylistically inappropriate results.

The recording made during the second studio session did not reveal this to be an issue. Neither the acoustics nor the microphones recognized the lazy legato technique as an inadequate one. The disjunctions in sound were mini-

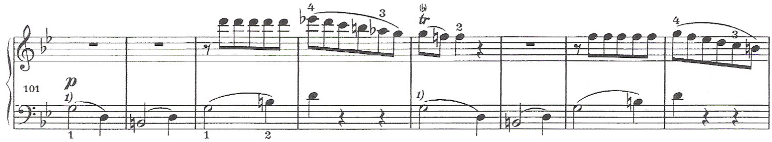

Figure 1. Allegro from W.A. Mozart's Sonata B*b* Major KV 570 (bars 101-108).

Figure 2. Allegretto from W.A. Mozart's Sonata B*b* Major KV 570 (Bars 1 to 5).

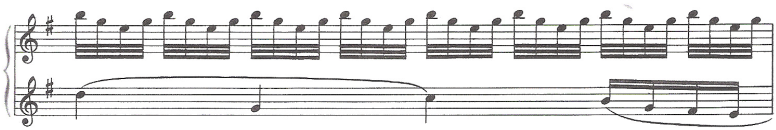

Figure 3. Andante dolente section of Juliet's Girlhood from Prokofiev's Romeo and Juliet Suite for Piano Op. 75 (bar 82).

mized and the legato that was achieved sounded rather like a cello. With fewer disturbances in the lower voice, rests in the first voice became transparent, providing a clear entry of the melody in the upper voice.

The second case study is from the third movement, *Allegretto*, of the same Sonata, shown in Figure 2. The light-hearted, even irresponsible character of the theme dominates this movement. To complement its mood, the pulse unit should be treated in a leisurely fashion, but with no delays.

The initial feeling after the first recording was that it had achieved the right pulse and that the variety of detached notes were properly felt and executed. Subsequent evaluation, however, concluded that the differences between finger staccato, hand staccato, and all different articulations from portato to staccato could not be clearly distinguished. This compromised some of the shades of expression that were being sought. Furthermore, a certain amount of sostenuto can be heard in the theme that was not obvious at the time of playing. This can be attributed to the splashing acoustics of the hall that did not allow staccato notes to clear in time for the next to proceed.

Attempts to hear the end of one tone before producing the next ended in creating impression of sostenuto, which was undesirable for this movement.

The general conclusion from the first recording of the *Allegretto* was that the attempt to engage with the acoustics and large proportions of the hall did not result in the type of sound that was desired. The recording equipment captured the initial moment that the sound was produced but very little of its full journey. Therefore the decision was made that the next recording of the same piece would explore the accustomed interpretation without any spontaneous adjustments provoked by the studio environment. There is a sense in which this is counterintuitive as pianists routinely make fine adjustments in response to what they are hearing.

The follow-up session proved that this was an extremely difficult and awkward task. The second recording did, however, achieve something much closer to a desired interpretation of the work. Its character is now supported by an appropriate variety of articulation, and an effective pulse enables detached notes to speak freely yet coherently.

The third case study is the *Andante dolente* section of *Juliet's Girlhood* from Prokofiev's *Romeo and Juliet Suite for Piano Op.75*. It implies, for the first time in the suite, a tragic conclusion to the opus, a shadow forming over Juliet's portrait. While shifting away from the rest of the piece, it speaks through a dimmed tone of voice in the theme of the left hand (see Figure 3) and a continuous vibration in the upper register.

In the first recording, the *Andante dolente* achieved its *tranquillo* state to a certain extent. Some mild finger action was employed in executing the thirty-second notes in the upper voice. The recording revealed that the microphones picked up every bit of that action so that the mechanics of the piano (the hammer action in particular) became overwhelmingly present in the sound. Consequently, the right hand passage sounded more as a work of labor and less as a continuous vibration. Along with it, the lower voice had lost its peace. Dynamics in this section were very well balanced, so the main concern for the re-recording session was the substance of the tone.

To project this section more successfully, the voices had to become more specific in shades of expression. The lower voice required a somber quality of tone, while the upper needed to achieve the effect of an inevitable and continuous occurrence.

Issues regarding the melody were resolved by voicing. The somber color of tone can be obtained by feeling the key motion with greater sensitivity so that any fast contact with the bottom of the key is avoided. By making a very slow and controlled descent to the bottom of the key, the moment and the place of the birth of the tone becomes uncertain. Supported with the right amount of sound, the gloomy and somber effect is achieved.

To eliminate the intrusion of the hammer action in the right hand sound and to accomplish the effect of vibration, finger action needs to be minimized. The sound should be produced by a swaying of the weight over the keys, employing as little finger movement as possible.

This method was easier to implement than in the case of the Mozart work, as it utilized only recognized pianistic skills. In fact, the acoustics of the hall worked to the benefit of the piece and were of great help in the delivery of the final product.

DISCUSSION

This paper addresses a set of issues that has been remarked upon by many professional pianists but which has escaped serious, structured attention. It identifies particular technical and artistic approaches that enable the pianist to make the transition from concert hall to recording studio without compromising artistic outcomes. The first case study confirms that subtle changes in articulation can be made to counteract tonal irregularities between registers. Such irregularities would go unnoticed in the concert hall but become magnified in a recording. The second case study established that focusing attention on the immediate sound feedback received from within the piano (rather than from the acoustics of the hall) could be a key to a successful recording. The final example concludes that studio recording requires much greater sensitivity towards the key motion if traces of the hammer action are to be cleared from the recorded sound. In cases where subtle shades create an essence of the tone, this proved to be a crucial issue.

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Analyzing and representing Transylvanian village music by using motion capture

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Techniques based on motion capture can be useful to analyze and transcribe a foreign musical system: Transylvanian village music. Two musical parameters were the object of study: rhythm and desynchronization between two performers, a violinist and a viola player. Results showed that rhythm is a local variant of the *aksak* system and is based on two duration units (S=short, L=long), which respect the formula ${}^{2}/_{3}<{}^{S}/_{L}<{}^{3}/_{4}$. Performances are characterized by large deviations of the ${}^{S}/_{L}$ ratio from period to period, which have an expressive function. Deviations are related to a swinging interpretation, consisting of a voluntarily desynchronization between the performers.

Keywords: ethnomusicology; Transylvania; gesture; rhythm; desynchronization

Analysis and transcription of non-western music has always been a controversial subject in ethnomusicology (England 1964). The Western musical theory and notation system are often unadapted to describe musics of oral traditions that rely on different concepts of rhythm, scale, interval, etc. which are often implicit. For this reason, ethnomusicologists have progressively developed specific techniques in order to analyze and represent formal proprieties of the music they study (Rouget 1981). Emerging technologies based on motion capture offer new possibilities for a deeper understanding of music production and perception (Leman 2007). The main idea underlying the present study is that these techniques can be particularly useful to analyze and represent Transylvanian village music.

Two musical parameters of the *de meseli* or *de jale* repertoire ("table songs" or "songs of sorrow") were the objects of study: rhythm and desynchronization between two performers, a violinist and a viola player. These parameters are particularly apt to be studied by motion capture because they are directly related to body movements. The metrical-rhythmical system of these slow listening tunes belong to the family of *aksak* (from the Turkish "lame") rhythms, which have been documented in different parts of the world and especially in Turkey and the Balkan region (Brăiloiu 1952). A rhythm is an *aksak* when (1) it is periodical and (2) each period is composed by the combination of two duration units (short=S and long=L), which are in a ratio of $^{S}/_{L}={}^{1}/_{1.5}={}^{2}/_{3}$ (Brăiloiu 1952). *Aksak* rhythms are usually indicated by the series constituting the period, for example 2.2.3, 2.3.2, 2.2.2.3, etc. The repertoire concerned here is characterized by a 2.3 period. *Aksak* has been at the center of controversial debates in French ethnomusicology, and there is no agreement on the way to theorize it (in terms of an irregular bichrone beat, or of an underlying monochrone beat; see Arom 1992, Bouët 1997, Cler 1994, Cler and Estival 1997). Rather than with theoretical matters, the present study deals with a concrete issue: precise measurement of the $^{S}/_{L}$ ratio, which is an important indicator of how the *aksak* model is locally conceived by musicians. A related issue concerns deviations of $^{S}/_{L}$ ratio from norm values in live performance. Our hypothesis is that *aksak* deviations are related to a swinging effect, consisting of a voluntary desynchronization between performers.

METHOD

Participants

Two professional gypsy musicians from Ceuaş, a small village of the Tîrgu Mureş region, were invited to the INSERM Laboratory of the University of Burgundy. They are among the best (and last) interpreters of Transylvanian village music, were born in 1953 and 1951, and have played together since they were children. Csanyi plays the melody on the violin and Csangalo the rhythmic-harmonic accompaniment on the *contră*, a specially prepared viola with three strings tensed on a bridge with a flattened curve, tuned A-D-G.

Materials

The movements of 38 retroreflective markers (15 mm in diameter), placed at various anatomical locations on the body, were measured using an optolectronic device, Smart (BTS, Milan, Italy). Six infrared-emitting cameras were attached to six tripods, 2 m from the ground on each side of the subject, at a distance of 3 m from each subject's body. In this experiment, the motion of only two markers was analyzed—that is, the ones located on the top of the bows. Kinematic parameters in three dimensions (X, Y, and Z) were calculated from successive frames taken at 10 ms intervals. Kinematic variables were low-pass filtered using a digital second-order Butterworth filter at a cut-off frequency of 5 Hz. Sound was recorded separately and the session was filmed with two additional standard cameras. Synchronization between sound and image was obtained by using a clapper board equipped with two additional retroreflective markers.

Procedure

Musicians were standing at the center of a circular region surrounded by the six infrared cameras. They were asked to play 30 s fragments of six tunes issued from the local *de meseli* repertoire. One tune (Duo14, test melody) was played 3 times (Duo12, Duo13, and Duo14). The session lasted about 3 hours and musicians, who are used to much longer musical performances, felt comfortable in the experimental setting.

RESULTS

Figure 1 shows the rhythmical pattern obtained by tracking the marker positioned at the top of the viola bow on the Y dimension. The periodical cycle of the *aksak* rhythm is clearly recognizable. The short (S) and long (L) durations for each period were obtained by measuring the time interval between one pick and the next. The picks indicate a change in the bow direction, corresponding to the beginning of a short rhythmic unit (superior picks) and of a long rhythmic unit (inferior picks). This measure was obtained with a margin of error of ±7 ms. For the test melody (Duo14), short and long durations vary as follows: 1.05 s≤S≤1.127 s, and 1.541 s≤L≤1.817 s. The mean value of $^{S}/_{L}$ ratio for Duo14 is 0.7 (corresponding to $^{S}/_{L}={}^{2.2}/_{857}$, if S=2 as in *aksak* convention), and varies largely from period to period in the same performance ($^{2}/_{3.044}\leq{}^{S}/_{L}\leq{}^{2}/_{2.448}$). The mean values of $^{S}/_{L}$ ratio for the three performances of the same melody are very similar: $^{S}/_{L}$=0.695 for Duo12 and 0.696 for Duo13. Finally, for all 8 melodies the proportion $^{S}/_{L}$ respected the formula: $^{3}/_{4}\leq{}^{S}/_{L}\leq{}^{2}/_{3}$ (see Table 1).

Desynchronization was analyzed by superposing the movements of the violin bow (melody) with those of the viola bow (accompaniment) (Figure 2 top). These patterns were projected on a stave to obtain a musical transcription (Figure 2 bottom). Musicological analysis linked the notes of the melody

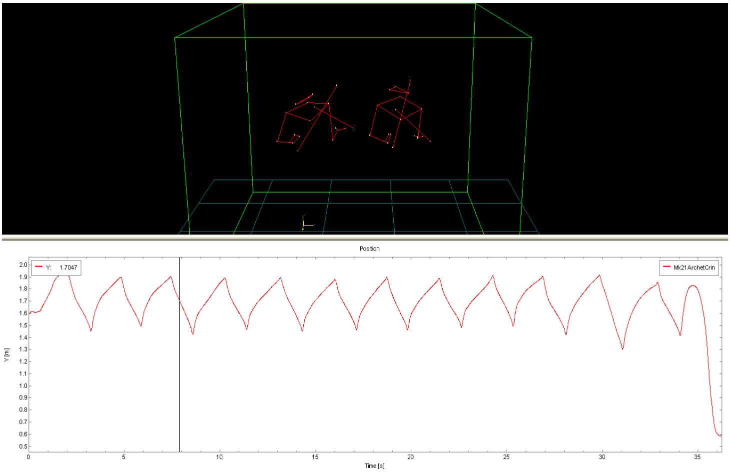

Figure 1. SMART viewer window. Top: Musicians' virtual silhouettes (violinist left, violist right). Bottom: Rhythmical pattern of Duo14, obtained by tracking the marker positioned at the top of the viola bow on the Y dimension. (See full color version at www.performancescience.org.)

Table 1. $^S/_L$ mean values for eights de meseli tunes (Duo12, Duo13, and Duo14 are different performances of the same tune). Aksak ($^2/_3$) and $^3/_4$ ratio are included in the table for comparison.

	Ratio $^S/_L$ (mean)	*Rhythm (S, L)*
Aksak norm	0.667	2.3
Duo12	0.695	2.2, 878
Duo13	0.696	2.2, 874
Duo14	0.700	2.2, 857
Duo18	0.735	2.2, 721
Duo19	0.679	2.2, 946
Duo20	0.689	2.2, 903
Duo21	0.687	2.2, 911
Duo22	0.729	2.2, 743
3.4	0.750	2.2, 667
Mean value on 8 tunes	0.701	2.2, 853

with the expected chords of the accompaniment (Figure 2 bottom). What emerges is a desynchronization between the two performers at almost each period: melody both anticipates and follows the relative chords.

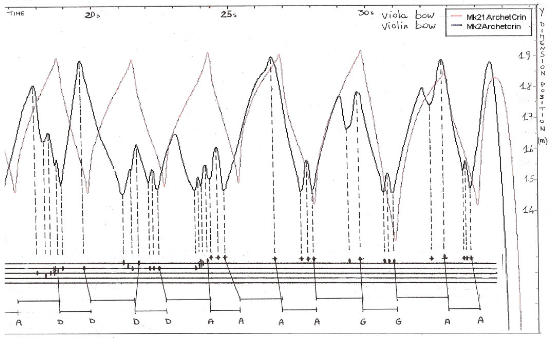

Figure 2. Top: Superposition of violin and viola bow movements for Duo14 (extract). Bottom: Transcription of melody (violin bow) and harmonic-rhythmic accompaniment (viola bow) obtained from changes of bows directions. Lines linking melody to accompaniment highlights desynchronizations between the two performers.

DISCUSSION

Motion capture technologies have been used here to study two parameters of Transylvanian *de meseli* repertoire in live performances: rhythm and "swing," defined as the desynchronization between melody and harmonic-rhythmical accompaniment. The tracking of only two markers (positioned at the top of the bows) allowed us to obtain easy readable representations of (1) *aksak* rhythmical patterns and (2) type and degree of desynchronizations. These gesture-based representations served here both as a measuring tool and as a support for musicological analysis and transcription.

While measures have been done for Turkish village music (using a sound analyzer, Cler and Estival 1997), to our knowledge Transylvanian *aksak* repertoire has been analyzed only qualitatively (Bouët 1997). In relation to a similar repertoire as the one concerned here, Bouët (1997) raised the problem of determining if musicians conceive the rhythm in terms of an "orthodox" *aksak* (2.3) or of a "heterodox" *aksak* (3.4). Results showed that the rhythm concerned here is between the two: the *de meseli* repertoire is based on a local variant of *aksak* characterized by the function $^2/_3<^S/_L<^3/_4$.

Deviations from norm durations, which are generally linked to expressivity in live performances (Gabrielsson 1995), were found. While in the case of turkish *aksak,* Cler and Estival (1997) described a stability of $^S/_L$ deviations along the entire performance, our results showed that they vary widely from period to period. This difference may be attributed to the different social function of the repertoire studied. Transylvanian listening tunes, as opposed to Turkish dance tunes, may leave to the performers more liberty in rhythmical deviations. We advanced the hypothesis that these deviations in *aksak* proportions are related to a swinging interpretation, intended as a desynchronization between the two performers. Motion capture, associated to musicological analysis, attested the large presence of desynchronizations between melody and accompaniment, which suggests that they are introduced voluntarily. Further research is needed to confirm if *aksak* deviations and desynchronizations are systematically linked and in which manner they depend from the musical structure of the *de meseli* tunes.

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Studying a score silently: What benefits can it bring to performance?

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Mental practice and analysis can be considered as efficacious and useful for performers, as they help them to develop a mental representation of music. This paper discusses what information in the score is potentially useful in developing performance expertise, and how performers can and do utilize it. First, we are concerned with the process of learning and performing a new score and, in particular, in which stages of this process performers find mental practice and analysis with the score useful. Second, we explore what information can be learned from the score before it is performed, i.e. what sort of cognitive representations the performer can obtain from the score. Third, we ask how performers can organize and use that information, i.e. the benefits of mental rehearsal in the attainment of performance excellence. These questions will be addressed through the statements of psychologists, teachers, performers, and musicologists in the relevant literature.

Keywords: expert performance; notated score; cognitive schemas; mental rehearsal; analysis

Mental rehearsal is a cognitive process that complements physical rehearsal and helps lead to the development of performance expertise. For the performer, musical ideas are primarily registered in written notation, and mental rehearsal can take place with or without the score. Studying a score silently has benefits for musicians, and can enhance the quality of the eventual performance. Mental rehearsal with the score enables the musician to gain an understanding of the structure of the piece and to form coherent mental representations of it, including cognitive, auditory, and motor representations. As musicians become more experienced, they become better at interpreting and communicating musical ideas, and also better able to self-evaluate and to consider strategies of learning.

Mental rehearsal with the score is clearly connected with analytical study, and analytical insight no doubt interacts with the performance plan. Understanding levels of structure and hierarchical organization or categorization within various musical parameters, for instance, can help the performer's interpretation. Analysis connotes conceptual skills as well as allowing the improvement of perceptual and motor skills, in particular those related to an expressive performance.

MAIN CONTRIBUTION

Our focus is on exploring how we map the conceptual and perceptual structures in the music to cognitive mental representations through score reading. We will also explore the structure of the learning/performing process of a new score, in connection with the implied cognitive models, to understand better how it can inform performance through feedback.

Mental rehearsal as a learning strategy

Mental imagery has similarities to perception but occurs in the absence of an external stimulus, instead based on information in memory. It relies on internal representations, to which we ascribe specific meanings (Zbikowski 2007). Auditory representations are important in all stages of musical performance preparation, including sight-reading, recalling music from memory, and polished performance (e.g. Repp 2001). Lehmann and Davidson (2002) subdivided mental representations in performance into goal representations, production representations, and representations of the current performance.

Williamon *et al.* (2002) investigated how mental representations in pianists affected their recall of music. They found that pianists used longer practice segments and recalled larger sections of music in the later stages of practice, when they also became more able to shift their attention between different levels of the musical structure.

Through the process of learning contemporary music, Hill (2002) experienced the value of earlier mental practice, which he found was a way of understanding the musical implications of the piece: he writes, "as much as possible is learned before we take a work to the instrument. But the main aim of mental study is to liberate our musicality, to make sure that musical goals—not technical constraints—come first" (p. 143).

Hultberg (2008) described a qualitative and collaborative study with two instrumental students. The two students were able to identify certain complex strategies for exploring musical meaning, which were related to their previous musical education. Two different learning strategies were revealed, one giving

Table 1. The stage(s) of the learning/performing process of a new score when performers find mental practice and musical analysis with the score useful (n=75).

Stage	*Mental rehearsal*	*Analysis of the score*
Sight-reading the score for the first time	33	25
Exploring and getting to know the music	35	41
Becoming fully familiar with the piece	33	34
Playing the whole piece fluently and musically	26	21
Memorizing the piece	32	22
Trial performances	15	9
Other	2	2

priority to exploring structural aspects in the printed score, the other focusing on exploring the music while playing, i.e. auditory rather than visual.

An exploratory survey on performers' experience of mental rehearsal and the importance of music analysis in learning and performing a new piece is currently being conducted. Two questions are pertinent to this paper, and asked at which stages the performers tended to find these strategies most useful. Current results (data are still being collected) for mental practice and analysis are shown in Table 1.

As is apparent from the Table, mental practice is particularly useful right from before initial sight-reading up to memorizing the piece for performance. Score analysis was thought to be most useful while the performer is exploring and becoming fully familiar with the piece, but less so before sight-reading.

What we can learn from the score

At a basic level, we need to observe the global parameters of musical notation, such as clef, key signature, meter, and tempo. At an expert level, performers use knowledge of music theories (explicitly or implicitly) as techniques for obtaining information. According to Williamon *et al.* (2002), music theories present valid descriptions of the cognitive processes in music, they explain how sound is structured in musical contexts, they lead to understanding the underlying processes of mental representations, and they are "hierarchically sophisticated representational systems to describe human cognition" (p. 516). Some relevant music theories are outlined below.

Models of musical perception and cognition

Reductive theories (e.g. Schenker 1979, Lerdahl and Jackendoff 1983) reduce the piece to its underlying contrapuntal-harmonic structure. They can explain how listeners represent what is aurally understood in a piece of music. They may clarify a piece's structure, reveal how it was composed, and draw attention to its hierarchical levels. Harmonic region based theories (e.g. Longuet-Higgins 1987, Lerdahl 2001) evaluate harmonic distance, according to pitch relationships, and map the harmonic progressions along the entire musical piece. They account for sequential and hierarchical harmonic tension, voice-leading, and harmonic attraction. Like reductive theories, they can represent whole pieces of music graphically and succinctly.

Categorization theories (e.g. Deliège and Mélen 1997, Ockelford 2005) account for surface level events and their similarities, transformations, and derivations, and how these events can be categorized. Mathematically based theories (e.g. pitch-class set, see Forte 1973) allow the discovery of rules and their manipulation, explain permutations and combinations, and account for levels of structure, particularly in contemporary music. Descriptive theories explain and describe musical symbols and events along the score in a narrative way. They promote insight into the referential meaning of the piece and guide the aesthetic experience (e.g. Agawu 2009).

We can suppose that all the above theories, which talk mainly about how we represent the music we hear, can be applied to how we analyze the printed notation when we see a score. When expert musicians see a score, the analysis they do may involve hearing the music internally and understanding its structure, therefore creating an association between seeing and hearing.

How performers can utilize that information

The views of music psychologists, music teachers, expert performers (e.g. pianists and conductors), and musicologists can all shed light on the contribution of analysis to music performance.

Aiello and Williamon (2002) describe how mental rehearsal can allow performers to: describe and analyse music in terms of macrostructure and microstructure; learn the landmarks of the piece; and identify melodic and rhythmic patterns, closures, and points of tension and resolution.

In terms of pedagogy, Provost (1994) suggested that teachers should encourage students to sing new pieces they are learning and use ear training exercises, complemented by music theory, enabling more advanced students to develop all the skills needed to play a range of music at a professional level.

Mental rehearsal in expert pianists (Chaffin *et al.* 2002) and conductors (Battisti 2007) has been investigated and shown to contribute to the understanding of musical events, such as form, texture, and other musical dimensions. It also improves interpretation and memorization and provides knowledge of the piece's phrase structure.

According to Howell's (1996) musicological perspective of analysis, analysis enables us to go behind the surface detail and get an overview of the score. Through analysis, performers can become familiar with musical styles, produce informed and aesthetically satisfying interpretations, and better plan, execute, and evaluate general musical performances, including questions of emphasis, articulation, and technique (e.g. bowing and fingering). Analysis also enables performers to discover how different interpretations affect the listener's perception and understanding of the musical work.

IMPLICATIONS

The usage of mental rehearsal and analysis helps various aspects of performance practice, including sight-reading, audiation, memorization, and technique. It also has implications for pedagogy and teaching, by stimulating intellectual inquiry, creative interpretation, and improvisatory skills in the student. A good level of analysis implies expertise and helps performers to be versatile, not least by enabling them to create their own learning strategies, and to acquire a capacity for evaluation of their own (self-evaluation) and others' performances. It enables musicians to generate and use mental representations efficiently, and this aspect is a fundamental requirement to be an expert performer (Lehmann *et al.* 2007). Future studies will investigate the effects of expertise on strategy development.

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The learning cultures of performance: Applying a cultural theory of learning to conservatoire research

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As educational institutions that play a role in the training of many performers, conservatoires have increasingly become the focus of research. Researchers have explored the one-to-one lesson context, identified and tested means of achieving musical excellence, and worked to enhance musicians' health. There remains, though, little research that investigates the conservatoire as a learning site, characterized by a set of interactions between performer, institution, and music profession. Students learning at conservatoires, as well as teachers and researchers attempting to embed new pedagogical approaches or curricula, must negotiate an educational and musical system embedded in years of history: a system that has, in other words, a "learning culture." This paper explores the central tenets of learning culture as a theoretical approach, arguing that conservatoire research could benefit from a lens that views learning as inherently cultural. The methodological implications of learning culture are discussed, including the need for qualitative methods that seek interpretive understandings and in-depth, rich data. The paper concludes by offering implications for the application of learning culture within the field of performance science, addressing Jørgensen's (2009) call for increased research on the institutional culture of conservatoires.

Keywords: conservatoire; institution; learning culture; social practice; qualitative methodology

As educational institutions at the centre of the quest for "performing excellence," conservatoires have increasingly become the focus of research. Given its unique position within the higher education system, the one-to-one lesson has been the subject of plentiful enquiry, with focus given to student-teacher relationship, pedagogical approaches, and the "master-apprentice" model of learning. Recognizing the need to look beyond the individual classroom, researchers have more recently begun to identify and test means of achieving musical excellence (Williamon 2004), including strategies for enhancing practice (Jørgensen 2004) and enhancing the health and wellbeing of music students (Kreutz *et al.* 2009). Others have focused on assessment methods within conservatoires, pioneering new approaches that include peer assessment (Lebler 2008) and group assessment (Barratt and Moore 2005).

There remains, though, little research that investigates the conservatoire as a learning site, addressing what Jørgensen (2009) terms the under-researched "institutional culture." While Nettl (1995) and Kingsbury (2001) both consider aspects of institution and of culture in their work in the USA, their ethnomusicological stance steers them away from exploration of the interrelationships between institution, culture, and—crucially—learning. Conservatoire students, as well as teachers and researchers attempting to embed new pedagogical approaches, must negotiate an educational system embedded in years of musical, social, and institutional practices; what I will term "learning culture." Such practices will influence both the types of learning that are promoted or inhibited within conservatoires, and also the ways in which learners become socialized during their time at a conservatoire (see James *et al.* 2007). Knowledge of these practices offers scope for identifying challenges to effective learning and barriers to institutional change.

How, though, can research access practices (or cultures) that are often hidden, tacit, or deeply embedded in day-to-day life? This paper outlines a theory of learning culture, arguing that the conceptual and methodological angles that it brings to the fore offer scope for new understandings of the cultures of institutions that train students for performing excellence.

MAIN CONTRIBUTION

The term learning culture is not new to educational writing, yet there are relatively few attempts to conceptualize the term or to operationalize it as a theoretical tool. The exception is the work of James *et al.* (2007), who used learning culture as a means of accessing the complexity of further (post compulsory) education in the UK. At the center of their thinking is the definition of learning culture as the "social practices through which people learn" (p. 23). So defined, it is not simply the contexts within which people learn but rather the practices *through* which people learn, practices which "promote, inhibit or rule out certain kinds of learning" (p. 28). The key assumption here is that learning takes place in, and through, a cultural setting (Hodkinson and

James 2003). That is, if we are to meet the oft-posed challenge of "changing the culture," we need to look beyond the one-to-one lesson, practice studio, or concert platform to discover the practices that belie what *can* and *is* learned at conservatoires; "how different learning cultures enable or disable different learning possibilities for the people that come into contact with them" (James *et al.* 2007, p. 28).

As yet, learning culture has not been adapted for theoretical use in higher education institutions or in music education. While space limits a full conceptualization here, there are two central tenets to the theory as we consider its application to performance-based institutions:

- Learning culture incorporates, but is not bound by, institutional culture. Rather, it is bound by the broader fields (see Bourdieu 1984) in which the institution and its students and teachers operate. That is to say, knowledge of the practices at play in a conservatoire will come from research that seeks understanding of the lived experiences of learners as they move into, within, and beyond the institution. This includes learners' performance history, previous education, family, friends, gender, specialism, and so forth, as well as social and cultural interactions within the institutional setting. Operationally, this means taking a holistic approach to researching culture, recognizing that the institution plays a large but not exclusive part in constructing the practices through which performers learn.
- Learning culture is a complex amalgamation of agency and structure, assuming that individuals both shape and are shaped by the learning cultures of which they are part (James *et al.* 2007). Social space is not seen as an equal playing field but rather one in which people compete for resources (Bourdieu 1984). In the context of performance, for example, learners compete for recognition, the "best" teachers, performance opportunity, publicity, and so on. These sometimes obscured struggles occur within, and interact with, a complex web of power relationships and practices that both shape learning possibilities within a learning culture and that shape the way in which the learning culture itself develops. In order to uncover these interactions, researchers must embrace the complexity of culture, searching for knowledge that may be obscured or hidden in order to reach in-depth understandings that have the potential to inform institutional change.

Conceptually, then, learning culture focuses researchers on the practices through which performers learn, assuming that these practices will be both institutionally-mediated and constructed within the performer's own experiences and values. In uncovering these practices—or forms of learning—it becomes possible to (1) highlight complex enablers and barriers at play for young performers and the role that the institution plays in alleviating or consolidating these, (2) highlight institutional priorities and assumptions, and their fit with those of performance students and teachers, and (3) highlight cultural assumptions within a particular community or institution (such as a conservatoire), which can illuminate barriers to institutional change. Knowledge of what these practices are, and the roots of their construction, forms an important first step in understanding the culture of learning to perform, and the potentials for transformation of this culture.

Where does learning culture lead us methodologically?

Learning culture brings with it a host of methodological assumptions, all of which work to capture the complexity needed to research culture in this manner. First, it demands an epistemology that reflects the nature of knowledge as constructed in social space, shaping and shaped by cultural factors such as gender, class, instrument type, or institution. That is to say, post-positivist paradigms that seek explanation (often through support or rejection of a hypothesis) are rejected in favor of broadly constructionist stances that seek understanding of how people interact within, and with, their surroundings. This steers the researcher towards a qualitative methodology, with its emphasis on capturing the "nuance and complexity of the social situation under study" (Janesick 2000, p. 380). In taking a qualitative approach, attention is paid to the social world as it is understood by participants, actively seeking different interpretations of the learning culture in order to capture its complexity.

In particular, learning culture commits researchers to spending time in the field, working with ethnographically-informed methods to "reassemble the parts into the wholes from which they were originally taken" (Bloomer 2001, p. 430). The process of knowledge-construction includes a range of methods, most prominently interviews, participant documentation, observation, and document analysis, all of which span across learners, teachers, and management staff. In sum, taking learning culture as a theoretical lens requires the researcher to embrace the "messiness" of social life, using qualitative methods to make the hidden visible, and thereby shedding new light on the cultures in, and through which, performance students learn.

IMPLICATIONS

This paper has proposed learning culture as a theoretical lens for tackling the under-researched area of conservatoire culture. At the time of writing, fieldwork has been recently completed at a UK conservatoire, limiting this paper to a discussion of theoretical, rather than empirically-based, implications. However, the potential for new understandings is, I argue, two-fold. First, learning culture offers understanding of the "hidden" skills of performance; those that accompany the more frequently researched motor skills, psychological training, and physiological preparation. In assuming that learning occurs through social practice, learning culture emphasizes the skills involved in mediating the (often blurred) transition from student to professional, capturing ways of knowing and doing that are integral to the process of becoming a musician but that remain remarkably under-researched. Institutional practices such as criteria for orchestral selection, for example, or social practices such as peer networking, play a large but often sidelined part in performers' success. Knowledge of these practices has the potential to inform both student experience and institutional curricula, as conservatoires strive to offer competitive and world-leading preparation for performance-based careers.

Second, learning culture answers Jørgensen's (2009) call for further research focusing on conservatoires' institutional culture. Identified as an area where research is lacking, refrains such as "we need to change the culture" are not uncommon. Yet such statements are notoriously slippery, referring to practices that are historically located, influenced by wider policy agendas, and often fraught with divided opinion and inaction. In viewing learning as occurring *through* cultural practice, learning culture provides a theoretical lens that grounds cultural discussions in the core task of educating young performers. That is, institutional culture and the learning of performers are considered as inextricably intertwined and best understood as such. The first step to transforming culture may well be to understand it; indeed, in establishing performance science and its associated curriculum development within the conservatoire landscape, knowledge of the learning culture at play may prove a valuable tool.

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Musical narrative deconstruction: Ritual and transgression

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Envisaging musical narrative as a sequence of ritual structures, this research lies on the concepts of ritual, transgression, and narrative as applied in a case study of a musical theatre piece, *Sound Bridges*. In traditional musical narrative, the focus is on construction, and one could speak of fields around which hierarchies, systems, and rules of musical language are built. In this piece, we find unpredictable transgressive musical gestures, acted out by performers, combined with conventional narrative procedures, as successive musical suspensions in the piece generate pauses in the musical discourse. This research aimed to demonstrate that the concepts of musical narrative and ritual dimension cannot be seen as isolated objects but as entities of transformation by composers, and how the trilogy composer/performer/listener (audience) is associated with narrative and ritual. Ritual and transgression can thus be linked to traditional concepts of musical narrative connecting composing, performing, and listening activities. The concept of ritual can be successfully manipulated by the composer and the performer, particularly in the context of contemporary music. Transgression of ritual, as planned by the composer, can act as a deconstructive factor; as mediators, performers take a crucial role in the process.

Keywords: performance; narrative; transgression; ritual; deconstruction

The term narrative has been addressed differently in research fields such as literary studies, linguistics, aesthetics, and anthropology. In musical research, different approaches to narrative have been discussed (Almén 2008, Klein 2004, Maus 1988, Tarasti 1979), resulting in several reorientations of the concept: "…new consensus is developing about musical narrative that is aware both of the limitations of musical expression and of the rich potential of music as a narrative medium" (Almén 2008, p. 3).

All these studies shed light on an issue that can be observed through different angles, but "common to virtually all approaches to musical narrative is the recognition of a degree of similarity between musical and literary discourse" (Almén 2008, p. 11), a similarity that can be extended to theatrical discourse, since "narrative mechanisms native to one medium…frequently cross-pollinate with other media, resulting in complex semantic hybrids" (p. 38).

In music, the use of theatrical devices can enhance performance. They are also linked to ritual practices, a powerful idea that has been, and still is, applied to compositional works. In the context of theatrical and performance studies, this idea has been developed by authors such as Richard Schechner, and it remains a key concept in ethnomusicology studies: "Rituals are collective memories encoded into actions…. Play gives people a chance to temporarily experience the taboo, the excessive, and risky…. Thus, ritual and play transform people" (Schechner 2007, p. 52). If musical narrative is envisaged as a sequence of ritual structures, which involve an emotional attachment from the audience to the musical work, it then becomes one of the effects that a composer intends to produce in the listener, and the performer, as mediator, plays an essential role in this process.

This paper aims to demonstrate that the concepts of musical narrative and ritual dimension cannot be seen as isolated objects but as entities of transformation by composers, and how the trilogy composer/performer/listener (audience) is associated with musical narrative and ritual.

MAIN CONTRIBUTION

This research lies on the concepts of ritual, transgression, and musical narrative, as applied in a case study of a musical theatre piece, *Sound Bridges*. The study focuses on how musical gesture takes different meanings in the trilogy composer/performer/listener and discusses different concepts connecting the role of embodied ritual in performance, and its effects in the listener.

In traditional musical narrative, the focus is on construction, and one could speak of fields around which hierarchies, systems, and rules of musical language are built. In this piece, we find transgressive musical gestures, acted out by performers, combined with conventional narrative procedures, as the successive suspensions in the piece generate pauses in the discourse and challenge conventional hierarchical values. An effective non-verbal communication by the performers can mediate a narrative deconstruction of the listener's expectations, through the connection between musical gestures on the one hand, and musical narrative and ritual on the other.

Deconstructing musical narratives

In the words of Livingston (2008, p. 363):

> The content of the narrative includes not only a series of represented events, but actions whereby these events are presented to an implicit audience, as well as the agent(s) responsible for those actions. Narrative entails narrating which entails a narrator.

Therefore, we could extrapolate that in a piece of music we may speak about musical narrative, and the composer, the performer, and the listener are the participating agents: the composer as narrator, the listener as the audience, and the performer as the mediator. A composer sets up a narrative in an analogous way to a literary/theatrical work by establishing a close relationship between verbal and musical modes of perception.

Verbal and non-verbal events are often configured into various relationships, establishing a network of values that leads to understanding in the listener. If this network is broken, the awareness of the narrative processes can have an impact on the listener, as "narrative acts as a potential link to important aspects of human experience" (Almén 2008, p. 41).

Familiarity builds on our common understanding of things. When listening to music, our imagination constructs narrative contexts and/or discursive trajectories. Nevertheless, the incomprehension of a musical experience also creates barriers and splinters the construction of a continuous thought. The deconstruction of the individual narrative can be achieved through abrupt interruptions in the musical flow. In this paper, the concept of flow, taken from Csikszentmihalyi's (1988) concept of flow or optimal experience, is applied to the listener's perspective as an action that can be enjoyable and rewarding, creating understanding and individual sense of control.

The main objective of the musical theatre piece *Sound Bridges* is the narrative deconstruction of the listener's thoughts. Thus, we find unpredictable musical gestures that challenge conventional concert-performance rules, and cyclically return to traditional settings. The central idea is to create suspense, disruption, discontinuity, and rupture in the way the musical narrative fragments are perceived, breaking the traditional formal outline of the piece.

Non-verbal gestures and non-verbal communication clearly play an important role in music performance. Among the functions ascribed to non-verbal behavior, Highlen and Hill (1984, p. 368) point out that "behavior is a primary means of expressing or communicating emotions.... In relation to verbal behavior, non-verbal behaviors can repeat, contradict, complement, accent, or regulate meaning." Verbal and non-verbal communication helps to configure musical events into different categories that may organize musical narrative perception.

Verbal tools

The piece's title and the program notes are verbal communicative tools, which function as a direct way of transmitting an intention from the composer to the performer and to the listener, and engage them into a narrative strategy. Tempo indications, agogic and dynamics, as well as music theatre also function as means of verbal communication between composer and performer, and can act indirectly in the listener's perception of narrative.

Non-verbal tools

In non-verbal communication, we find both musical and physical gestures; in the case of this piece, it is through the music theatre genre that the composer develops a non-verbal form of communication. The use of several gestures (as described below) generates abrupt cuts in the musical flow. Composer, performer, and listener play several roles in this (de)constructed world. The composer challenges both performer and listener to accept an unconventional sequence of events. The efficacy of the piece requires the performer's engagement and willingness to adopt alternative behaviors.

Resorting to cuts as a dominant style, suppressing and subverting the traditional rules of musical writing are ways of intervening in the musical material, creating multiple sensations and experiences. The musical narration becomes discontinuous, compromising the linearity of the listener's musical thinking. The deconstructed musical narrative prevents the indifferent acceptance of the listener in an attempt to provoke reflection.

Ritual and transgression

Music theatre performances create ritual-like ways of expression. The trilogy composer, performer, and listener becomes deeply embedded with narrative and ritual. *Sound Bridges* was planned as a pre-ordered set of ritualized moments: six blocs of music, cyclically interrupted by compositional devices that break musical flow, disrupting the expected musical syntax. These compositional devices include: mobile ring tone, score pages out of order, players' cough, motionless and repetition, and leaving the stage. In explanation:

- Mobile ring tone: In concerts, turning off phones is a common ritual. Nevertheless the audience is willing to "forgive" the transgression.
- Score pages out of order: An uncommon, but possible, mishap. One friend, a member of the audience, comments: "Such bad luck! Maybe they should restart…."
- Players' cough: At this point some members of the audience realize that the interruptions may be intentional.
- Motionless and repetition: The performers stop, motionless, for 15 to 25 s; then they repeat the same phrase, over and over again. Most of the audience understands that the first three interruptions were planned and that the piece includes an intended transgression.
- Leaving the stage: One of the performers continues to play while the other two leave the stage.

Three different perspectives can be distinguished in rituals involving Western art music: performance, composition, and listening. It is possible to apply Schechner's (2007, p. 56) four perspectives of rituals and ritualizing—namely structure, function, process, and experience—to characterize the intervening "actors" (composer, performer, and listener).

Performers have to think about the manner in which they are going to present the ritual, how to use the given space, and most importantly how to enact that same ritual. In *Sound Bridges*, while acting and playing a role, performers momentarily become someone else, actors of the intentions inscribed in the score. Effectiveness is the prime concern, and entertainment is relegated to a secondary plane.

The ritual process used in composition involves the organization of performance concepts and imagined dynamics, namely meaning, modes of performance, choice of physical space, and performers. Composers also deal with the aspect of function and experience, projecting how the composition will impact performer and listener.

Listeners are also participants in the ritual action. van Gennep proposed a three-phased structure of ritual action: "the preliminal, liminal, and postliminal" (cited in Schechner 2007, p. 58). The liminal phase corresponds to "a period of time when a person is 'betwixt and between' social categories or personal identities" (p. 66). As pointed out by Schechner (2007, p. 66), during the "liminal" phase, participants in the ritual "become 'nothing', put into a state of extreme vulnerability where they are open to change." Turner (1969) used the term "liminoid" to distinguish voluntary activities (including the arts and popular entertainment) from "liminal," which refers to rites of passage. Applying this concept to *Sound Bridges*, we can assume that listeners lose their individual voice in order to accept a new musical narrative deconstruction.

IMPLICATIONS

Music theatre can thus function as a relevant field for research of non-verbal techniques. Pieces written for the theatre can then be seen as a theatrical action that is generated and determined by the music; in *Sound Bridges* these theatrical actions, previously called blocs of music and interruptions, are generated by the music itself and allow for the deconstruction of musical narrative through ritualized forms of transgression. Ritual and transgression can be linked to traditional concepts of musical narrative connecting composing, performing, and listening activities. The concept of ritual can be successfully manipulated by the composer and the performer, particularly in the context of contemporary music. Transgression of ritual, as planned by the composer, can act as a deconstructive factor; as mediators, performers take a crucial role in the process, allowing the creation of multiple sensations and experiences in the listener.

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The piano repertoire preparation: A research method as a potential tool for reflective instrumental practice

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This paper presents a qualitative research method that was constructed to investigate how undergraduate piano students at different stages of their academic education prepared their repertoire during an academic semester. Three undergraduate piano students—a first semester, fifth semester, and eighth semester students—were followed during an academic semester using a phenomenological approach. For each of the three case studies, three data collection stages took place: the presentation interview, the observation of the repertoire under preparation, and finally, the observation of the student's recall of his own study process. Four complementary research techniques were employed: the semi-structured interview, observation of the performance of the music pieces, a non-structured interview about the repertoire under preparation, and a recall stimulated interview, in which the student reflected about his own performance recorded in video and audio in the previous sections. During the data collection, the methodology gave the undergraduate piano students the opportunity to develop reflective thinking. Instrumental and verbal testimonies have shown that the interviews afforded the students moments to show their thoughts and actions about their piano repertoire preparation. The students acted as active agents in their piano practice, demonstrating awareness of their weaknesses and strengths through self-knowledge.

Keywords: piano practice; musical knowledge; reflective thinking; qualitative research; repertoire

The literature has discussed progress made in instrumental practice research toward the understanding of concepts related to practice and the resources frequently used in instrumental practice contexts (see Williamon 2004).

There is a consensus in the literature that instrumental practice depends on the nature and context of the task, as well as on the interests and engagements of the student (see Barry and Hallam 2002, Gabrielssohn 2003).

According to Elliot (2005), students must reflect critically on the various levels of meaning in the musical works that they are interpreting and performing before, during, and after they make and listen to their music. Nevertheless, most of the research in instrumental practice has neglected to highlight critical and reflexive approaches toward epistemological issues that students may face in daily musical practice. In formal education, undergraduate instrument students are supposed to prepare a repertoire containing works from different styles within a given time, and they are to interpret the score while taking into account stylistic aspects, without losing creativity within narrow constraints. As Burnard (2006) pointed out, we should develop reflexive thinking more effectively in our professional practice, taking into account the potential for the use of this thinking in processes as a source of professional agency. Reflection involves forms of thinking that include: (1) continuous evaluation of beliefs, assumptions, and hypotheses (Burnard 2006), (2) nurturing of opportunities for intersubjective interactions, and (3) interdependent reflexive thinking to illuminate creative thought and action as a condition of the creative process.

In Brazil, the academic formation of undergraduate instrumental (piano) students comprises eight semesters. In each semester, the student must prepare repertoire composed of about three to five pieces by composers from different periods or styles. The present study took into account that undergraduate students present an epistemic relationship with the systematized experiences and with the normative patterns within the tradition of the occidental classical music, and this musical knowledge influences their practice through the preparation of their piano repertoire. The present paper is intended to contribute to instrumental teaching and learning by presenting a method constructed to investigate musical knowledge, which in turn is shown to be a potential tool for encouraging students to adopt critical and reflexive approaches toward their own practice.

METHOD

Participants

Three undergraduate students from the same institution (out of a total of 30 volunteers belonging to three universities in the south of Brazil) were selected: a first semester, a fifth semester, and an eighth semester student.

Materials

The students' piano repertoire in preparation during an academic semester was examined, under a phenomenological perspective.

Procedure

In this research, phenomenology was employed as a philosophical methodological principle for the construction of the object. According to Bowman (1998), the phenomenological method focuses on the experience. The phenomenological fundamentals represent an aperture toward the delimitation of the problem and the tools to set boundaries for data collection and analysis. The research was constructed in a qualitative interpretative approach, considering the following principles (Schawandt 1994):

- human action is considered significant and intentional
- the ethical vis-à-vis respect for the participants, as well as fidelity toward the student's own life experience
- the epistemological perspective that emphasizes the contribution of human subjectivity to knowledge

The collecting procedures involved four research techniques: the semi-structured interview, observation of the recorded performances (aimed at revealing some indices of tacit knowledge mobilized by the student that were not verbalized but could be demonstrated in the performance), a non-structured interview about the repertoire under preparation, and a recall stimulated interview, in which each student reflected on his own performances recorded on video and audio in the previous sections.

The observation of the repertoire under preparation was carried out during a university semester in which the collecting sessions took place every 2.5 weeks, with a total of four or five meetings. Interviews combining verbal testimonies and instrumental performances could be favorable for understanding how the repertoire was prepared during an academic semester, as well as for revealing consistent clues of mobilized musical knowledge during the preparation. These meetings aimed at monitoring and observing the preparation of the repertoire, reported by the student himself. The observation of the repertoire was carried out by combining two research techniques: a non-structured interview about preparation and practice and the observation of the performance of the musical pieces. In the non-structured interview, the questions came from information reported by the student, without imposing determined questions that did not deal with his personal experience at that moment. This attitude was based on phenomenology as a philosophical method. In the final part of the research, the stimulated recall interviews were conducted, focusing on the performances recorded during the previous sections. This stimulated interview at the end of the semester was used to avoid influencing the student during the repertoire preparation.

RESULTS

During the interviews, answers to questions regarding musical comprehension (verbal and instrumental) of the works under preparation revealed that some facts were tacit in nature. Often, while explaining our thinking (tacit), we identify and articulate several aspects in order to feel understood. In these situations, some ideas, perspectives, and thinking that remain latent up to that moment arise as possibilities for further reflections and decisions. This situation occurred during the interviews, when the communication and explanation of the student's own decisions, doubts, and certitudes to the researcher promoted moments of reflection. This happened, for instance, in the first interview of the fifth semester student, and he himself confirmed, by the end of the collecting period, one of our suspicions (NB. according to the fifth semester student, having to explain aspects of the repertoire preparation caused him to reflect after each interview):

> Reporting to someone prompted me to think more. And by verbalizing, new possibilities arose, which I continued to think about after the interviews.... I thought on the things I said, if it was right or not...or if I should explore that idea more.

Along with the data collection, several other occasions demonstrated that the interviews, since they implied moments of reporting their repertoire preparation, functioned as a catalyst for reflection upon students' strategies, their problems, and their conquests. Listed below are some excerpts from the students' comments.

The first semester student regretted his approach toward Bach's Fugue in the first recall stimulated interview. He said:

> This Fugue! I prepared the first page for almost four months.... In the exam, it was clear that the first page was good, and the others were inferior to the first one...! This would be unacceptable now! I need to read the whole piece, even though I cannot play it well. But I have to read it completely, to realize: Here I will need to spend much time!

The fifth semester student mentioned:

> I am realizing something now. Something that is becoming visible…. We have much accumulated knowledge. How many pieces we have studied, how many records we have listened to, read about music, and many think we have inside the mind, and often, we do not use all this knowledge in our favor. Because the first time we open a score, we already have an idea, but we do not chase it…or simply, diverge in the direction of other questions, such as those which are technical, which are secondary.

The cases also provided some other interesting testimonials. The first semester student in the third recall stimulated interview mentioned:

> For me, it is always worthy to show for other people what I am doing. And in this way, recording, it became worthier. Now I can watch…. I think that this self-critic is very important. It helps! Sometimes it is more efficient than any other thing.

The fifth semester student, during the third recall stimulated interview commented:

> During the preparation, it was interesting, because it forced me to think more about the works…. Now, watching the video, I could have a retrospective vision…of my process…. It was very interesting…. I have already begun to modify something…. One aspect that became very strong for me…is this stuff with timing, to which I have to be more devoted.

The eighth semester student, in the second recall stimulated interview said:

> At the beginning, I had a little dread. I thought it might consume much time and attention. But thereafter…I felt wonderful…to be able to watch myself from far away and from that distance, acquire more clearness…regarding the ideas, the video…even in listening to me.

DISCUSSION

According to these testimonials, the employed methodology provided opportunities for undergraduate students to develop reflective thinking. The strategies employed during data collection were shown to act potentially as effective tools for instrumental teaching and learning, since they allow the students to expose their thoughts and actions regarding preparation in order to value their own musical experience. During the process of data collection, piano undergraduate interviewees were active agents in their preparation and demonstrated awareness about their weaknesses and strengths in music self-knowledge. Fostering situations, in which the student may be given room to question and to reflect upon his/her own process and products may be a valuable strategy in instrumental teaching. Videos of the students' performance may provide opportunity for the piano teacher and student to reflect upon the instrumental practice and performance.

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The role of the soft palate in woodwind and brass playing

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Expired air provides the basis for sound production for musicians playing a wind instrument. This air stream must be controlled and directed into the mouthpiece of the instrument via a reed mechanism at the mouth. To be able to do this, firm velopharyngeal closure is required to prevent air leaking out through the nose from the oral cavity. In some musicians impairment of soft palate function may result in this air leak occurring, which is known as velopharyngeal insufficiency (VPI). A review of the functional anatomy of the soft palate and how it relates to wind and brass playing is discussed with a brief review of VPI as it is reported in musicians. A better understanding of the soft palate anatomy will assist students and music teachers to optimize their performance and prevent performance related medical problems.

Keywords: soft palate; wind musicians; functional anatomy; velopharyngeal closure; velopharyngeal insufficiency

To play a wind instrument requires a sustained mouth pressure and a constant airflow through the instrument. As the air stream reaches the mouthpiece of the instrument, it causes a variety of mouth pressures, depending on the amount of resistance applied by the particular instrument. Bouhuys (1964) found that the normal maximum pressures sustained in playing a wind instrument can range from 10-126 mmHg, with the highest pressure of 158 mmHg measured in a muted trombone. These pressures are at least 30 times greater than required for normal speech production (Dibbell *et al.* 1979).

These high levels of intra-oral pressures can result in a serious medical condition that can terminate the career of a wind musician, known as stress velopharyngeal insufficiency (Klotz *et al.* 2001, Schwab and Schultze-Florey 2004). VPI results in the seal of the soft palate between the oropharynx and the nasopharynx being incomplete, allowing air to escape from the nose when playing (Ingrams *et al.* 2000). Other than in musicians, this condition is most frequently reported as a consequence of a structural cleft palate deformity, hence is often termed "stress VPI" when it occurs as a result of the stresses imposed by playing a wind instrument. It has been observed that this condition usually occurs in advanced students pursuing a professional career, due to an increase in physically demanding practice and performance regimen which imposes undue stress on the soft palate over a prolonged period of time (Schwab and Schultze-Florey 2004).

The majority of research into VPI has been by speech pathologists or otolaryngologists, and the literature deals primarily with cleft palate or speech disorders. Of only ten articles investigating VPI in musicians, fourteen cases were reported (see Table 1).

A dissertation thesis presented a case series of clarinetists with VPI (Gibson 1995). The author later published two articles summarizing his research and outlining recent trends in the treatment of VPI (Gibson 1998, 2008). There have been three questionnaire studies conducted in London, Germany, and the USA. The authors reported, respectively, that 7%, 31%, and 34% of the participating student and professional wind musicians have experienced VPI (Ingrams *et al.* 2000, Schwab and Schultze-Florey 2004, Malick *et al.* 2007). Due to the small sample sizes of these studies, these figures do not accurately represent the significance of this condition, although informal discussions with fellow musicians and music teachers suggest that this condition is a well-known phenomenon.

The purpose of this review is to present the functional anatomy of the soft palate and how this anatomy potentially relates to wind and brass instrument performance.

MAIN CONTRIBUTION

When playing a wind instrument, air passes from the lungs up into the upper respiratory tract and is eventually channeled into the mouthpiece of the instrument via some form of reed mechanism. As the air meets this resistance when flowing into the instrument there is an increase in pressure in the upper respiratory cavity, requiring firm control of the soft palate.

The soft palate, also known as the velum, separates the nasopharynx from the oropharynx. This closure of the two parts is known as velopharyngeal or palatopharyngeal closure and is important for swallowing, speech, and blowing. The soft palate extends posteriorly from the hard palate, and five muscles control its movement. Each of the paired muscles can be divided into

Table 1. Review of published cases of musicians treated for VPI.

Authors	*Instrument*	*Sex*	*Age (years)*
Weber and Chase (1970)	oboe	female	23
Massengill and Quinn (1974)	bassoon/saxophone	male	18
Dibbell *et al.* (1979)	oboe	female	20
Dibbell *et al.* (1979)	trumpet	male	23
Peterson-Falzone (1985)	clarinet	female	n/a
Gordon *et al.* (1984)	bassoon	female	31
Conley *et al.* (1995)	trumpet	male	17
Wolff (1995)	trumpet	male	n/a
Wolff (1995)	trombone	female	n/a
Ingrams *et al.* (2000)	trombone	male	20
Ingrams *et al.* (2000)	clarinet	male	18
Klotz *et al.* (2001)	french horn	female	19
Klotz *et al.* (2001)	oboe	female	20
McVicar *et al.* (2001)	clarinet	male	18

their principal actions on the soft palate. The levator veli palatini and the musculus uvulae are elevators, the palatoglossus and palatopharyngeus are depressors, and the tensor veli palatini is a tensor.

The muscles of the soft palate

The *tensor veli palatini* is the only muscle of the soft palate that is innervated by the cranial nerve V (Moore and Dalley 2006). The muscle bellies are attached superiorly to the scaphoid fossa of the medial pterygoid plate, the spine of the sphenoid bone, and the cartilage of the pharyngotympanic tube. It is then inferiorly attached to the palatine aponeurosis. The main action of the tensor is to tense the soft palate which opens the pharyngotympanic tube during swallowing and yawning (Moore and Dalley 2006). In playing a wind instrument, the tensor acts with the levator to maintain velopharyngeal closure which allows the airflow through the mouth.

The *levator veli palatini* is innervated by the pharyngeal branch of the vagus cranial nerve X and is superiorly attached to the cartilage of the pharyngotympanic tube and the temporal bone. Like the tensor, the levator is attached inferiorly to the palatine aponeurosis (Moore and Dalley 2006). The levator is the most important muscle in the elevation of the soft palate during swallowing and yawning. As described above, the action of the levator is important in closing the oronasal cavity ensuring airflow is directed through the mouth.

The *palatoglossus* and the *palatopharyngeus* are innervated by the vagus cranial nerve X (Moore and Dalley 2006). The palatoglossus is attached superiorly to the palatine aponeurosis and is attached inferiorly to the side of the tongue. The main action of this muscle is to elevate the posterior part of the tongue and may also depress the soft palate onto the tongue (Moore and Dalley 2006). If the palatoglossus depresses the soft palate—opening the nasal cavity and elevating the tongue, thereby closing the oral cavity—then it may be these actions that assist in the breathing technique known in musical pedagogy as circular breathing. This technique, occasionally used by wind instrumentalists, involves the simultaneous expiration of air through the mouth and inspiration through the nose, which allows the player to blow continuously through the instrument. Although circular breathing has been discussed in the music literature, the action of these muscles needs further research.

The *palatopharyngeus* is superiorly attached to the hard palate and the palatine aponeurosis and is inferiorly attached to the lateral wall of the pharynx. The palatopharyngeus tenses the soft palate and pulls the pharynx walls superiorly, anteriorly, and medially during swallowing (Moore and Dalley 2006). Huang *et al.* (1998) found that the inferior action of the palatopharyngeus acts against the inferior action of the levator. Additionally, upon contraction of these muscles the velum stretches to make contact with the posterior pharyngeal wall, enhancing velopharyngeal closure (Huang *et al.* 1998).

The *musculus uvulae* is also innervated by the vagus cranial nerve X (Moore and Dalley 2006). The muscle is attached to the posterior nasal spine and the palatine aponeurosis superiorly and is attached to the mucosa of the uvula inferiorly. The main action of this muscle is to shorten the uvula and pull it superiorly (Moore and Dalley 2006). It also assists the levator veli palatini in palatopharyngeal closure by adding bulk to the soft palate, which seals off the nasopharynx (Kuehn 1979). When the soft palate is elevated, the uvula can be seen drawing upwards and backwards towards the back of the throat.

Two other muscles that belong to the pharynx are also associated with the soft palate. Both the *superior pharyngeal constrictor* and the *salpingopharyngeus* are innervated by the pharyngeal branch of the vagus cranial nerve X (Moore and Dalley 2006). The superior pharyngeal constrictor, which is attached superiorly to the pterygoid hamulus, and the pterygomandibular raphe, inserts into the pharyngeal aponeurosis forming the sides and back walls of the nasopharynx and the back of upper oropharynx. The salpingopharyngeus is attached to the cartilaginous part of the pharyngotympanic tube and inserts inferiorly to the palatopharyngeus muscle (Moore and Dalley 2006). The superior constrictor, assisted by the salpingopharyngeus which elevates the pharyngeal wall, pulls the pharyngeal wall forward to help gain velopharyngeal closure.

IMPLICATIONS

As can be seen from this review, the function of the soft palate is essential for maintaining upper respiratory tract structure under pressure and hence allowing optimal airflow. It is crucial for wind and brass players to be able to maintain firm velopharyngeal closure for optimum performance. Much more research needs to be conducted into the mechanisms behind the performance related problems, which may be associated with the soft palate. It is important for musicians and music teachers to increase their understanding of the functional anatomy and physiology for optimizing performance and injury prevention.

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The Vincenzo Vitale piano school: Famous school but little known

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This paper introduces some aspects of the Vincenzo Vitale piano school; a twentieth century Italian school generated from the intersection of the Neapolitan piano school and other European musical realities. Although the School is recognized to be important by many, there is very limited specific literature about either the School or Vincenzo Vitale (1908-84). The thesis entitled *The Piano Teaching of Vincenzo Vitale*, undertaken toward the completion of a Bachelors degree and specialization at the University of Bologna in 2005, is still to my knowledge the only in-depth scholarly study on the topic so far. The focus of the thesis was on the principles of Vitale's teachings, his theories, the formulation of these theories, and their background.

Keywords: Vitale piano school; pedagogy; technique

Alongside the German, Russian, and French schools of piano playing during the 1800's in Naples, the Neapolitan piano school, founded by Francesco Lanza (1783-1862) and subsequently by Sigismund Thalberg (1812-71), was flourishing. Well into the first part of the 1900's, Naples with its conservatory was the center of piano playing in Italy. Pianists such as Michelangeli, Ciccolini, Pollini, and most of the Italian pianists have their roots in this school. Furthermore, the Neapolitan school's prerogatives of piano playing have been exported outside of Italy—for example, Beniamino Cesi (1845-1907) taught piano in St. Petersburg, Vincenzo Scaramuzza (1885-1968) in Buenos Aires, and Vincenzo Vitale (1908-84) in the US. During the second half of the twentieth century, the Vincenzo Vitale piano school was considered the apex of the Neapolitan piano school and Vitale one of the most important Italian piano teachers (e.g. Campanella 1994, Di Benedetto 2004, Valori 1981). Although Vitale died in 1984, his name appears in many curricula vitae, some of whom, in many cases, were just auditors to Vitale's lectures; it would seem that his name stands as a sort of "brand" of good piano playing and professionalism. Because Vitale himself did not write his method of teaching in a volume, the important legacy risks to be misinterpreted or even become extinct. Since 2002, I have addressed this problem by completing a 64,000 word thesis entitled *The Teachings of Vincenzo Vitale* (2005) at the University of Bologna, and I am continuing the research into the application of Vitale's teaching principles toward a PhD at the University of Melbourne. The focus of the thesis completed in Bologna in 2005 was on the principles of Vitale's teachings, his theories, the formulation of these theories, and their background. Schematically, now we know that the Vitale school was generated from Vitale's teaching dating back into the 1930s. The school is informed by two main principles: (1) technique and interpretation cannot be separated and (2) piano playing is manifested though sound production. Furthermore, sound production is at all times resulting from a combination of two fundamental techniques—weight technique and percussive technique—that originate from the only two antithetic actions of the finger on the keyboard (sustainment of weight or percussion action). We also know that the school is based on a specific system of training and Vitale's teachings are propagated today through the teaching of Vitale's disciples and their students. This paper aims to report on the results of the Bologna thesis as well as on the aims of the current research into the evolution of the Vitalian system of teaching.

MAIN CONTRIBUTION

The Vitale piano school is predominantly an Italian phenomenon that is centered on the Neapolitan figure of Vincenzo Vitale (Naples, 1908-84). Vitale's piano teaching took place mainly in conservatories, academies, and summer schools, in Italy, in many European cities, as well as in Buenos Aires, Bloomington (Indiana, USA), and Cairo. Students from many parts of the world have come into contact directly or indirectly with Vitale's teachings. Vitale was also active as a historian, writer, journalist, and promoter in the field of music—activities that significantly enriched his teaching. Vitale developed by intuition, experimentation, and rational process a pedagogical system of training intended as a tool in piano teaching, in its technical/interpretative aspects, from preliminary to the highest level. His pedagogy can be intended as an amalgamation of elements derived from the "finger school" (Clementi/Lanza and Thalberg), through the Neapolitan piano school, as well as the "weight school" (Liszt, Steinhausen, Deppe, Breithaupt, Matthay) filtered through the Neapolitan Attilio Brugnoli's treaties on the dynamics of piano playing published in 1926 by Ricordi: *Dinamica Pianistica, Trattato* *sull'Insegnamento Razionale del Pianoforte e sulla Motilità Muscolare ne' suoi Aspetti Psico-Fisiologici.*

The Vitale piano school does not refer to a finite institute because such an institution never existed. It came about spontaneously in the Italian pianistic entourage (pedagogues, students, journalists, music critics) as a way to identify a specific and prolific phenomenon. Its specificities were denoted by the technical drill that was part of the Vitalian training, the particular typology of a fundamental sound (intense, full, round, direct, very clear), and a significant number of skilled and/or successful professional musicians (pianists, conductors, musicologists, pedagogues, journalists) who have referred to his teaching, such as Michele Campanella, Bruno Canino, Carlo Bruno, Riccardo Muti, Renato Di Benedetto, and Paolo Isotta.

Vitale seemed to have embraced and "officialized" the entity of his school of teaching by releasing, in collaboration with Fonitcetra, three sets of recordings between 1974 and 1981 with annexed booklets: *La Scuola Pianistica di Vincenzo Vitale* (1974), *La Scuola Pianistica di Vincenzo Vitale [2]* (1980), and *Muzio Clementi, Gradus ad Parnassum: Incisione Integrale dei 100 Studi* (1981). In the opinion of the critics, the recordings appeared as a showcase of both the sound production and the principle traits of the school. If the 1974 booklet was an introduction to the school, the 1981 booklet was intended as lessons on how to approach pianistic interpretative/technical issues. Today Vitale's concise comments can be of little practical use in piano pedagogy in general without a more expanded knowledge of Vitale's teaching. This seems to confirm that Vitale believed that knowledge can be transmitted between teacher and student only directly and that any written suggestions can be misunderstood or non-productive due to the incapacity to adjust the explanation to the real needs of the student. The three sets of recordings with the annexed booklet are the only historical reference points authorized by Vitale himself, so therein lays their historic importance as a basis for further study in Vitale's teachings.

Rattalino (1981), reviewing the Clementi album, placed Vitale's teaching as a successful modern realization of the concept of the virtuoso pianistic sonority. The term "pianistic sonority" does not refer to the timbre by itself but rather the timbre as an integral part of the expressive "lexicon" of pianistic composition. More precisely, this lexicon is formed by the specific pianistic use of an extensive use of scales, arpeggios, double thirds, double sixths, octaves, and pianistic modulus that seem to originate from the interaction of the pianist's physiology of the arm complex and the specific sound qualities generated by the mechanism of the instrument (Rattalino 1983). Furthermore, Rattalino suggests that the piano compositions of Clementi, Liszt, and Ravel provided Vitale with an axis that exemplified this concept of pianistic lexicon, and that axis stands as a referential typology of pianistic sonority. Interestingly enough, Vitale sourced the fundamental ingredients of the specific typology of sound, the *cantabile* and the *brillante* sound, from the brief introduction in Thalberg's *L'Art du chant appliqué au piano* volume published in 1850 by Girard in Naples. As Rattalino (1983) observed, Thalberg modeled these two sonorities on the singing voice (*cantabile*) of the *bel canto*, specifically on the distinction between *cantar di petto* and *cantar di grazia*.

Schematically, Vitale's interpretation toward the realization of the two fundamental ideas of sound on the instrument concerned the amount of weight of the arm complex (shoulder, forearm, and hand) released on the keypad. The cantabile sound requires a major amount of weight to be released on the keypad and the brillante sound requires a major amount of suspension of the weight to be released on the keypad. The following was deduced in this line of thought: (1) the more weight released on the keypad, the more the finger must sustain the weight which limits its percussiveness; and (2) the more weight that is suspended (in other words, the weight of the arm, forearm, and even hand is sustained by the appropriate muscles that have this function), the more the finger has the right muscular/articular condition to solve its percussive action on the keypad. These observations brought Vitale to assert that sound production on the piano can be categorized from the point of view of touch mechanisms in only two fundamental techniques: the weight technique (*tecnica di peso*) and the percussive technique (*tecnica percussiva*).

The two different technique typologies were inferred from what Vitale believed the only two fundamentally different possibilities of physiological action of the finger on the keypad. The finger can either sustain, as a point of support, the weight of the arm (necessary in delivering the expressive effects in legato, cantabile, and in polyphonic passages), or it can execute a percussive action (what is commonly known as articulation) necessary in the performance of fast passages. In Vitale's theory, the two technical categories (weight and percussive) serve as a referential point of piano playing. In reality, Vitale spoke openly of a compromise of the two mechanisms, as piano performance (*l'esecuzione pianistica*) necessitates a "continuous technical construct"—the hybrid technique.

Vitale's necessity to find practical solutions in piano playing made him realize that there is no separation between interpretation and technique of execution, as one informs the other constantly. In fact, Vitale in his notes (undated notes transcribed by the author) writes that the Greek terms *techne*, which stands for "art," and *technicos*, which means "serves art," clarify the inseparable dichotomy: imagination and concretization. The first generated from *Sehensucht*, the other from the means of expression (Vitale, Document 9 in Ferrari 2005). Vitale intended technique as the functionality of interpretative means: it can be velocity, precision, or timbre. Technique represents the means of appropriate sound production in order to deliver the musical piece. The executor's expressive capacity is manifested through the pianistic execution by achieving varied sounds in intensity, giving each note its appropriate accent with the appropriate touch dictated by the pianist's interpretation of the composer's indications. The more the technical means are controlled and precise, the more the interpretation can be exteriorized with precision of intent. A virtuoso pianist is one who achieves control over all the means involved.

Thus, Vitale insisted that the first thing a student must know is the use of the physical element that is in direct contact with the keys: the fingers. The third phalanx of the fingers constituted the focal point of attention: its action is the result of complex muscular processes that involve the entire organism. For this reason one must know the physiological mechanisms that preclude the motor activity. According to Vitale, without a proper understanding of fundamental physiology at least of the upper limb, there is a greater risk of imprinting an erroneous foundation for technique and consequent interpretation. Vitale's aims were to give the student sharp, clear guidelines in how to resolve interpretational problems without limiting the student by imposing one's own interpretational views. The practicality of theories interested him, not their abstract value. This is reflected in his considerations about the use of concepts and terminology such as relaxation, weight, and muscular dissociation. Vitale stated that any description of the act of piano playing from the point of view of muscular activity can be only approximate and any definition on weight technique, arm technique, dissociation, relaxed arm, cannot be considered differently.

The Vitale technical drill is probably the most famous element of the school. It consists of a series of concise exercises set in a progression that respects the assimilation of physiological difficulties. These range from the single note mechanism (four notes and five notes and chromatic exercise, scales, arpeggios, trills, and repeated notes) to the double notes mechanism (double thirds, sixths, octaves) as well as the combination of the weight and percussive mechanism (one, two, or three fingers sustain the weight over long notes while the other fingers act percussively on notes of a shorter value). All exercises are to be executed in all tonalities, with different graduations of volume (from *forte* to *piano*, as well as in *crescendo* and *diminuendo*), at different *tempi*, and with different accents determined by a fixed set of rhythmic variations (groups of two, three, or four notes). Vitale did not compose the exercises; these were sourced from traditional piano pedagogy and were assembled by him within a system of rational criteria of determined aims.

IMPLICATIONS

The underlying problem is: what is, or can be, the use of the Vitale system of teaching in the larger panorama of piano pedagogy? Possible solutions stand in presenting the findings to a larger audience, and thus encourage scholarly attention and debate to a substantial pianistic phenomenon.

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Expertise in cryptic crossword performance: An exploratory survey

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This paper investigates the link between practice and level of expertise in cryptic crossword solvers. A survey was conducted of 241 expert solvers, which established that, even among crossword experts, the range and frequency of cryptics solved and the time spent upon this varied greatly. The link between practice and level of expertise was therefore not straightforward, but seemed to be connected to the primary focus of the solver—whether they aimed to "speed-solve" or solve "advanced cryptics" of exceptional difficulty. A brief review of motivational drivers for solvers of cryptics is also included.

Keywords: crossword; problem solving; expertise; motivation; practice

Puzzles of all standards and for all ages are routinely available in newspapers and magazines, and crazes for particular types of brainteasers—such as Sudoku—regularly sweep the world. One particularly long-lived puzzle type is the crossword, which exists in two basic forms: cryptic and non-cryptic. In the non-cryptic form, a clue word or phrase prompts the solver to discover a synonym word which will fit into the grid and intersect with cross-checking letters. This type of crossword is found throughout the world and is the main (virtually the only) type of crossword to be found in the USA.

The focus of this study, however, is the "cryptic" crossword, which may be found in broadsheet newspapers and quality magazines throughout the UK and Commonwealth. In these puzzles, the surface reading of the clue is phrased to be deliberately misleading. The solver learns to ignore this reading, and to identify and crack a grammatical set of coded instructions which, if executed precisely, will lead to the correct (and only) answer.

Although cryptic crosswords are not audience-oriented, many solvers strive for self-improvement and recognition within the crossword community, by tackling successively harder crosswords, attempting “personal best” times, entering public speed-solving challenges, or maintaining annual statistics of correctly completed crosswords. There is thus ample opportunity to develop and demonstrate one’s expertise in cryptic crossword solving.

In contrast to the many expert-novice studies of performers in domains such as chess (e.g. Gobet and Campitelli 2007) and music (e.g. Waters and Underwood 1998), very little research exists into either the processes and aptitudes required to complete cryptics or the development of cryptic crossword solving expertise. A few small-scale studies at Nottingham University explored the relationship between lexical abilities and cryptic crossword solving skill and touched upon the role of practice and expertise development in passing (Underwood *et al.* 1988, Underwood *et al.* 1994, Deihim-Aazami 1999); otherwise research has been primarily directed toward the mechanics of individual clue elements such as synonym retrieval or anagram solving (e.g. Novick 2004), and has generally been based upon US-style “non-cryptic” crosswords (e.g. Hambrick *et al.* 1999).

This exploratory survey of regular cryptic crossword solvers with a high level of expertise aimed to investigate the cognitive skills, motivation, and development of expertise in this domain. The survey was wide ranging, and only those results relevant to performance expertise are reported here.

METHOD

Participants

Crossword “experts” were sought to participate, defined as those able to achieve one of the following:

- Solve one standard “block-style” (i.e. latticed-grid) cryptic crossword, at the more difficult end of the spectrum, in 30 minutes or less. Cryptic crosswords of varying difficulty are found in many daily newspapers (see Biddlecombe 2000, link to *Puzzle Sources*); of these the most famous is probably the (London) *Times* crossword. Competitors in the annual *Times* Speed-solving Championship are set the challenge of solving four *Times* crosswords in 1 hour (i.e. 15 mins each).
- Tackle “advanced cryptics.” These challenging barred-grid prize puzzles appear in a number of weekend newspapers and magazines (Biddlecombe 2000); of these, the *Listener Crossword* (in the *Times* on Saturdays) is the most notoriously difficult, employing a high degree of concealment in the clue mechanics, obscure vocabulary, grids of startling originality, and a thematic challenge, involving a number of tricky lateral thinking steps

on the basis of very little guidance. Speed is not important: competition entrants are allowed at least a week to submit solutions. Only a handful of *Listener* solvers submit all 52 puzzles in a year correctly; those who solve 42+ appear on a roll of honor.

Participants for the survey were sought by means of advertisements circulated (1) on *The Crossword Centre* website (www.crossword.org.uk, a UK-based cryptic crossword forum, membership approx. 950) in May 2007 and May 2008; (2) on the *Guardian* newspaper crossword message board in June 2007; (3) at the *Times* speed-solving competition in Cheltenham, England, in October 2007; and (4) with the annual *Listener Crossword* statistics, distributed (on request) in March 2007 by the official statistician.

The advertisements were deliberately released in both competitive (Cheltenham/Listener statistics) and non-competitive (website/message boards) settings. Care was also taken to advertize the survey both on and off the web.

Materials

A questionnaire was developed, piloted, and released seeking responses to 90 wide-ranging questions relating to the cognitive skills, motivation, and development of expertise involved in the completion of cryptics.

Procedure

Respondents were invited to complete the survey online using SurveyMonkey®. A paper copy of the questionnaire was also available.

RESULTS

In total, 256 people responded. Due to missing data, 241 questionnaires were analysed (209 M, 32 F; mean age=53 years, range=23-83). The mean starting age for solving cryptics was 17 years; solvers typically spent 10 years on "block-style" cryptic crosswords before going on to more advanced ones and were highly experienced (mean years solving=36, range=2-66). There were 221 *Listener Crossword* solvers, although the majority of respondents had first seen the survey advertized on the *Crossword Centre* website (n=161).

Respondents tended to solve cryptics regularly (mean time spent=8 hours per week, range=1-30) and from various newspapers (mean different cryptics regularly attempted=4.5; range=0-28). There were, however, significant differences within these ranges at the individual level.

Table 1. Percentage of participants, by expert sub-category, showing volume of crosswords solved.

Expert sub-category	*Focused*	*Moderate*	*Broad*	*Extensive*	*Voracious*
Crossword Pro	34	57	6	3	0
Speed/Listener Super Expert	28	39	17	6	11
Speed Super Expert	38	31	25	6	0
Listener Super Expert	70	25	5	0	0
Ordinary Expert Participant	61	32	5	2	0

Table 2. Percentage of participants, by expert sub-category, showing hours spent solving per week.

Expert sub-category	*0-5*	*6-10*	*11-15*	*16-20*	*21-25*	*25+*
Crossword Pro	33	52	6	6	3	0
Speed/Listener Super Expert	22	56	11	11	0	0
Speed Super Expert	38	44	19	0	0	0
Listener Super Expert	27	50	15	7	2	0
Ordinary Expert Participant	49	31	14	5	0	1

Table 3. Mean number of years spent solving cryptics, by expert sub-category.

	Pro	*Speed/List*	*Speed*	*List*	*Ord*	*Average*
Years solving	38	36	40	36	35	36

In order to investigate these differences, respondents were divided into five expert subcategories, on the basis of responses given in the survey:

- Those who edited or composed cryptics professionally (n=35);
- Those who could speed-solve a cryptic in <15 mins *and* who had completed 42+ *Listener* crosswords correctly in one year (n=18);
- Those who could speed-solve a cryptic in <15 mins (n=16);
- Those who had completed 42+ *Listeners* correctly in one year (n=60);
- Other expert participants who had not achieved any of the above (n=112).

These groups were first analyzed by the volume of crosswords they tackled (number of different crosswords solved by each participant, weighted by the frequency with which they tackled them; see Table 1 for results). The groups were then analyzed by the hours spent tackling cryptic crosswords each week (Table 2). The average number of years spent solving cryptic crosswords was also calculated for each sub-category (Table 3).

Respondents were also asked to consider and rate, on a 1-5 scale, a series of 26 statements compiled specifically for the survey exploring a range of potential motivational drivers (both extrinsic and intrinsic) behind their solving behavior. Respondents' replies indicated high levels of intrinsic motivation. Primary intrinsic drives were related to (1) the "buzz" of succeeding in an intellectual challenge (68% rated this "very/highly motivating") and (2) preserving mental "sharpness" (61% "very/highly motivating"). Expert crossword solving was seen as a solitary hobby: 88% of respondents claimed that participation in team solving was not motivating for them. Generally, extrinsic motivational drivers such as prizes or public acclaim were also seen as less important; however, 33% had participated in public speed-solving contests, and 73% of those who tackled the *Listener* crossword (n=221) routinely submitted it for the official personal annual statistics, with 54% aiming to appear on the *Listener* roll of honor.

DISCUSSION

Becoming an expert in any domain requires practice, hard work, and strong motivation, both intrinsic and extrinsic. However, this study highlighted that even among crossword experts the range and frequency of cryptics solved varied greatly. "Super-Experts" in speed solving (alone or in combination with high *Listener* expertise) seemed to attempt routinely a much broader range of crosswords than others. It is possible that the high volume of clues covered enables more of the problem solving process to become automatic for these speed experts, leading to an increasingly instantaneous recognition of the clue architecture. By contrast, those who were solely *Listener* "Super-Experts" solved in a conspicuously more focused range. Despite this, the time spent on crosswords per week was relatively constant across the "Super-Expert" categories, with 77-82% of participants spending 0-10 hours on crossword solving, predominantly in the 6-10 hours category: the rapidity of the "Speed" experts may have contributed to their ability to cover a wider range of material in relatively quicker time; whereas the *Listener* "Super-Experts" may have deliberately focused on harder and more time-consuming puzzles.

Those falling into the "Ordinary Expert" category, however, generally lagged behind the "Super-Expert" categories both in the range of crosswords tackled and in the time spent, with 49% of respondents spending 5 or fewer hours per week on solving activities. This suggests that practice may be one key factor in achieving "Super-Expert" status.

Expert solvers were highly intrinsically motivated, and pursued cryptic crossword solving primarily as a source of intellectual stimulation and pleasure. Solving is a solitary pastime, however, and many experts seemed to use various extrinsic goals, such as the maintenance of annual statistics, as a source of extra extrinsic incentive to supplement their own internal drive.

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Relationship between playing strategy and surface electromyograms in playing drums

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Skills in controlling drumsticks correctly are required to play rhythms without making any mistakes at suitably dynamic levels of sound. Results obtained by analyzing drummers' movements using visual information, such as motion capture or camera recordings, have been reported in past studies, but analysis using biological information has been the focus of fewer studies. To play rhythms without making mistakes at suitably dynamic levels of sound throughout a piece of music, trained drummers are assumed to use different playing strategies: a short-term playing strategy (e.g. every stroke) and a long-term playing strategy (e.g. every piece of music). The aim of this study was to investigate the relationship between trained drummers' playing strategies and muscle movements by recording their surface electromyograms (EMGs) when playing the drums. Three trained drummers and three non-drummers participated in an experiment to record their surface EMGs when playing single-strokes. As a result, it was confirmed that trained drummers play the drums under both short-term and long-term playing strategies.

Keywords: electromyogram; drums; strain and laxity; movement analysis; playing strategy

In drumming, the skill of controlling drumsticks correctly is required to play rhythms without making any mistakes at suitable dynamic levels of sound. Results of analysis concerning drummers' movements from visual information, such as motion capture or camera recordings, have been reported in past studies (e.g. Dahl 2006), but analysis using biological information has been studied much less. Movements of arms and hands when playing the drums are understood to be complex, so the actual way muscles control these movements has not been clarified. To play rhythms without making mistakes at suitable dynamic levels of sound throughout a piece of music, a drummer needs to consider how to perform. Such consideration is called a "playing strategy." Trained drummers are thought to have different playing strategies: a short-term playing strategy (e.g. every stroke) and a long-term playing strategy (e.g. every excerpt). In addition, a playing strategy is based on a drummer's skill and experience, so it is implemented with or without a drummer being conscious of it. The aim of this study was to investigate the relationship between trained drummers' playing strategies and muscle movements by recording their surface electromyograms (EMGs) when playing the drums. The amount of EMG signals is proportional to the amount of muscle strain. Therefore, by analyzing the EMGs of arms and hands when playing the drums, it is possible to investigate the way arms and hands control drumsticks, in terms of muscle laxity and strain. In addition, by recording the EMGs, information can be obtained about drummers' conscious and unconscious movements, so analyzing the EMGs is thought to be suitable for investigating drummers' playing strategies.

METHOD

Participants

Three trained drummers and three non-drummers participated in an experiment to record their surface EMGs when playing single-strokes under three different tempi of 80, 100, and 120 bpm. All the participants were right-handed.

Procedure

They were asked to play four beats for three minutes under the tempi denoted above. The musical score played in this experiment is shown in Figure 1. All the participants were allowed to rest for a minimum of one minute after each performance. The flexor carpi ulnaris muscle of both arms, extensor carpi ulnaris muscle of both arms, metronome signal, and oscillation of drumhead were all measured. The movement of flexor carpi ulnaris muscle corresponds to the movement of bending the wrist forward, and the movement of extensor carpi ulnaris muscle corresponds to the movement of bending the wrist backward.

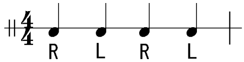

Figure 1. The musical score.

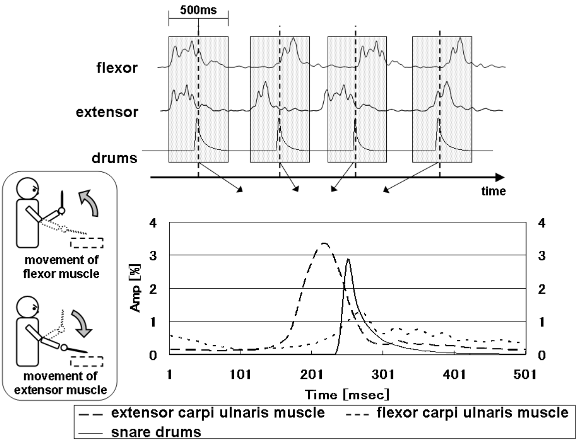

Figure 2. Example of one-stroke mean EMG.

RESULTS

To investigate the relationship between playing strategies and muscle movements, the short-term and long-term playing strategies were individually analyzed.

Short-term playing strategy

To analyze the short-term playing strategy, mean EMG of the range of around 500 ms centered at the time a drumstick strikes a drum is called "one-stroke mean EMG" and is compared among each measured muscle and each drummer (see Figure 2). The results of the analysis of one-stroke mean EMG are shown in Tables 1 and 2. Table 1 shows the results of a comparison between the one-stroke mean EMGs of the flexor carpi ulnaris muscles and those of extensor carpi ulnaris muscles for all participants. Table 2 shows the styles of arm movement in terms of muscle for each participant. Table 2 confirms that significant differences in the one-stroke mean EMG of all participants' extensor carpi ulnaris muscles are less/more than those of flexor carpi ulnaris muscles. "Flexor dominance" is when the one-stroke mean EMG of the extensor carpi ulnaris muscle is less than that of the flexor carpi ulnaris muscle. "Extensor dominance" meanwhile is when the one-stroke mean EMG of the flexor carpi ulnaris muscle is less than that of the extensor carpi ulnaris muscle.

Table 1. Results of comparison between one-stroke mean EMG of flexor carpi ulnaris muscle and one-stroke mean EMG of extensor carpi ulnaris muscle.

Player	*Tempo (bpm)*	*Left arm*	*Right arm*
D1	80	flexor>extensor**	flexor>extensor**
	100	flexor>extensor**	flexor>extensor**
	120	flexor>extensor**	flexor>extensor**
D2	80	flexor>extensor**	flexor>extensor**
	100	flexor>extensor*	flexor>extensor**
	120	-	flexor>extensor**
D3	80	flexor<extensor**	flexor<extensor**
	100	flexor<extensor**	flexor<extensor**
	120	flexor<extensor**	flexor<extensor**
ND1	80	flexor<extensor**	flexor>extensor**
	100	flexor<extensor**	flexor<extensor**
	120	flexor<extensor**	-
ND2	80	flexor<extensor**	flexor<extensor**
	100	flexor<extensor**	flexor<extensor**
	120	flexor<extensor**	-
ND3	80	flexor<extensor**	flexor<extensor**
	100	flexor<extensor**	flexor<extensor**
	120	flexor<extensor**	flexor<extensor**

Note. **=$p<0.01$, *=$p<0.05$, - =not significant.

DISCUSSION

Short-term playing strategy

Tables 1 and 2 confirm that four players have the same style of motor control in both arms. Specifically, all trained drummers have this feature, whereas just one non-drummer has it, indicating that trained drummers use the same style of motor control in both arms when playing the drums. Conforming right arm movements to left arm movements is thought to be essential to play the drums without making mistakes throughout a piece of music. In short, trained drummers play drums with the same style of motor control in both arms under the short-term playing strategy.

Long-term playing strategy

Table 3 confirms that non-drummers' mean EMGs during the last one minute were significantly higher than those of the first one minute. Such results were

Table 2. Style of arm movement (flexor dominance or extensor dominance).

Player	*Left arm*	*Right arm*
D1	flexor dominance	extensor dominance
D2	flexor dominance	extensor dominance
D3	extensor dominance	extensor dominance
ND1	extensor dominance	-
ND2	flexor dominance	extensor dominance
ND3	extensor dominance	extensor dominance

Table 3. Results of comparison between mean EMGs during first and last one minute.

Player	*Tempo (bpm)*	*Flexor of left arm*	*Extensor of left arm*	*Flexor of right arm*	*Extensor of right arm*
D1	80	**	**	**	-
	100	**	-	-	-
	120	-	*	*	*
D2	80	-	*	-	**
	100	-	*	-	**
	120	**	**	**	**
D3	80	-	-	-	-
	100	-	**	-	-
	120	-	-	**	-
ND1	80	*	**	*	**
	100	-	**	-	*
	120	**	*	*	**
ND2	80	*	**	-	**
	100	-	**	-	**
	120	**	**	*	*
ND3	80	*	**	-	*
	100	**	-	**	-
	120	-	-	**	*

Note. **=$p<0.01$, *=$p<0.05$, - =not significant. Ratio of significant differences for D1, D2, and D3=17/36 (42%). Ratio of significant differences for ND1, ND2, and ND3= 26/36 (72%).

obtained only for the non-drummers. This demonstrates that only non-drummers' mean EMGs during the last one minute were significantly higher than those of the first one minute, indicating that trained drummers are sufficiently relaxed when playing the drums throughout a piece of music. That is to say, trained drummers play the drums with less strain in terms of muscle control under the long-term playing strategy.

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Between hedonism and atomism: Discrepancies in the performers' musical perception

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The performer's double hypostasis—receiver and music maker, not just transmitter—entails different approaches, sometimes acting divergently, as well at the global level as at the sub-compounds of the musical text. Music is perceived mainly through its supra-segmental level, while the performance routine calls for a syntagmatic approach at a strict phonemic-morphemic level. Over the technical relationship between sounds, the Western music performer has to build the emotional expression through logic unities equivalent to words of a discourse undergoing several temporal and spatial hypostases on the way from the composer to the last participant of the musical process, the listener. Numerous trials aiming at an objective analysis comprise, beside traditional musical structures, also *ad hoc* "meaning units" extracted from imagery, memory cues, or gesture. However, the internal holistic representation of the Western performer is contradicted by both the concrete steps of his practical action and the detailed analytical features. This research tries to identify those musical "ideas" susceptible to play the role of intermediate links between perceptual meaning units and concrete gesture. An attempt aiming at bringing nearer analysis and living performance not only unifies the segmental elements, but ensures a necessary "space" for their psychological resonance.

Keywords: performers; analysts; meaning units; segmental; supra-segmental

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Effect of music in a healing room for recovery from mental fatigue: A psychological experiment of the relation between relaxing music and listening space design

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Two experiments were performed in order to examine an interaction of relaxing music and listening space design. In Experiment 1, two types of music were prepared, and a change of room evaluation was investigated. The background music (BGM) used was either relaxing or non-relaxing. Participants were asked to rate the degree of harmony between music and room interior design. The results showed that (1) relaxing music was judged more appropriate for room interior design than non-relaxing music and (2) the room interior design was estimated as more calm when the BGM was relaxing. In Experiment 2, the change in the impression and the likes and dislikes concerning this room were examined by using two types of lighting: calm lighting and ordinary lighting. Sixty participants were asked to rate the impression concerning this room. The results showed that (1) the change in the impression from the lighting did not change the atmosphere formed by the interior design and (2) the good impression of the room improved when the calm lighting was used. This study showed that BGM, as well a room acoustics and lighting, can play an additional role in a highly-designed indoor room.

Keywords: music; healing room; mental fatigue; relaxing music; listening space design

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Performing proportion: Crux awareness in Scarlatti interpretation

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This study aims to determine if crux occurrence in Scarlatti's K. 159 sonata conforms to a *golden section* or other proportionate position as found in other sonatas and, if so, is interpreted thus by performers.

Keywords: Scarlatti; crux; golden section; performance; background/ foreground tempi

Performer-scholar Ralph Kirkpatrick identified a compositional phenomenon in the majority of the Domenico Scarlatti sonatas, which he termed "crux": "the point in each half where the thematic material at the ends of both halves establishes the closing tonality" (Kirkpatrick 1953, p. 255). Thus, the crux has a triple function: melodic, harmonic, and structural. In previous research that compared Scarlatti's *Essercizi* and *Cantabile* sonatas, a very high incidence of golden section proportion (GS) was found at the crux's occurrence (Harper 2007), regardless of the character (Halton 2002). Also, in a sonata with GS proportion (K. 380), it was determined that performers consciously or unconsciously react to this proportion by expressing it in both foreground (surface) and background (structural) tempi (Harper and Henriques 2008). Using digital audio editors, the current study obtains data from a control group and an experimental group in performance of the Sonata in C Major, K. 159 "La caza", in order to measure performance consistency and tempo-crux perceptions.

MAIN CONTRIBUTION

Scarlatti's Sonata in C Major, K. 159 was chosen due to its structural proportions and easy accessibility. In 6/8 and with a range of D-d''', it is marked *allegro* in various manuscripts. This bi-partite sonata is 64 measures long (26

Table 1. Crux proportions.

Crux Proportions	*Length (L)*	*Phi or GS L x .618034*	*Crux*	*Differential Crux-phi*	*Conclusions*
A1 (1st half)	26 measures	16, 068884 =16	ms. 13	16-13= 3 measures	mirrored to second half
B1, A1 (2nd half)	38 measures	23, 485292 =23	ms. 52 (26)	26-23= 3 measures	mirrored to first half
A' Recap. only	21 measures	12, 978714 =12,9	ms. 9	12,9-9= 3,9 measures	close to mirror proportion

*Figure 1.*The crux in A and B sections.

bars+38 bars) or 128 measures with the repetitions and no first or second endings. In the overall AB form, the B part consists of B+A' (or rounded binary form with developmental aspects and recapitulation), which may be seen with repetitions as: [A1] [A2] [B1, A3,] [B2, A4]: A2=repeat of A1, B2=repeat of B1, A3=variant of A1 in recapitulation, A4=repeat of A3. The crux appears in measure (ms.) 13 (A section) and in ms. 52 (=ms. 26 of that section or ms. 9 of the recapitulation).

Before measuring the placement of the crux, a one measure discrepancy was found in various manuscripts and editions in the first half (ms. 16); this had to be considered with the logical conclusion that Scarlatti's copyist accidentally omitted it because of its repetitious nature. Gilbert's *Urtext* edition was chosen because of the logical symmetry of the sonata's halves.

The *phi* or golden section measurement of each half was taken in order to compare with the crux position (Table 1). Although GS proportion is not present, a mirrored symmetrical proportion is found: the crux occurs three measures before *phi* in the first half and three measures after *phi* in the second half. A proportion of +3 measure-differential (almost 4 measures) occurs when exclusively measuring the crux position of the recapitulation.

Table 2. Real-time comparisons at key moments (in seconds).

Real time	*Crux A1 ms. 13*	*Crux A2 ms. 13 (39)*	*End A1 ms. 26*	*End A2 ms. 26 (52)*	*End B1 ms. 43 (95)*	*End B2 ms. 43 (107)*	*Crux A3 ms. 52 (88)*	*Crux A4 ms. 52 (116)*	*End A3 ms. 64 (90)*	*End A4 ms. 64 (128) Total duration*
Asperen MM=128	11,294	35,357	23,713	47,790	65,435	102,401	73,318	110,197	84,748	125,991
Crudelli MM=126	11,379	35,861	24,403	48,774	66,685	105,434	74,537	113,202	87,077	128,896
Nicolson MM=120	11,834	36,628	24,883	50,000	68,579	108,028	76,761	116,186	87,077	131,788
Halton MM=113	13,506	42,483	28,587	57,613	79,386	123,419	88,519	132,452	102,235	149,432
Pogorelich Model MM=112	13,304	41,196	27,942	56,550	77,080	122,082	86,063	131,248	101,065	149,316
Harper MM=110	13,542	42,468	28,742	57,543	78,539	124,424	88,085	134,061	103,112	153,162
Tilney MM=110	14,252	44,176	30,048	59,786	81,062	125,922	90,541	135,561	104,998	153,074

Performers' proportion

Technical problems prevented the comparison of equal live (experimental group) and commercial recordings (control group): five commercial recordings (harpsichord, fortepiano, modern piano) were used and two live studio performances (harpsichord, modern piano). The performers of the live recordings knew of the position of the crux, although it is unknown whether the performers in the commercial recordings were aware of the position of the crux and chose deliberate interpretations.

Real time and equalized time timings

Using audio digital editors, time readings of performances of all performers were taken at several key moments (Table 2): crux A1, A2, end of A1, end of A2, end of B1 (end of modulatory part in ms. 43), end of B2, crux A3, crux A4,

Table 3. Equalized time comparisons at key moments (in seconds).

Real time	*Crux A1 ms. 13*	*Crux A2 ms. 13 (39)*	*End A1 ms. 26*	*End A2 ms. 26 (52)*	*End B1 ms. 43 (95)*	*End B2 ms. 43 (107)*	*Crux A3 ms. 52 (88)*	*Crux A4 ms. 52 (116)*	*End A3 ms. 64 (90)*	*End A4 ms. 64 (128) Total duration*
Asperen length ratio=0,843	13,326	41,814	28,166	56,640	77,502	121,351	86,779	130,556	100,412	149,316
Crudelli ratio=0,863	13,086	41,423	28,266	56,665	77,274	122,082	86,290	131,081	100,861	149,316
Nicolson ratio=0,882	13,256	41,323	28,156	56,607	77,641	122,370	86,962	131,547	101,000	149,316
Halton ratio=1,007	13,506	42,483	28,587	57,613	79,386	123,419	88,519	132,452	102,235	149,316
Pogorelich MODEL ratio=1,000	13,304	41,196	27,942	56,550	77,080	122,082	86,063	131,248	101,065	149,316
Harper ratio=1,0257	13,784	41,333	28,001	55,983	76,540	121,289	85,861	130,693	100,523	149,316
Tilney ratio=1,0251	13,784	42,950	29,296	58,324	79,053	122,823	88,286	132,262	102,393	149,316

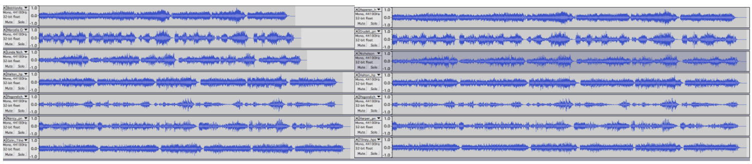

Figure 2. Real time and equalized timings; Pogorelich and Halton were the same in real time; all recordings were adjusted to Pogorelich's model for equalized timings. (See full color version at www.performancescience.org.)

end of A3, and end of A4. This information gave foreground or surface tempo measurements. Tempo and real time timings ranged from MM 110 to MM128 and from 125.991" to 153.074". To determine the internal or background

Table 4. Real time/reference model time: table ratio comparisons at key moments.

Real time/ reference model time	*Crux A1*	*Crux A2*	*End A1*	*End A2*	*End B1*	*End B2*	*Crux A3*	*Crux A4*	*End A3*	*End A4*
Asperen length ratio=0,843	0,8490 >0,843	0,8582 >	0,8486 >	0,8450 >	0,8489 >	0,8387 >	0,8589 >	0,8396 -	0,8385 >	149, 316
Crudelli ratio=0,863	0,8553 <(…)	0,8704 >	0,8733 >	0,8624 <(…)	0,8651 >	0,8636 >	0,8660 >	0,8625 -<(…)	0,8615 <(…)	149, 316
Nicolson ratio=0,882	0,8895 >	0,8891 >	0,8905 >	0,8841 >	0,8897 >	0,8848 >	0,8919 >	0,8852 >	0,8820 >	149, 316
Halton ratio=1,007	1.0157	1,0312	1,0230	1,0187	1,0299	1,0109	1,0285	1,0091	1,0115	149, 316
Pogorelich MODEL ratio=1,000	13,304 1,000	41,196 1,000	27,942 1,000	56,550 1,000	77,080 1,000	122,082 1,000	86,063 1,000	131,248 1,000	101,065 1,000	149, 316
Harper ratio=1,0257	1,0178 <!	1,030 >(…)	1,0286 >(…)	1,0159 <!	1,0189 <!	1,0191 <!	1,0234 <!	1,0214 <!	1,0214 <!	149, 316
Tilney ratio=1,0251	1,0712 >(…)	1,0723 >(…)	1,0753 >(…)	1,0572 >(…)	1,0516 >(…)	1,0314 >(…)	1,0520 >(…)	1,038 >(…)	1,0389 >(…)	149, 316

tempi of the performances, all recordings needed to be equalized to the same tempo-length. Pogorelich's recording was chosen as the model (Table 3) due to the steady and musical consistency of the performance (MM=112; 149,316"). Recordings longer than Pogorelich's were compressed; if shorter, expanded. When compressed, the time modification ratio is a number smaller than the model ratio of 1.000, and when expanded, it is larger than the model (Table 4).

Table 4 shows that when one compares the length-ratios of the recordings that were time-modified with the analysis ratios at the chosen key points that, in most cases, the performers tend to modify their overall tempo at those key points so as to stay closer to an underlying temporal framework that favors a clear, well-measured tempo. In the expanded recordings (Asperen, Crudelli, Nicholson), ">" indicates a convergence toward the reference model, or rather the analysis ratios that are larger than the length ratios indicate that the expansion of time is happening slightly faster around the analysis points (crux, etc.) and is going faster in order to catch up to the reference. The indication of (…) means that the result is contrary to the prediction. Thus, comparisons and analysis of length ratios reveal that Nicholson's performance has the highest rate of convergences toward the timings of the model at 100%: Asperen=88%, Harper=77%, Crudelli=55%, and Tilney=0%.

IMPLICATIONS

It is concluded that: (1) although the crux does not fit into direct GS proportions, the symmetrical mirrored relationship between the two halves of the sonata of three measures is significant, (2) when repeats are made by the performers, the length of the A section corresponds to the occurrence of the crux in the B section (52 measures), making a strong case for the necessity of the repeats, and (3) regardless of live or commercial recordings or choice of instruments, there occurred two performances of the same duration: Pogorelich (piano, commercial/model performance), Halton (harpsichord, live performance). We may infer that there is a proportional sense of crux by composer and by performers, which is evident in both foreground (surface) and background (structural) tempi.

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Piano playing skills in a patient with frontotemporal dementia: A longitudinal case study

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Patients with dementia, such as Alzheimer's disease, can continue to play the piano skillfully despite profound cognitive impairment. It has been suggested that this may be because these skills have been well-rehearsed and become automatic motor movements. Less is known about how these musical skills may be related to the performance of everyday functional abilities and, also, how the ability to play a musical instrument may be affected in other dementia types. Recordings of a patient diagnosed with behavioral-variant frontotemporal dementia, a dementia syndrome clinically characterized by marked behavioral and cognitive changes, playing the piano was taken 12 months apart. Aspects of musical performance (accuracy, tone quality, dynamics, rhythm, tempo, and interpretation) were rated by professional musical teachers. The physical and mental skills required to complete activities of daily living were assessed. Tests of cognitive functioning and brain imaging were also conducted over this period. Results showed that over one year, significant declines were observed in the areas of cognition, the mental abilities required for everyday skills, as well as brain atrophy on imaging. Physical skills for the performance of activities of daily living were relatively preserved, as was the ability to play the piano. These findings confirm previous reports and demonstrate the relative independence of procedural skills in the context of significant cognitive impairment in patients with dementia.

Keywords: frontotemporal dementia, piano playing; activities of daily living; cognitive assessment; neuroimaging

Dementias are progressive neurodegenerative brain diseases characterized by multiple deficits in cognition (e.g. memory, language, etc.), changes in behavior, and everyday functional impairment. Clinical profiles tend to be distinct for the different dementia types, although overlaps do exist. In contrast to cognition, musical skills may be well-preserved in dementia (Baird and Samson 2009), although this is an area that has not been well studied. Several case reports have described patients with Alzheimer's disease who remain capable of playing musical instruments skillfully over a number of years despite increasing cognitive deficits (Beatty *et al.* 1999).

Patients with dementia who have shown an ability to play musical instruments typically play pieces that have been well-rehearsed prior to the onset of disease. It is speculated that these skills may therefore reflect automatic motor movements which are reliant on the implicit memory system (Crystal *et al.* 1989). Some of these patients perform normally on tests of implicit skills (e.g. speeded mirror reading, Crystal *et al.* 1989).

The neural basis of preserved musical performance skills in dementia has been thought to rely on the motor circuits in the brain (i.e. basal ganglia, cerebellum, motor areas of the thalamus, and cortex; Beatty *et al.* 1999) as these remain relatively intact until the end stages of the Alzheimer's disease process.

No studies to date have compared musical performance skills with the formal examination of performance on activities of daily living (ADLs), abilities that can also be conceptualized as skills that have been learned and well-rehearsed prior to the onset of dementia. In addition, little is known about how musical performance skills may be affected in other dementia syndromes.

The aim of the study was to investigate change in piano playing skills together with assessments of cognitive functioning, everyday skills, and brain imaging over a 12-month period in a patient diagnosed with behavioral-variant frontotemporal dementia (FTD; Neary *et al.* 1998). FTD is a dementia syndrome clinically and pathologically different to Alzheimer's disease. It is characterized by marked behavior change and executive dysfunction. Brain pathology is most pronounced in the prefrontal and anterior temporal cortices.

METHOD

Case description

RD is a 70-year-old, right-handed man with 18 years of education and an amateur pianist. He has played the piano since childhood. In mid-2007, he was diagnosed with behavioral-variant frontotemporal dementia. Disease duration from the symptom onset to the time of the assessment was 3 years.

Procedure

Video recordings of RD playing Rachmaninoff's Prelude in C# minor (Edition by Jean St John) with the music score were obtained a year apart in 2007 and 2008. This piece was well known to RD prior to the diagnosis of dementia. At the time of the recordings, RD was playing it about once a week.

Each recording was subdivided into six sections of 30 to 60 s duration, and each section was rated for the following: accuracy, tone quality, dynamics, rhythm, tempo, and interpretation. Five independent raters who were professional music teachers and blind to RD's condition rated each aspect on a Likert scale (1-5, where 1=poor and 5=excellent) analogous to that used by Beatty *et al.* (1999). Intra-class coefficients calculated to examine agreement among the raters were statistically significant ($p<0.05$).

Cognitive ability and ADLs were also measured on these two occasions. Cognitive domains of orientation, memory, fluency, language, and visuospatial skills were examined using the Addenbrooke's Cognitive Examination-Revised (ACE-R; Mioshi *et al.* 2006). Physical and mental skills required to complete ADL activities were measured using the Assessment of Motor and Process Skills (AMPS; Fisher2003). In addition, high resolution structural T1 images were obtained on a 3T MRI scanner in 2007 and 2008. Percentage brain volume change was estimated using SIENA (Structural Image Evaluation, using Normalisation, of Atrophy; Smith *et al.* 2002), which is part of FSL (Smith *et al.* 2004, www.fmrib.ox.ac.uk/fsl).

RESULTS

At baseline, cognitive performance on the ACE-R was 70/100, which is below the cut-off of 82 typically used to indicate the presence of dementia. RD lost points primarily on the orientation, memory, fluency, and language sections of the test. Visuospatial skills were found to be preserved. At the 12-month follow-up, RD's score had dropped to 50/100; again, scores remained within the normal range for visuospatial skills.

On the AMPS, RD's motor and process scores at baseline were 1.61 and 0.64, respectively. Both these scores were below the level expected for his age, indicating impairment in physical and mental skills required to complete ADLs. At follow-up, AMPS motor and process scores were 1.32 and -0.09, respectively. The relative decline in the AMPS scores over this period was

Table 1. Mean ratings for eight attributes of RD's piano playing skill.

	Year 1	*Year 2*	$F_{1,8}$
Accuracy of notes	2.63	2.16	2.27
Tone quality	2.90	2.70	<1
Dynamics	2.67	2.37	1.31
Accuracy of rhythm	2.17	2.10	<1
Tempo	1.87	1.67	<1
Interpretation	2.23	2.10	<1

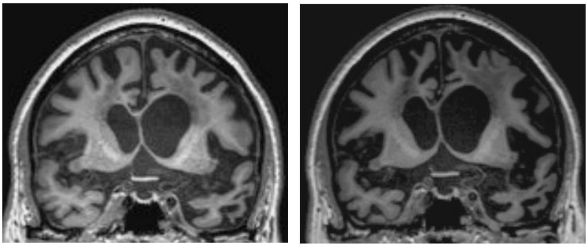

Figure 1. Coronal MRI T1 images obtained in 2007 (left) and 2008 (right).

smaller for the motor than process scales and suggests that the physical aspects of ADL performance were relatively preserved in RD.

Mean ratings for RD's piano playing for both recordings are summarized in Table 1. While all ratings of piano playing attributes at Year 2 were lower than at Year 1, none of the changes reached statistical significance.

Structural MRIs showed significant orbitofrontal and anterior temporal atrophy (see Figure 1), which became worse over 12 months. The estimated percentage total brain volume loss over one year was 3.17%.

DISCUSSION

This case study examined piano-playing skills in a patient diagnosed with behavioral-variant frontotemporal dementia over a 12-month period in conjunction with assessment of cognition, ADL abilities, and brain imaging.

Over the interval of one year, deterioration on formal assessment of cognition, functional abilities, and brain imaging was observed. In contrast, RD's ability to play the piano remained consistent over this period. These findings are similar to case reports in the literature of patients with Alzheimer's disease who have relative preservation of musical performance skills despite impairment in other domains (Beatty *et al.* 1999).

Although physical abilities required for the performance of ADLs remained relatively stable in RD over 12 months, the mental skills necessary for the same ADLs had worsened. This finding suggests that motor skills were reasonably preserved in RD and may have supported RD's ongoing capacity to play familiar musical pieces on the piano.

This case study has some limitations. First, the rating scale for the assessment of musical performance used emphasized the motor aspects of playing a musical instrument (e.g. accuracy of the notes and rhythm). The ability to convey the mood and nuances of musical pieces was not studied. Development of a scale to measure these aspects of musical performance will be of interest, particularly as deficits in emotion processing are a prominent feature of patients with frontotemporal dementia. Second, while there was an increase in atrophy over time, it is unclear where this may have occurred. Analysis of atrophy in the motor regions of the brain, relative to the frontal and temporal lobar areas, would also be of interest in the future.

Finally, RD was seen relatively early in the course of FTD. It is unclear whether there is a resilience of musical skills overall in dementia or whether different abilities decline at different rates with disease progression. Further longitudinal assessments of musical performance skills as well as cognition and activities of daily living should also be examined.

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Chin force in violin playing

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The aims of the present study were to develop a chinrest that could directly assess chinrest force during musical performance and to provide baseline force data. A force transducer-mounted chinrest was designed and built by the present authors. Data were obtained from 11 elite violinists while they performed scale tasks at different dynamics (*p*, *mf*, and *f*), tempi (1, 4, and 8 Hz), and hand positions (first and eighth). Data were also obtained from playing the tasks with vibrato, and the excerpts were from the Bruch and Dvorak concertos. A mechanical test of the chinrest confirmed good linearity of the force up to 100 N. During the scale tasks, chinrest force was around 14 N at *p*, which increased to 18 N at *f*. Neither the playing tempo nor the hand position largely affected the force, but it was significantly increased during vibrato. During playing the Bruch concerto, the force was elevated to 28 N (peak force=39 N; the peak-force range in all players=26-76 N). Typical chinrest force to stabilize the violin during ordinary musical performance is thus less than 20 N, but it can be tripled or more when performing technically demanding musical tasks.

Keywords: violin; chinrest force; force sensor; pedagogy

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The nature of professional accompanists and their roles: Performing with musical excellence and enjoying communicative interaction

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The aim of this paper is to explore the traits and roles of professional accompanists. This study is based on an internet survey. Professional accompanists were asked to complete a questionnaire through an internet website. The participants (n=96) identify themselves mainly as being sensitive, thoughtful, logical, and optimistic. At the start of rehearsal, accompanists generally try to establish a collaborative tempo and timing while seeing the big picture of the music. At the end of rehearsal, they concentrate on mood/feeling, dynamics, and aesthetic goals much more than at the start. Although some insist that accompanists should follow the soloist's expression, most accompanists enjoy and expect communicative musical activity within music. Expert accompanists point out that they have an important role in making music that is better than that created by the soloist him/herself. It would seem that professional accompanists should have an ability to perform with an overall structure of music with confidence from the very start of rehearsal. Furthermore, it is likely that particular techniques for accompaniment, including practical communication skills (social, physical, and musical), with flexibility and artistic excellence, have considerable influence on their work.

Keywords: accompanist; personality; rehearsal; roles; ability

Accompaniment has been researched by only a few authors, including Moore (1943) and Adler (1965), whereas there are more ensemble studies, for example, by Shaffer (1984) and Davidson and King (2004). Furthermore, Kemp explored musicians' personalities (1981, 1996).

The aim of this research is to investigate the nature of professional accompanists and their roles. In undertaking this research, I have set my heart on raising the status of professional accompanists, many of whom have excellent artistry.

METHOD

Participants

Two hundred and twenty professional accompanists were asked to fill in a questionnaire. The questionnaire was completed by 96 professional accompanists (experience of accompaniment: mean=23 years; men: n=38 and women: n=58) from 11 different nationalities. They are musicians (55%), school or piano teachers (11%), teaching staff in an academic position (10%), and others (19%). They accompany instrumentalists (34%), vocalists (32%), choirs (12%), chamber ensembles or orchestras (3%), all styles of ensemble (18%), and others (1%).

The criteria used in this study for professional accompanists are as follows: (1) people who have more than ten years of accompaniment experience; (2) people who have had formal education in piano performance or the relevant experience; and (3) people who identify themselves as professional accompanists and are paid from their accompaniment work.

Materials

This research is based on an internet questionnaire with 15 multiple choice questions, 23 rating scales, and 8 open-ended questions. The questionnaire covered personality, interests, rehearsal, solo/ensemble concerts, and ability.

Procedure

The questionnaire was uploaded onto a website, and the answers from the participants were analyzed.

RESULTS

Nature of professional accompanists

Personality

The accompanists describe themselves as being sensitive (60.4%), thoughtful (46.7%), optimistic (38.5%), logical (37.5%), inquisitive (31.3 %), calm/gentle (17.7%), quiet (12.5%), stubborn (11.5%), argumentative (7.3%), or something else.

Kemp (1981, 1996) explored musicians' personalities. He found high levels of tendency to introversion (self-sufficiency). In contrast, he found high levels of extraversion among keyboard players. In this research, the results also did not show the typical trends of introversion of the accompanists. Just 28.0% of respondents were classed as introverts, 39.6% as neutral, and 31.3% as extraverts. Furthermore, there are more accompanists who prefer to be a leader (38.9%), or are neutral (32.6%), than a follower (28.4%).

Interests

The accompanists take an interest in their own accompaniment work; 70.8% of the accompanists prefer ensemble to solo performance, 15.6% prefer solo performance, and 12.5% like both. Through their work, 83.3% of the accompanists expect musical communication within music, 57.3% expect musical aspects (e.g. sound) in ensemble, and 32.3% expect social aspects.

Accompanists with less than 25 years of experience expect more social aspects than those with above 25 years ($p<0.01$). On the other hand, performers who have accompanied for more than 25 years expect musical communication within the music more than less experienced players ($p<0.05$). Furthermore, accompanists aged over 60 expect more individual improvements than those in their 20's and 40's ($p<0.05$).

Roles and ability

Gaps between performers

The biggest gaps, that is, differences and difficulties between their co-performer(s) and themselves, which the accompanists experience are: tempo (35.8%), ritardando (30.5%), articulation (30.5%), and boundaries involving places (27.4%) and treatment (27.4%). They also feel gaps of different expression caused by a different instrument (22.1%), accelerando (18.9%), dynamics (18.9%), mood (17.9%), and tone quality (16.8%).

Pianists who have accompanied for more than 30 years, especially those aged 41-50 ($p<0.05$), feel more gaps of dynamics than less experienced players ($p<0.05$). Furthermore, pianists who accompany instrumentalists feel more gaps of ritardando than those who accompany singers ($p<0.001$).

Aims of rehearsal

Although the accompanists' aims changed throughout their rehearsal, the levels of attention toward every goal at the end increased considerably ($p<0.001$). Their main aim in rehearsal is synchronization. At the start, ac-

Table1. Aims of rehearsal with level of importance (1-10, with 10=very important).

At the start		*Mean*	*SD*	*At the end*		*Mean*	*SD*
1	Synchronization	8.5	1.9	1	Mood/feeling	9.7	1.0
2	Tempo	8.4	1.8	2	Synchronization	9.5	1.1
3	Mood/feeling	7.7	2.5	3	Aesthetic	9.3	1.3
4	Overall structure	7.5	2.4	4	Dynamics	9.3	1.2
5	Timing	7.3	2.3	5	Tempo	9.1	1.6
6	Dynamics	7.2	2.3	6	Characteristics	9.1	1.8
7	Characteristics	7.2	2.5	7	Overall structure	9.0	1.7
8	Motion	7.2	2.5	8	Timing	8.9	1.7
9	Aesthetic	7.1	2.6	9	Motion	8.9	2.0
10	Structure (local)	6.9	2.4	10	Structure (local)	8.4	2.2

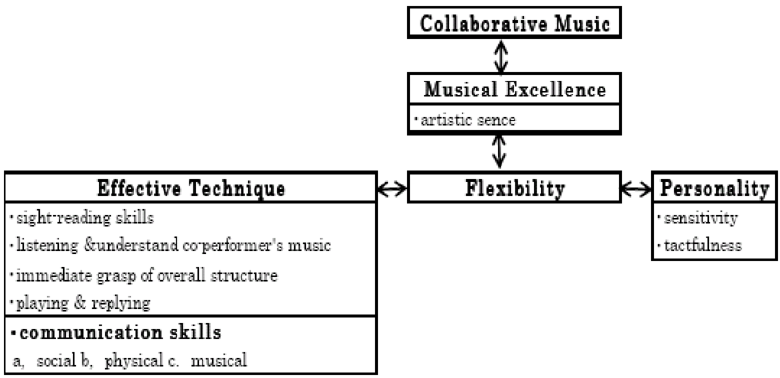

Figure 1. Abilities required as a competent accompanist.

companists generally try to establish a collaborative tempo and timing, while seeing a big picture of the music and its overall structure. At the end, they concentrate on mood/feeling, aesthetic goals, and dynamics much more than before (see Table 1).

Ability

As far as the accompanist's ability is concerned, three themes emerged: effective technique, personality, and musical excellence (see Figure 1).

Firstly, accompanists require a particular (effective) technique for their work. Most accompanists insisted that sight-reading, listening skills, and ability to have an immediate grasp of the overall structure of the music are important. Furthermore, accompanists report that communication skills have a significant influence on their work; these involve social, physical (keys of synchronization/leading the co-performer), and musical (give and take) skills.

Secondly, personality affects their work considerably. Most reported that sensitivity and tactfulness are important for their effective work and flexibility is a necessity. Without accepting and leading the other's expression and opinions, collaborative expression will not work satisfactorily.

Finally, musical excellence (artistry) was mentioned by a number of participants. Although some accompanists insist that they should follow the soloist's expression, the majority of accompanists would agree with expressions like these:

> Accompanists have an important role in making music better than that created by the soloist him/herself (participant 7).

> Make your partner comfortable, while not losing your own musical integrity (participant 91).

As a result, it seems that the levels of both performers' musicality and technique are the keys of successful performance.

DISCUSSION

The expression of a pianist (timing/dynamics) with a violinist (including their rehearsal) was investigated in my previous research (Kubota 2008). Student performers played a Mozart Sonata for Violin and Piano.

It seems that there is a difference in the process of rehearsal between students and professional accompanists. The student performers' aims of rehearsal at the beginning were solving technical problems, sharing general ideas, and synchronization, and at the end the aims were developing ideas with broad structures, more creative expression, and synchronization/fluency. The student accompanists' expression developed considerably throughout the experiment, especially in the period before a concert. It is likely that less experienced accompanists grasp the overall structure of the music gradually while practicing together. On the other hand, it seems that expert accompanists should have the ability to perform with appropriate and artistic interpretation of overall structure from the beginning.

> At the beginning of rehearsal, I prefer to seek a big picture rather than details. If all parties are well-prepared and experienced, the music will sync with minimum negotiation (participant 85).

Ensemble performance has the social and psychological aspects of music-making. Accompanists might be attracted by the art of synthesis.

> Accompaniment is the most rewarding and fun thing one can do as a musician! (participant 48).

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I would like to thank all the participants in this survey.

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How memory fades: Very-long-term recall of Bach

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A cellist memorized the *Prelude* from J. S. Bach's *Suite No. 6* for solo cello and identified performance cues (PCs) that she attended to in performance. During the next three years, she recalled the piece twice, playing and writing out the score from memory on both occasions, in counterbalanced order. Played recall was better than written recall. Written recall was better at expressive and structural PCs, suggesting that these cues provided content accessible access to declarative memory. Written recall was worse at PCs for basic technique but less so when written recall followed played recall. In written recall, serial cuing was impaired by the absence of sensorimotor cues, particularly at basic PCs. These directed the cellist's attention to her actions. Reinstating sensorimotor memory by playing through the piece reduced the impairment caused by the absence of these actions during written recall.

Keywords: music; performance; memory; cello; recall

The demands placed on memory during solo performance in Western art music are extraordinary. Not surprisingly, memory and attentional lapses are not uncommon. Thus, when preparing for a memorized performance, it is important for musicians to develop a memory retrieval system that is flexible and that will permit the performance to proceed whatever may go wrong (Chaffin *et al.* 2002, Lehmann and Ericsson 1998). During music performance, memory for what comes next is normally activated by *serial cuing* as the current passage cues motor and auditory memory (Chaffin *et al.* 2009a). Serial cuing has the limitation that the chain of cues starts at the beginning of the piece so that if the performance is disrupted the musician must start over. For this reason, experienced performers usually prepare an alternative memory retrieval system that provides *content addressable* access, allowing the musician to recall any passage in the piece by simply thinking of it (e.g. the "G section"). Content addressable access is provided by *performance cues* (PCs) representing landmarks in the music that the performer is able to think about consciously during performance. PCs provide a mental map of the music that allows the performer to monitor the performance as it unfolds and to recover from mistakes and memory lapses.

Written recall of the score has proved an important source of evidence that PCs provide content addressable access to memory (Chaffin and Logan 2006, Chaffin *et al.* 2009b). Recall is better at PCs representing musical expression and structure and declines in the bars that follow (an effect of serial position). This pattern suggests that musicians have content addressable access to memory at these points and then retrieve the following bars by serial cuing. In contrast, recall is poorer at PCs representing decisions about basic technique. One possible explanation is that musicians attend more to details of technique at these points and so pay less attention to the notes. We tested this explanation by comparing written and played recall of a well-prepared piece. We have reported elsewhere that the *written* recall was better at structural and expressive PCs and poorer at basic PCs (Chaffin *et al.* in press). Here we ask whether the same effects occurred when the musician *played* the piece at around the same time.

METHOD

Participants

Tânia Lisboa, the cellist and first author was trained in classical cello and piano in Brazil, England, and France and currently lives in London performing as a cello soloist.

Materials

The *Prelude* from J. S. Bach's *Suite No. 6* for solo cello explores both the mellow quality and virtuoso aspects of the instrument. The cellist had never learned the *Suite No. 6* for performance before, although she was very familiar with it and had played other works by Bach throughout her career. Written for an instrument with five strings, *Suite No. 6* presents contemporary cellists with substantial technical challenges, as fingerings and left-hand positions must be adapted to play the notes written for the fifth string on the four strings of a modern cello. Musically, however, the *Prelude* is comparable to the other five Bach cello suites. Notated in 104 bars in $^{12}/_{8}$ time, the piece takes about five minutes to perform.

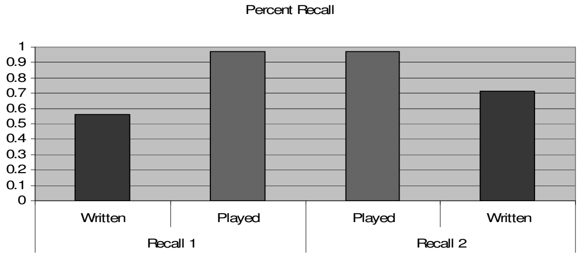

Figure 1. Percentage correct on two tests of written and played recall, shown in temporal order from left to right.

Table 1. Regression coefficients for the effects of serial position of half-bars from PCs on probability of correct recall for first/second written recalls.

Effect of serial position following	*Effects*	*Interaction indicating difference between recall tests*
Expressive PCs	-0.073*	0.033
Structural PCs	-0.032	0.025
Interpretive PCs	0.031	-0.007
Basic PCs	0.086**	-0.050*
Structural PCs x Expressive PCs	-0.018*	

Note. *p<0.05, **p<0.01, ***p<0.001.

Procedure

The cellist learned the *Prelude* for a series of eight public performances. She then provided reports about the musical structure and PCs she attended to during performance (expressive, interpretive, intonation, and basic technique) as part of another study (Chaffin *et al.* in press). Written and played recall were each tested twice in counterbalanced order. The first test began ten months after the last public performance with the cellist writing out the score from memory. She then played it from memory seven weeks later, recording her playing. Twenty months later, she began the second test by playing the piece from memory again, and then wrote it out for a second time four weeks later. She did not otherwise play or study the piece during this time. Written and played recall were scored for accuracy.

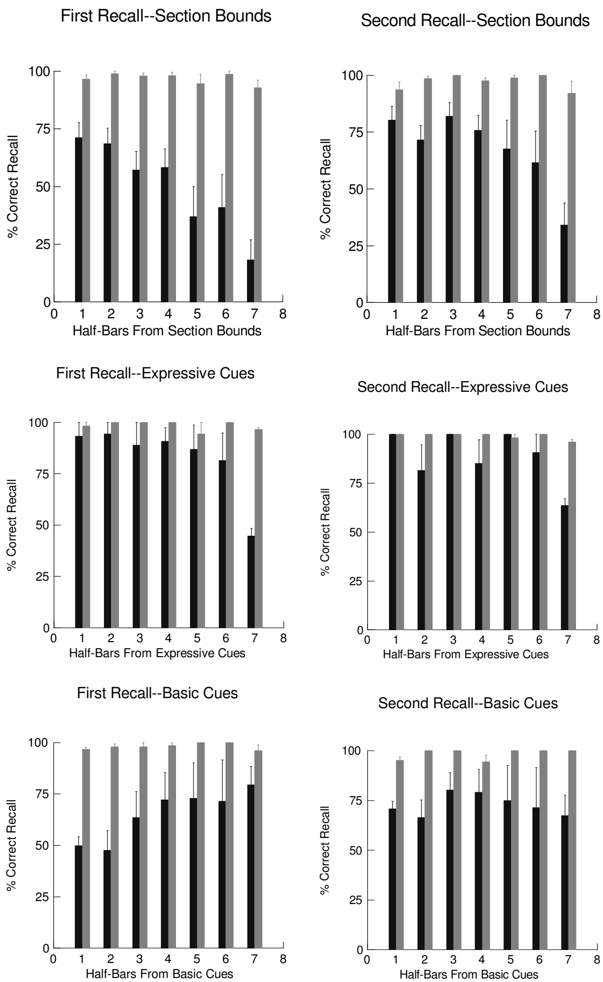

Figure 2. Mean probability of correct recall [written (black) and played (grey)] as a function of serial position of half-bars numbered sequentially from beginnings of subsections (structural PCs), expressive PCs, and basic PCs for first/second recall tests.

RESULTS

Recall was almost perfect for the two played tests and substantially lower for the two written tests (Figure 1). The difference demonstrates the large role played by motor and auditory memory. Written recall was better (71%) in the second round of testing than in the first (56%).

Table 1 summarizes the results of a mixed hierarchical regression analysis testing the effects of serial order and their interaction with the first and second set of tests. For beginnings of sub-sections and expressive PCs, recall declined as distance increased (see Figure 2, top and middle panels, respectively). For basic PCs, the effect was in the opposite direction—probability of recall was lowest at basic PCs and increased with distance—and was larger on the second test (see Figure 2, bottom panels).

DISCUSSION

The cellist's ability to play almost without error after more than two years of not playing or thinking about the music is notable. The cellist described the experience in an email to the second author shortly afterward:

> It is awful to play without having practiced the piece for so long because, besides memory, the hands feel soggy and I have no technical control of anything even when I remembered it. I…was hesitating all the way through but managed to get to the end. At some places…my fingers seemed to go by themselves…. Mostly, it was thinking of bowing and fingering (basic PCs) that…got me through.

At the end of this account, she points to the importance of the sensorimotor cues created by her playing, which provided effective serial cuing of her actions, even in the absence of any declarative memory for what came next.

Sensorimotor cues were important to both played and written recall. The reduction in sensorimotor cues in written recall explains why (1) written was worse than played recall, (2) written recall was worse on first test than on the second, and (3) written recall was worse at basic PCs. First, written recall was worse than played recall because it provided fewer sensorimotor cues for what came next. Second, written recall was better on the second test than the first, despite the passage of two years, because the cellist had recently refreshed her sensorimotor memory by playing the piece in the played recall test four weeks earlier. Third, written recall was worse at basic PCs because they directed the cellist's attention toward her actions and away from the music when learning the piece, so that in recalling it, she relied more heavily on cuing by the sensorimotor context. In written recall, the absence of the sensorimotor context provided by her playing had a bigger impact at basic PCs because she relied more heavily on these contextual cues at these points.

Thus, basic PCs operated as part of the serial chain of associations that reminded the musician of what came next (Chaffin *et al.* in press).

Structural and expressive PCs, in contrast, provided content addressable access to the cellist's declarative memory, allowing her to recall a passage simply by thinking of it. Direct access to these landmarks in memory produced better recall by allowing the cellist to recover and to begin writing again after gaps in her memory where she was unable to recall anything. Once begun, the memory of each passage cued recall of what followed until, at some point, a link failed and the chain was broken, resulting in a poorer recall as distance from the landmark increased (Roediger and Crowder 1976).

The results for the second written recall replicated the previously reported finding that her recall was better at expressive PCs than at the beginnings of subsections (Chaffin *et al.* in press). The difference supports the idea that expressive PCs marked the highest level in the cellist's hierarchical organization of the music into harmonic sections (marked by expressive PCs) and melodic subsections. By contrasting played and written recall, this study has increased our understanding of how basic PCs differ from other kinds of PCs.

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What do children think of music teachers? Their conceptions about cello teaching and learning

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We present an exploratory study about the conceptions held by basic level conservatory students about what they think of cello teachers and how different teaching strategies could improve their learning skills, focused on the educational-evolutionary variable. In this research, twelve Spanish children participated, and they were evenly in four different grades of basic level in Spanish conservatories. The main aim of this study was to describe, from a qualitative perspective, the different conceptions about cello teaching and learning. This project helped to develop and test the goodness of the materials, tasks, and criteria of analysis needed. Data were collected through a structured interview, which contained questions and tasks on five different studios related to teaching and learning musical instruments. It seems that children come with constructive ideas to the music lessons, but when they receive instruction, these ideas disappear gradually. Theoretical and educational implications suggested by the findings of this investigation are discussed.

Keywords: learning conceptions; music students; teaching approaches; learning outcomes; conceptual change

As is happening in other educational areas, learning and instruction of instrumental music performance is being subjected to changing demands. Both the curriculum reforms that have taken place and the development of recent research require a more constructivist approach to learning and teaching in this domain, which, however, is hardly seen in the music classrooms. We could find many different causes for the resistance to this educational change in music performance classrooms (e.g. Bautista and Pérez Echeverría 2008, Pozo *et al.* 2008, Torrado *et al.* 2005). Among them, this project focuses on

Table 1. Assumptions of the different theories about learning and teaching (adapted from Bautista *et al.* in press).

Assumptions	*Direct theory*	*Interpretive theory*	*Constructive theory*
Epistomological	Knowledge (partial and/or complete) reflects reality in a direct way.	Knowledge reflects reality in a blurred and distorted way.	Knowledge is a construction elaborated by the student, who builds own and personal models to interpret reality.
Ontological	Learning is conceived in terms of states or static products.	Learning happens over time, in a basic way, and it is conceived in terms of processes.	Knowledge is a construction elaborated by the student, who builds own and personal models to interpret reality.
Conceptual	A direct and linear relation is established between conditions and learning outcomes.	A direct and linear relation is established between learning conditions, learning processes, and learning outcomes.	A complex and interactive relation is established between the three learning components.

investigating the role of *the conceptions that students have about teaching and learning music,* as an essential component of their learning practices.

Research on the conceptions that students have on how to learn is still a nascent area, but remarkable importance has been obtained in the last two decades thanks to the research on metacognition, theory of mind, strategies and styles of learning, and conceptual change from the implicit theories in various domains (Pérez Echeverría *et al.* 2006). The studies carried out at the Autonomous University of Madrid concerning these conceptions have shown that achieving a constructivist approach requires a real conceptual change, a new mentality in teachers and students. This means that the implicit *direct* theory of learning (see Table 1), close to behaviorism, or *interpretive,* which assumes a cognitive activity by the student but subordinate to the achievement of results or learning product previously defined, should be changed to promote *constructivist* ideas, in which the student's mental activity is not only the engine but the goal of learning (Pozo *et al.*, 2006).

METHOD

Participants

This study was carried out with 12 cello students aged 8-12 years (5 male, 7 female) who were in four different courses of basic level (BL) in Spanish conservatories. While we were carrying out this study, all participants developed their activity in various official conservatories from the regions of Madrid and Valencia.

Materials

We designed and implemented structured individual interviews to assess the conceptions of children, through questions about processes, conditions, and results (in line with Pozo 2008). Starting from the interviews used by Scheuer *et al.* (2002, 2006) in their research with children, we designed different tasks which were the goal of this preliminary investigation.

We prepared three different videos responding to cases of the three implicit learning theories of teaching music. In these videos, a girl makes a pitch mistake in her weekly cello lesson and her teacher reacts to the situation in three different ways to help her, according to the epistemological, ontological, and conceptual assumptions of the theory in question (see Table 1). After the children watched the three videos, they were asked to choose both the "worst" and the "best" way of teaching, as well as justify their choice.

Procedure

The four teachers of the 12 students were first asked about the students' availability, and the parents consented to record the interviews. After this, the children were interviewed in their conservatory or at their homes, and the interviews were recording with a video camera.

In order to describe qualitatively these students' conceptions about cello teachers, tasks of choice and rank provided data that enabled descriptive statistical analysis (taking as independent variables the developmental and educational level). The relationship between their responses and the theory maintained was analyzed to check the consistency of these implicit theories.

RESULTS

While we should take the results with caution, because of the small sample size, they indicate that the children in the 1st basic level (BL) chose the *constructive* teacher as the best, while children in the 2nd and 3rd BL preferred the

Table 2. Selection of the "best" and the "worst" videos of ways of teaching for students in each basic level (BL).

Participants	*Direct*	*Interpretive*	*Constructive*
1st BL (8, M)	Worst		Best
1st BL (8, M)		Worst	Best
1st BL (8, F)	Worst		Best
2nd BL (9, F)	Best	Worst	
2nd BL (10, M)	Best	Worst	
2nd BL (10, F)	Best	Worst	
3rd BL (10, F)	Worst	Best	
3rd BL (10, M)	Worst	Best	
3rd BL (11, F)	Best		Worst
4th BL (11, F)	Best		Worst
4th BL (12, F)	Worst		Best
4th BL (12, M)	Worst		Best

direct or *interpretive* way of teaching. Finally, if the students in the 4th BL chose the *direct* way of teaching as best, they also thought the *constructive* was worst. Inversely, the students who chose the *constructive* did not like the *direct* way.

As appears in Table 2, the *constructive* method was chosen least as the worst method, while the *direct* method was chosen most as the worst. According to the children's responses and choices, it seems that they think both *direct* and *constructive* theories of teaching and learning could be good for learning, and their reasons for this are simple. For example, in their opinion, a good *direct* teacher is demanding of their students and uses techniques such as repetition and correction as teaching methods.

> Asking the students to play it, to play it, and, and, and, if they make mistakes, ordering them to repeat it until things work out more or less…demanding from them, because the mistakes should be mentioned, and if they make mistakes again, they should be asked to repeat again, and sometimes, if necessary, he may play with students.

When talking about why they felt the *constructive* theory was best, they said that a teacher using this method should involve the student in his own learning process in an active and reflective way.

> He shouldn't mention the error if you make a mistake, or mention what the error was, or how the error was made, but just talk with you, if a teacher doesn't let you figure out the mistake you made and the way to correct it.

> Because the teacher let the girl think, which was a good idea, and, and the girl will do so at home…because she helped the girl think of what happened and, and analyze what she can do to correct herself…. In fact, you learn a lot in this way…in order that she can realize her errors, and it was the method the teacher used.

Finally we asked about the worst theory, most students immediately cited the *direct* method. They felt this method could obtain results but that the student would not necessarily understand the process to achieve them.

> She ends up doing it…because finally she managed to do it due to the repetition, but it's not, not the best solution she can find…. She may be gaining bad habits at home because there's no one who can tell her, "wrong, repeat 5 times again." Well I don't know, but I think that it is the worst, at least for me, particularly for other students, but, because a teacher can be there without doing anything, but, always, always in some cases he does so.

DISCUSSION

We would need to interview more children in order to confirm these findings, but the trends suggest that children arrive at the conservatory with *constructive* ideas, and then, in advanced courses, they opt for simpler, less desirable designs, focusing primarily on learning outcomes. Such conceptions evolve gradually according to the educational-evolutionary variable, reaching again a more complex theory in the more advanced grades. Therefore, teachers should consider what to prioritize in their lessons and what is happening in the classroom when they have a student who comes with previous *constructive* ideas. Finally, they should observe if a student loses or modifies that idea when he/she comes into contact with the education center.

Presently, we are working on refining the tasks and extending the sample to compare children educated according to different types of practices.

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The use of musical scores in order to perform: An exploratory study with flute players

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Sixteen flute students at two levels of expertise from conservatories in Madrid participated in an individual semi-structured interview designed to explore the activities they carry out when they learn a new piece of music, as well as the elements of the musical score that they work on. The learning process was divided into three stages: beginning, middle, and end. Twelve categories of analysis were developed and chi-square was used. Differences in responses were noted between the students at each level of expertise for each stage of practice. Findings are discussed in relation to previous research in development of musical expertise.

Keywords: musical score; expert; novice; instrumental learning; flute

In the last decades there has been an increasing research interest in the development of expertise in musicians through the ways they learn and practice music. The musical score, a main element in most of the Western music learning processes taking place in conservatories, constitutes a semiotic system such as texts, graphs, maps, and numbers. These systems are powerful tools through which we develop and accumulate knowledge. Drawing on evidence from different fields, researchers have described different levels of comprehension relating to some representational systems (see Bautista and Pérez Echeverría 2008, Friel *et al.* 2001, Kintsch and van Dijk 1978). Studies of the development of interpretation suggest that some musicians plan interpretation at the outset, primarily letting the expressive ideas guide the technical work (Chaffin *et al.* 2003), while others develop a performance plan after mastering most of the technical challenges (Nielsen 2001). Although practicing notes and difficult passages are important aims for students at all levels, the experts are also interested in expressing a musical idea of the piece from the beginning of learning it, as professional musicians state they do (Chaffin and Imreh 2001). Novice students are mainly focused on reading and performing the explicit symbols presented on the score (Gruson 1988, Hallam 1994).

The aim of this research was to explore how Spanish flute students at two different levels of expertise used the musical score during their normal learning practices outside the lessons and the nature of the activities they undertook.

METHOD

Participants

Sixteen flute students from five different conservatories in Madrid (four intermediate and one tertiary) took part voluntarily in the study. They constituted two groups of different levels, each composed by eight students (five females and three males). The Intermediate ("I") group (mean age=21.1 years), was in its tenth year in the Spanish specialized musical education system, which is the last year before starting the music performance degree. The Tertiary ("T") group (mean age=24.4 years), was composed of flutists in the last two years of the music performance degree.

Materials

An individual interview was carried out with each participant. They were asked to describe the usual study process that they follow when learning a new piece of music. The interview was designed to explore the activities that the students do when practicing a new piece, as well as the elements of the score in which they focus their attention throughout their practice. The process was divided into three stages, corresponding to the beginning, the middle, and the end of the process. We suggested to the participants that they imagined they were preparing the piece to perform in a concert. In order to give them a context to explain the process, we used the piece *An Evening in the Village* by Béla Bartók (Sz. 39), in an arrangement for flute and piano.

Procedure

Participants were asked to read Bartók's piece in order to get an overview of it. This took around seven mins. After, they were interviewed individually for approximately 10-15 mins. Data were audio recorded and coded into themes using an iterative process described by Tesch (1990) as empirical phenomenology. A double category system was produced, which is presented in Table 1.

Table 1. Category systems.

Category	*Definition*
System A: Practicing	
Reading	Mentioning any kind of entire reading of the score.
Passages	Mentioning any group of bars that seem difficult for the students, to practice them separately.
Recording	Mentioning any kind of activity using a recording of the piece, but not when referring to record himself/herself.
Pianist	Mentioning any activity to be done with the piano accompanist.
Speed	Mentioning any activity that involves modifying speed of the score.
Memory	Mentioning any process of memorizing the piece.
System B: Score or instrumental elements	
Notational level	Mentioning any explicit mark on the score, apart from dynamics and regulators (rhythms, notes, accents).
Dynamics	Mentioning dynamics and regulators.
Syntactic level	Mentioning any term that implies to relate two or more elements from the score—for example, melody, structure, motif, phrase, etc.
Expressivity	Mentioning expressive terms, about character or musicality.
Style/composer	Mentioning something about composer, style and/or historic period.
Skills	Mentioning the practice of skills that cannot be included in any of previous categories, like pitch, breathing, sound, etc.

System A refers to activities to carry out when practicing a piece. System B refers to elements from the musical score or to the instrument. Three independent judges categorized 20% of the total responses. Inter-rater agreement level was calculated by Cohen's Kappa coefficient, which ranged from 0.75-1.00. We use statistic chi-square to analyze differences between groups for each category at each stage.

RESULTS

In the beginning stages (see Figure 1), the "I" group reported being mainly focused on reading activities, listening to recordings, and working on specific passages. References to musical elements included focus on the notes, rhythms, and indications about tempi. Students from the "T" group referred to reading processes and to selecting and working on difficult passages. In contrast to the "I" group, they referred to activities related to syntax such as

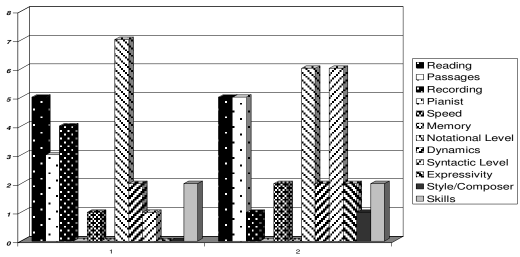

Figure 1. Categories reported in the beginning of the process (1=intermediate group, 2= tertiary group).

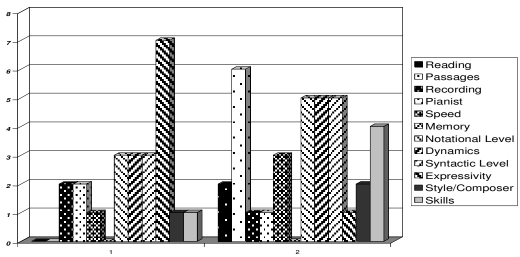

Figure 2. Categories reported in the middle of the process.

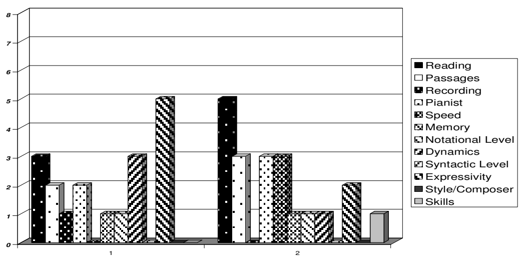

Figure 3. Categories reported at the end of the process.

identifying the structure of the piece, main themes, etc. These differences were statistically significant (X^2=6.35, p=0.012). In the middle stages, most students in the "I" group (88%) mentioned expressivity, and there was an increasing focus on dynamics. The "T" group demonstrated a less marked change from the beginning stage than the "I" group. Reading activities decreased with a greater emphasis on working at different speeds, developing skills, and focusing on specific passages and dynamics (see Figure 2). In the end stage, the "I" students continued to focus on expressivity and dynamics.

The "T" group referred to more activities (15 statements) than musical elements at this stage (5 statements). They seemed to return to a consideration of the piece as a whole with a reduction in the focus on specific elements from the score (see Figure 3).

DISCUSSION

The findings support those from earlier research demonstrating changes in the use of practicing strategies as expertise develops (Gruson 1988, Hallam 2001). The most expert participants approximated the pattern of learning reported by professional musicians, getting an initial overview of the work, identifying difficult passages and focusing on them, then as the performance neared focusing on the piece as a whole (Hallam 1995, Chaffin *et al.* 2003). Lane (2006) conceptualizes this as moving from macro to micro and returning to macro. Nonetheless, this pattern is not too clear and would need to be checked in further studies using a broader sample.

It is also relevant that the "T" group establishes relations among elements present on the score, which can be noticed by the presence of the syntactic level from the first stage of practice, whereas participants from the "I" group are mainly focused on notational elements at the beginning, moving from there to expressivity in the next stages. Although neither of these two groups can be considered novice, the high frequency of the notational level is relevant, mainly in the early stages of the learning process. According to previous research, experts are focused on expressivity from the beginning (Chaffin and Imreh 2001, Chaffin *et al.* 2003). This presence of notational level can be understood as the need to practice the elements on the score, which is a technical issue not related with the comprehension of the piece.

There are limitations in the extent to which the findings from this study can be generalized. It was an exploratory study based on a small sample of students, representing expertise on a single instrument, and who had undertaken their studies in a specific learning environment. In addition, the findings are based on self-report rather than direct observation of behavior itself. However, there is no reason to suppose that the conceptual strategies that the students reported adopting are not similar to those of other students studying in Western conservatories. Using categories as those developed in this research and studying the relationships established among them in each stage of practice can provide further evidence about comprehension and use of the musical score in instrumental learning processes.

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Pirouetting with pain: Attitudes surrounding female ballet dancers dancing with pain

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While female dancers performing classical ballet are expected to present an image of effortless grace, the actuality is often a much more painful experience. The current study examines questions related to this experience: what do dancers understand pain to be, why do they dance in pain, when should they stop dancing in pain, and how do they ultimately communicate this pain to others? This ethnographic research collects the views of current dancers, ex-dancers, dance teachers, choreographers, and artistic directors through in-depth individual interviews. The collected interviews are analyzed using Foucauldian perspectives of discipline, social hierarchies, power, knowledge, and discourse, along with feminist theory, prevalent physiological conceptions of pain, and contemporary theories of dance pedagogy, ethnography, and subjectivity. It is revealed through the interviews that pain is often a part of the dancer's life, a close acquaintance constantly watching over the dancer's shoulder. Pain is also seen to be instigated, influenced, and reinforced by the aesthetics, technique, institutions, and culture of ballet. The collected narratives demonstrate the highly subjective nature of pain and that the balletic environment still embrace a "no pain, no gain" mentality.

Keywords: ballet; pain; injury; aesthetics; ethnography

This research is driven by the key question: within the context of professional ballet, what are the attitudes surrounding female ballet dancers dancing in pain? The research focuses on the attitudes toward pain from the perspectives of dancers, ex-dancers, teachers, choreographers, and artistic directors, with my own personal experience also informing the research.

The term "pain" is complex, with multiple interpretations and meanings. Pain is defined in this research as "physical pain caused by noxious stimulus or bodily harm" (Melzack and Wall 1965, Woolf 1995, Loeser and Melzack 1999). This definition focuses on the physiological pain experience, rather than the psychological pain experience. Defining pain in this way is not to ignore how pain is also intrinsically linked and influenced by various psychological, environmental, and cultural factors. This research aims to draw on both a biomedical model of pain, and what could be described as a contextualist approach (Loland 2006) of how pain is interpreted and shaped within the social and cultural contexts in which people live.

The pain/ballet relationship can be seen emerging in academic scholarship, scientific research, autobiographical accounts, and performances, with a growing body of literature and research that investigates wider issues related to dancer's bodies, injuries, and health. Some notable quantitative research has investigated dancers' pain (e.g. Anderson and Hanrahan 2007, Encarnacion *et al.* 1999, Krasnow *et al.* 1994, Tajet-Foxell and Rose 1995). This research, although predominantly through quantitative investigation, is intended to provide an understanding and awareness that dancers are experiencing pain.

Significant qualitative readings of subjective scholarship has surrounded the dancers' body and aesthetics (e.g. Abra 1987-88, Foster 1996, 1997, Thomas 2003, Wainwright and Turner 2003a, 2003b, 2004, 2006, Wainwright *et al.* 2005). This qualitative research has illuminated attitudes surrounding dancers dancing with pain, though none of the above authors focus *specifically* on dancers and their attitudes toward the pain experience, which provides this research with a justification to address such a potential gap in the literature.

Krasnow *et al.* (1994) conducted research which demonstrated that most dancers do not seek medical treatment for injuries, with fewer than 50% of all dancers' injuries being treated by medical practitioners. There are various possible explanations for why dancers are hesitant to seek professional help for injuries, ranging from financial constraints, pressures from teachers, artistic staff or directors, as well as themselves, to continue dancing, and feeling that there is a lack of understanding from medical practitioners about their situation (Krasnow *et al.* 1994). Consequently, injured dancers may often rely on the advice from teachers and other dancers regarding how to treat and deal with pain and injury (Krasnow *et al.* 1994). Research has also queried whether dancers really can tell the difference between different types of pain (Anderson and Hanrahan 2007). Anderson and Hanrahan have found that dancers will endure performance pain or injury pain, and the type of pain experienced does not influence the cognitive appraisal made or the pain coping strategies used to manage the pain.

MAIN CONTRIBUTION

"I am a dancer, dancing makes me who I am.... Without it I wouldn't know who I was. I would feel like I would have lost my identity or at least a huge part of it" (Zoe). The use of the term "identity" has many and varied interpretations and meanings (Parfit 1971, Castells 2004). Identity can be described as "people's source of meaning and experience" (Castells 2004, p. 6). More specifically, one's own personal self-identity could be explained to be what makes each person "uniquely who they are" (Parfit 1971, p. 17), and further, our identity can be shaped and influenced by experiences, memories, and society (Parfit 1971, Wainwright and Turner 2004).

The subject of identity was an issue I did not foresee emerging from the interviews, though it was a discovery which gives context and understanding to the particular attitudes expressed by the interviewees. The dancers interviewed primarily identified themselves as dancers and expressed that the act of dancing contributed heavily to their identity. An interesting association emerged where dancers also often identified themselves with athletes in relation to their bodily experiences, understandings, and dealings with pain. Emily explains, "the thing is we are athletes, there is no difference."

All participants interviewed stated that they had danced in pain before. Some explained that they danced with some level of pain every day, such as Amy who states, "I would say every day in class or performance there is some sort of pain and something not quite right...." Others stated that they did not experience pain every day but only when their bodies had been overworked, they were performing new choreography, or they were managing or experiencing an injury.

The dancers interviewed often perceived pain as a purely physiological event, which was something they experienced in their body only, not in their mind. This raises the Cartesian dualist notion of mind/body separation, that the body is an object controlled by one's mind (Grosz 1994). This concept was carried throughout many of the dancers' perceptions and understandings of what they as dancers have to do, who they are as people and how they should respond to various pain situations. Several of the dancers revealed that they "chose" to ignore pain, stating that "I just block it out" (Amy) or "I don't choose to have it" (Tatiana). Such "mind over matter" in the ballet class or performance appeared to be entrenched in their thinking, with some of the dancers stating that they selected to ignore their thoughts and feelings of pain.

All interviewees voiced an understanding of the significance of the ballet aesthetic in relation to pain—that having the desired body type of long limbs, a well proportioned body, arched feet, and being slim yet strong, made the technique of ballet somewhat easier to physically perform and more aesthetically pleasing to the eye. Lisa, a dance teacher, explains this further: "...of course if helps to have the right body, it is a visual art form, and I think an audience wants to see a certain aesthetic.... [Ballet] can be so much easier when things like turn-out are naturally there, the right balance of strength and flexibility." Foucault's (1977a) notion of "normalization" of the body, through social practices and institutional structures and regimes, could be applied to the experience dancers have in trying to normalize their body into the ballet aesthetic.

From speaking to the interviewees it can been seen that pain is something that is part of their daily lives, so much so that many consider pain to be normal; yet most dancers felt uncomfortable to disclose or discuss pain openly. The lack of disclosure around the subject of pain was expressed by Kerry who said, "we don't discuss it, talking about it ruins the illusion that we work so hard for; talking about it puts us at risk of jeopardizing our opportunities...", or as Amy explains, "...it goes without saying that ballet hurts in some way at sometime, talking about it isn't going to change that; it will just make us look weak...."

The dancers, ex-dancers, and teachers and choreographers all spoke of the pressures from the ballet culture that contributed to dancers postponing the decision to seek treatment for pain or have time off dancing to let the injury causing the pain to heal. These included practical constraints of time, scheduling, and the need to produce a performance. Pressures felt by the dancers came from the company management, teachers, repertoire, and peers. This led to the feeling that their position in the company was not secure and that they were easily replaceable; moreover, time off from dancing was often seen as essentially "wasting time," jeopardizing their career progression. Foucault (1977b) describes culture as a "hierarchical organization of values, accessible to everybody, but at the same time the occasion of a mechanism of selection and exclusion" (p. 173). The ballet culture and hierarchy of the ballet company, with its own system of beliefs and structures, can shape how and when dancers decide to stop dancing with pain through the surveillance and disciplinary power it holds as an institution (Foucault 1977a).

IMPLICATIONS

From the analysis of the interviews and the narratives collected, it is apparent that dancers are dancing with pain. They are dancing for prolonged periods of time with pain. They often do not know when to stop dancing with pain and are fearful of the repercussions stopping dancing may have on their career and identity. In a dance style that is evolving, extending and creating new physical boundaries, while also trying to maintain and adhere to the structure and form of the classical aesthetic, do these attitudes surrounding female dancers dancing in pain need to change? It is one thing to acknowledge that there are particular attitudes towards pain in the ballet environment; it is another to demand that these attitudes must change. From this research it can be concluded that if we would like dancers to have longer and healthier careers with less physical pain, then yes, these attitudes will have to shift. The question of how this shift might occur within the balletic culture, which holds power over the dancers' bodies and minds, imposing constraints, prohibitions and obligations, is something that will take more than a "quick fix" solution and will require much research and investigation.

This research has not attempted to uncover one particular truth or prove a certain hypothesis; rather it has aimed to further open up a dialogue about ballet and pain, and through the collected ethnographical interviews and analysis, present multiple accounts and experiences. Ballet is not always easy; achieving the physical form it requires, and the mindset that allows this form to take place, may not always be pain free. Yet by beginning to understand how and why dancers feel the need to excessively conceal and silence pain, to dance through it, ignore it, even crave it, rather than listening to their bodies, there is potential to offer alternatives and directions to allow them to experience less pain while dancing.

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Cardio-respiratory responses to expressiveness in piano performance

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This study examined selected autonomic and cardio-respiratory responses of nine pianists during solo performances of the same single musical piece. The subjects performed the piece with and without self-perceived emotional expression, and with and without free ancillary body movements during expressive performance. Autonomic nervous system and cardio-respiratory parameters were continuously monitored during all experimental conditions. These parameters were heart rate (HR), sweating rate, the root mean square of successive difference (RMSSD) of heart rate variability, and respiratory measurements such as oxygen consumption (VO_2), minute ventilation, tidal volume, and respiratory rate. Kinematics of the trunk and arms were recorded during all conditions. The expressive condition had significantly higher levels of HR, sweating rate, minute ventilation, and tidal volume, and lower levels of RMSSD and respiratory rate than the non-expressive condition. No difference was found for VO_2 between these conditions. The expressive condition with ancillary body movements did not significantly differentiate any of the physiological measures except for respiratory rate from those without such body movements. These findings suggested that expressive musical performance could modulate the emotion-related autonomic and cardio-respiratory responses that are independent of the effect of physiological load due to expressive ancillary body movements in playing the selected music on the piano.

Keywords: expressive piano performance; heart rate; heart rate variability; autonomic nerve system; respiratory measurements

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The Listening Gallery: Integrating music with exhibitions and gallery displays

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The Listening Gallery is a collaboration between the Royal College of Music (RCM) and the Victoria and Albert Museum (V&A), the UK's National Museum of Art and Design. Stemming from recent research in music, art, design, and technology, the project connects objects in the V&A's collections with music that shares their rich and distinctive pasts. Specifically, new and existing recordings of music have been integrated into the V&A's spring 2009 exhibition, *Baroque 1620-1800: Style in the Age of Magnificence*, and into the museum's newly renovated *Medieval and Renaissance Galleries*. The impact of the project has been far reaching, as a novel approach to music in museums is achieved: the choice of pieces is underpinned by musicological research, performance follows the practices of the time, the instruments used are originals or faithful copies, and the provenance of the pieces is described. This article focuses on four new recordings that were made for the project. The objects with which the music is associated are briefly described, the connection with the music is explained, and details of the recorded pieces are given.

Keywords: museum; performance practice; medieval and renaissance art and music; recordings; historical instruments

Music has played a central role in popular and elite culture throughout European history, spanning sacred and secular spaces and representing private and communal experiences. Yet there was, until now, no museum of art and design that connected music and its performance with other art forms and objects in interactive and historically meaningful ways.

The Listening Gallery is a project in which new and existing recordings of music have been integrated into two major exhibitions at the V&A:

- *Baroque 1620-1800: Style in the Age of Magnificence*, a temporary exhibition in Spring 2009, which has subsequently travelled to other international venues
- *Medieval and Renaissance Europe*, a series of eleven newly refurbished permanent galleries, which re-opened in December 2009

The exhibitions provided an opportunity to incorporate music into galleries covering sacred and secular, northern and southern European art, between 1100-1800. The unparalleled variety of musical styles, genres, and instruments covered across this period required musicological knowledge drawn from a wide range of sources (e.g. *Medieval:* Testi 1969; *Renaissance* Gallico 1978, Fenlon 2002; *Baroque:* Fortune 1987, Bianconi 1991). In addition, the input provided by performers for the recording of new works proved essential, particularly for the earliest works where hands-on music making is often the best means of addressing interpretative questions (Nuti 2007).

The Listening Gallery demonstrates how the past, so clearly portrayed in the V&A's galleries, is to be discovered in music as well as other arts by providing music appropriate to the objects on display. Historical events, patronage, and fashions all contribute to changes in style that are reflected as much in music as they are in art and sculpture.

MAIN CONTRIBUTION

The expertise in music, history, and art that the project has brought together has given rise to *new* knowledge on performance. The examples of new recordings provided below are presented under separate headings, either *Baroque 1620-1800* or *Medieval and Renaissance Europe*. The rooms in which the music is heard, as well as the objects with which the music is associated, are briefly described in order to place the music in context.

Baroque 1620-1800

The magnificence and splendour of Baroque, one of the most opulent styles of the seventeenth and eighteenth centuries, was the subject of the V&A's 2009 spring exhibition.

A recording of Davide Perez (1711-1778), Domine Deus, from the Messa con 5 strumenti, c.1750

The *Sacred Spaces* section of the exhibition was dedicated to religious devotion and the ritual of Mass. Displays included Portuguese artefacts made in

Rome, for consumption in Portugal, during the reign of John V. The *Model of the Chapel of St John the Baptist in the Church of São Roque, Lisbon* (Rome, 1742-44), by Giuseppe Palmes, after drawings by Luigi Vanvitelli (1700-73), is a testimony to the characteristic of artefacts built in Portugal during this period: the influence of Italian style and artists. This became the focal point around which the music was chosen.

In 1743-44, the Portuguese king John V ordered a team of artists based in Rome to build, decorate, and fit out a royal chapel for the Jesuit church of São Roque in Lisbon. In 1751, John V called the Neapolitan composer Davide Perez to Lisbon. Under his influence, Portuguese music—both sacred and secular—became entirely dominated by the Italian operatic style, as is immediately apparent upon hearing this recording.

The music associated with this splendid altarpiece highlights the stylistic influences between Rome and Lisbon, felt as strongly in music as in art and architecture, and the influence of Italian opera in Portuguese music post-1750, including sacred music.

The manuscript of Perez's Mass is held in the RCM Library, MS 977. The *Domine Deus* was recorded in the RCM Studios in February 2009, with the orchestra and five soloists directed by Ashley Solomon. It is the only existing recording of this piece.

Domestic music for spinet and other instruments: A recording of RCM MS 2093

As well as the music for great religious occasions and occasions of state, the baroque period enjoyed performance of more intimate music for the delectation of a smaller audience; lesser households, too, could command music as integral to that richness of lifestyle.

The *Secular Spaces* section of the exhibition, in which the recording of music for spinet and other instruments could be heard, focused on the most intimate part of a household: the bedroom and closet. Beyond the "public" rooms of a house, in which guests were welcomed, the bedchamber was open only to the select few. Into the inner sanctum of the dressing room and closet was packed a level of furnishing and luxury unseen outside. The exclusivity of these rooms and their relative lack of ceremonial function also made them the setting for influential innovations in furniture and interior decoration. Among the objects that would have been found in these most intimate rooms is the spinet, a small keyboard instrument of the harpsichord family.

The main instrument used in this recording was built in London in the 1680s by Stephen Keene, preserved in the RCM Museum of Instruments

(RCM 179). The instrument's case is made of walnut wood, and there is a special decorative laburnum wood veneer on the panel above the keyboard.

The music in this recording is taken from a single, late-seventeenth century English keyboard manuscript belonging to the RCM Library, MS 2093. Although its ownership is uncertain, the manuscript is typical of the "virginal" books used to tutor players, especially women, at the time. It is remarkable for two reasons. Firstly, its contents are divided into two collections, one of preludes and the other of fugues. Secondly, it preserves pre-civil war music by Byrd, Bull, and Weelkes, alongside later Baroque composers such as Locke and Blow.

The recording of RCM MS 2093 was made in the RCM Museum in February 2009, with RCM students of harpsichord, violin, and recorder performing under the direction of Terence Charlston. This is the first recording of the manuscript, an important exemplar of virginal music of the period, as well as a testimony of the intimate type of music that would have been heard in a seventeenth century English home.

Medieval and Renaissance Europe

Medieval and Renaissance Europe is a major re-interpretation of a series of eleven permanent galleries in the V&A that opened in December 2009. The galleries will have a minimum lifespan of 25 years. The museum's collection is one of the finest in the world and covers European art and architecture from 800 to 1600.

A Missal from St Denis, Paris, c.1350

A missal is a book that contains the texts and music needed by a priest and choir to celebrate Mass. This highly decorated missal was probably made around 1350 in Paris for use at one of the altars at the royal abbey of St Denis. Research into the service books and the liturgical life of the abbey (Robertson 1991) led to the identification, performance, and recording of the Dionisian sequence *Salve Pater Dyonisi*, which would have been performed on the Feast Day of St Denis.

Many recordings of Gregorian chant are available commercially, yet this is the first recording to be made of *Salve Pater Dyonisi*, or indeed any part of the St Denis Missal. There are seven verses that praise St Denis and his two co-martyrs, St Rusticus and St Eleutherius. The words are sung in Latin to a tune that was borrowed and adapted from pre-existing pieces to create a fresh and new work. The recording was made in June 2009 at the Parish Church of

Our Lady of Mount Carmel and Simon Stock, London. Five male voices were used, under the direction of Jennifer Smith.

Notation knives

"One of the rarest sixteenth-century objects on display in the new Medieval and Renaissance Galleries at the V&A is both a knife and a piece of music. On one side of the broad blade of this hybrid exhibit is a clear, perfectly notated musical inscription of a blessing of the table, to be sung before a meal; on the other, a prayer giving thanks, to be sung when the meal has ended. Although we do not know where or for whom this curious object was made, it reveals a fascinating relationship between music and the material culture of the table during the sixteenth century, and represents the important formal role played by music in the rituals of dining" (Dennis in press).

As part of the project, the beautiful Grace and Benedictus engraved on this unusual notation knife were transcribed and recorded. It is the only existing recording of these blessings, or indeed—and surprisingly—of any of the music that is not infrequently found on Renaissance household objects such as cutlery and maiolica plates.

Four singers were recruited to sing *a cappella* for this recording; RCM students, under the direction of Giulia Nuti, recorded the notation knives in June 2009 in the RCM Studios.

IMPLICATIONS

The Listening Gallery has far reaching implications. The most obvious and immediate benefit has been for visitors to the V&A. The music performed on the four recordings discussed above originates from precisely the same years, from the same cities, and is chosen from works commissioned by the same patrons who commissioned artefacts on display in the exhibitions. The recordings of Perez and RCM MS 2093 are contemporary with their corresponding objects and have the same provenance; in the case of the missal and the notation knives, the music is actually written on the objects.

Much of the music associated with the objects in the Galleries was recorded for the first time for this project. Much of the music can now be heard via the V&A's website, with annual online traffic of approximately 15 million people. For further information on the pieces discussed above, see www.vam.ac.uk and www.listeninggallery.rcm.ac.uk.

The project has demonstrated that music and musical performance were central to the domestic and public life of those periods and how the experience of music and art reunited reveals much about Europe's geographical and cultural diversity. The objects on display, together with the worlds they represent, have been experienced today as they would have been in the past.

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Difficulty of violin vibrato in novice players: Fingerboard reaction force analysis

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The aim of this study was to investigate the difference in the nature of shaking (the longitudinal and lateral components) and press (the vertical component) forces during the production of a vibrato tone by 10 novice players as compared with 10 expert players of the violin. A violin installed with a 3-D force transducer was used for the measurement of the force while performing a successive A (open) and D (vibrato and force measurement) tone production task for 30 s at 4.5 Hz vibrato rate at *mf* (75-77 dB). The index, middle, ring, and little fingers were used for the measurement. The average, amplitude, and peak-to-peak time of shaking and press forces were evaluated for each trial data. The results indicated that the intra-individual variability of the amplitude of shaking force and its peak-to-peak time for all fingers was significantly larger for the novices than the experts. The novices had smaller mean values of shaking and press forces than the experts, and this group difference was larger for the index and little fingers than for the other fingers. Novices have been believed to use a grip too firm to shake the hand. The present data suggest that it is the opposite.

Keywords: violin; vibrato; finger force; novice; finger difference

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Musical learning and cognitive performance

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According to literature, there are broad associations between music and cognitive abilities, which apparently result from the frequency of music lessons. The aim of the present work was to test these associations between a group of music students and a control group of students with no music education, thereby contributing toward understanding the link between music learning, intelligence, and academic achievement. The Battery of Reasoning Tests (BPR/7-9), collated for the Portuguese population, as well as the academic classifications of two groups of students, provided the basis for this study's quantitative analysis. The sample population comprised students who frequented Year 7 of the basic music course in specialist music education and of the basic course in mainstream education (no music lessons). Compared with the students in the control group, those in the groups which included formal music education showed increases in their general capacity of reasoning (g factor) and in tasks of spatial and numerical reasoning. Equally, there were increases in academic achievement. The results suggest that the duration of exposure to music lessons is associated with an increased intelligence and increased academic achievement.

Keywords: specialist music education; mainstream education; general capacity of reasoning; academic achievement; cognitive skills

It has been suggested that music may be more than just an art form, and that it may indeed be able to produce benefits in other domains, such as cognitive abilities or general intelligence. According to Schellenberg (2005, 2006a), different lines of research have shown that both passive listening to music and formal musical training reveal such a connection. However, the differences between these two activities make it unlikely that both could have similar effects upon the non-musical aspects of human behavior (Schellenberg 2006a). This study focuses upon the hypothesis that music lessons could provide benefits in non-musical areas of cognition.

Of the musical activities that appear to improve cognitive performance, the most significant appear to be the playing of a musical instrument (particularly keyboard instruments), vocal training, musical learning in general, and rhythmic training. The underlying transfer effect (Barnett and Ceci 2002) may prove to be unique in children that have received music lessons for prolonged periods; as such, lessons involve activities such as:

> Focused attention…, regular…practice…, reading music, memorizing extended passages and entire pieces, learning about rules of pattern formation that define western musical structures…, incremental improvement of fine motor skills…, and learning to express emotions through music… (Schellenberg 2006b, p. 466).

The combination of these activities with genetic predisposition and environmental factors may play an important role, not only in music but also in other areas of cognition (Barbro 2006), particularly during childhood when cerebral development is still very flexible (Huttenlocher 2002).

Some researchers believe that music lessons are associated to specific sub-areas of intellectual skills. These include spatial skills (Bilhartz *et al.* 2000, Rauscher *et al.* 2006), reading (Lamb and Gregory 1993, Butzlaff 2000), subcomponents of literacy such as vocabulary (Orsmond and Miller 1999) and verbal memory (Ho *et al.* 2003), mathematics (Vaughn 2000, Maureen 2008), and mathematical subcomponents such as arithmetic (Rauscher *et al.* 2006) and geometry (La Mont 2008). According to Schellenberg (2004) "the most parsimonious explanation of these diffuse associations is that they stem from a common component, such as general intelligence" (Schellenberg 2004, p. 511). Schellenberg (2004, 2006a) also claims that music improves general intelligence. Increased intelligence and enhanced performance in subtests for academic competence were found in music students. There is also evidence that the duration of musical training is positively associated to intelligence, and that this association is general (i.e. not limited to a specific subgroup of intellectual skills) (Schellenberg 2006b).

The research described in this paper examines associations between music lessons and general capacity of reasoning (the so-called "g factor"), and between the duration of the musical training and the increase in the general capacity of reasoning. The performance of music students in each reasoning task (abstract, numerical, verbal, mechanical, and spatial) was compared with that of students who had not had music lessons. The general academic performance of the students was also taken into account.

METHOD

Participants

The sample population (n=134) consisted of students from the seventh grade of the basic music course (specialized musical education program), and others undergoing conventional education. The average age was 13 years. The students were divided into three groups, two experimental and one control: (1) students receiving specialized musical education, who had had between 5-7 years of musical training (n=63, "SME 5-7"), (2) students from specialized musical education with 3-4 years of musical training (n=21, "SME 3-4"). The control group (n=50) consisted of students undergoing conventional schooling ("CS"), which did not include music lessons. All students were from a similar socioeconomic and cultural background.

Materials

The data used in this study was obtained using a Battery of Reasoning Tests, BPR/7-9 (Almeida and Lemos 2006), designed to assess general capacity of reasoning (g factor). These tests, which had been specially adapted to the Portuguese population, included five instruments to evaluate performance in different tasks of reasoning: abstract, numerical, verbal, mechanical, spatial.

Procedure

The participants were recruited from ten schools around Portugal by means of an invitation addressed to their parents or guardians. The pupils were tested individually using the BPR/7-9 at the beginning of the school year. Statistical tests were then performed to gauge differences between groups.

RESULTS

Comparing the average g factor scores, it was found that the SME group with 5-7 years of musical education had the highest average, followed by the SME group with 3-4 years of musical education (see Figure 1). Sheffé's post hoc tests showed that only the differences between the groups "CS" and "SME 5-7" were significant (mean difference=-2.12, SE=0.493, p=0.000). In short, the students that had musical education displayed a higher general capacity

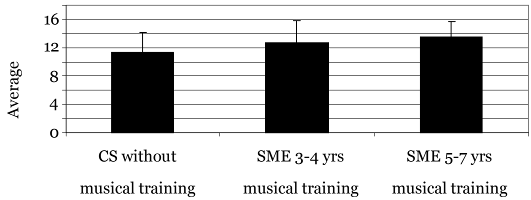

Figure 1. Mean general capacity of reasoning for the CS, SME 3-4, and SME 5-7 groups.

of reasoning than the students from the control group, a difference which became more pronounced with the duration of musical training.

Using MANOVA, the performances of the three groups was compared with relation to each task. Scheffé tests were used to assess the differences between the various tests in the three groups. Although the students from the SME 5-7 and SME 3-4 groups scored better than those from the CS group in abstract and verbal reasoning and those from the SME 5-7 group scored better than the CS group for mechanical reasoning, the differences were not significant. However, in the spatial reasoning tasks, the difference between the averages obtained by the CS group and the SME 5-7 and SME 3-4 groups was significant (respectively, mean difference=-2.97, SE=0.710, p=0.000, and mean difference=-2.44, SE=0.974, p=0.046). In the numerical reasoning task, there was a significant difference between the CS group and the SME 5-7 group (mean difference=-3.15, SE=0.666, p=0.000).

DISCUSSION

The results of this study corroborate the hypothesis that there is a significant relationship between musical education and cognitive growth. This association between the general capacity of reasoning and the number of years' involvement with musical education is confirmed by literature dealing with the relationship between musical education and cognitive ability (Schellenberg 2005). As in some of the studies cited above, this research showed that associations were limited to specific tasks. However, when we considered educational performance as a whole, it was found that music lessons affected general intellectual abilities. Students that had a musical education generally obtained higher grades in academic achievement than their counterparts who had not, and this difference seemed to increase with the number of years of music lessons. We might infer that music lessons play an important role in the results achieved, rather than extracurricular activities as this was tested elsewhere (Santos-Luiz *et al.* 2009).

The music students in our sample had been tested for musical aptitude, among other things, before embarking on their musical studies. Researchers examining whether musical aptitude is associated to other cognitive capacities have noted that performance in this type of task tends to be positively correlated with general intelligence (Lynn *et al.* 1989). Therefore, it is possible that increased musical aptitude through musical training is accompanied by improved general cognition (Schellenberg 2006a).

The association of music with intelligence and academic performance may result from a simple characteristic or from a cluster of abilities that are fostered by musical education or musical stimulation. Musical structures are abstractions that involve a range of transformations, and mental representations of music must be sufficiently abstract to allow recognition of similarities between varying patterns. Formal musical training may promote the ability to recognize regular patterns and think in a flexible way (Schellenberg 2006b). These abilities are central to the g factor. This study therefore appears to corroborate the assumption that there are associations between music lessons and intellectual ability, although further research is required before this can be asserted with confidence.

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A longitudinal observation of one-to-one singing lessons: The effects of personality and adult attachment

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Instrumental and singing teaching has previously been studied with particular focus on pedagogical, cognitive, technical, and developmental aspects. However, the relationship and interactions that take place between the teachers and students in that setting deserve more extensive exploration. This study approaches the singing teacher-student relationship with a particular focus on the observation of personality traits and the levels of attachment identified between teacher and student. Eleven singing teachers with 54 students were observed in one-to-one singing lessons through video observations made during one academic year. Additionally, teachers and students completed the questionnaires NEO FFI-R and Adult Attachment Scale to evaluate personality and attachment. The interaction between teacher and student include a wide list of variables: personality combination, the individual background, kind of attachment felt toward each other, and many other singing aspects, suggesting that the relationship with the student could have major impact on other aspects of singing.

Keywords: singing; relationship; adult attachment; longitudinal; personality

Instrumental and singing teaching has previously been studied with particular focus on pedagogical, cognitive, technical, and developmental aspects. However, the relationship and interactions that take place between the teachers and students in that setting deserves extensive exploration.

Teacher-student interactions have powerful potential to improve and facilitate learning (Siebenaler 1997), with relationships playing a role in student's development. Burland and Davidson (2002) suggest that the teacher in a "master-student" relationship plays a "vital role" in the development of the student's performance, as well as in their overall artistic personality, and that students who do not find the ideal teacher may have consequences reflected in their professionalism and artistry. The interaction of teacher and student may constitute an important base for the students' knowledge building. With the purpose of exploring these interactions between the teacher and student, this study aims to (1) identify behavior in a longitudinal relationship of singing teacher and student, (2) analyze the effects of personality and adult attachment on singing teacher and student relationship outcomes, (3) distinguish combinations of singing teacher and student characteristics.

METHOD

Participants

The participants in the current study were 11 singing teachers and 54 undergraduate and postgraduate students from six colleges and universities in the UK and Portugal. All students were studying singing as their main instrument. From the same sample, 35 participants completed personality and adult attachment scale measures.

Materials

The study had three stages where participants were video recorded during one academic year. These recordings were complemented with existing psychological questionnaires in order to access the personality types and the levels of attachment in each dyad. For the personality identification, the NEO FFI-R by Costa and McCrae (1985) was used, and adult attachment was measured using the Adult Attachment Scale by Collins and Read (1990).

Procedure

Six higher education institutions (universities and colleges) from the UK and Portugal were contacted through their heads of vocal studies. These two countries were chosen to allow a wider range of comparison and a diverse cultural environment. The head of vocal studies were asked to choose several singing teachers who were seen as being different or contrasting in relational terms, and these staff were approached for a longitudinal video collection of their singing lessons. The teachers who agreed to participate were then asked to choose at least two contrasting students that would follow these differences: (1) age, (2) academic year, (3) levels of development, (4) that the teachers felt they related to in different ways, and/or (5) students they felt approached their teaching differently. No reference to gender was stipulated. At the second and third stages of video recordings, the teachers and students completed the personality and attachment tests.

RESULTS

Ongoing analysis illustrates that the interaction between teacher and student includes a wide list of variances: personality combination, the individual background, kind of attachment felt toward each other, and many other aspects suggesting that the relationship with the student could have major impact on other aspects of singing. The longitudinal observation indicated that the relationships develop into becoming more personal and often include elements from the personal lives of both teacher and student. These elements of students' lives are often used toward interpretative development and become interesting strategic tools for the singing teachers. The relational interactions between teacher and student are in all cases conditioned by the academic year's schedule and there is a noticeable peak of relationship approximation during the middle stage of the year in relation to the beginning of year (where participants are getting to know each other) and the last stage (where the pressure of examination normally drives the lesson).

The observational part of the study presented fluctuations of behavior and adaptability between teacher and student during the course of the one academic year. Particularly interesting to note is the teachers' adaptability to each student, making the relationship unique. The personality and attachment types of each participant seem to play an important role in the individuality of each relationship.

DISCUSSION

This study observed the psychological involvements of the teacher-student relationship and the effects of those in the behavior in each lesson and from a longitudinal perspective. The personality combination between teacher and student, and the kind of attachment that is implicit in this relationship, may be a predisposition for successful or unsuccessful relationships.

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Emotional lingering: Facial expressions of musical closure

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We report evidence that singers maintain emotional facial expressions after vocalization has terminated, introducing a form of emotional lingering. Emotional lingering extends and complements acoustic signals of emotion, providing a visual signal of musical closure. We first describe evidence from production studies that emotional facial expressions continue beyond the acoustic dimension of music. We next describe evidence that perceivers are sensitive to facial expressions that occur beyond the production of sound, and that such signals carry reliable emotional information. We note that audiovisual experiences of music are compatible with current understandings of multisensory integration in the central nervous system. As such, investigations of performance should include consideration of facial expressions and other performance gestures.

Keywords: music cognition; emotion; singing; closure; facial expression

Music is a powerful medium for conveying emotion (Juslin and Sloboda 2001). Emotional information is carried not only in musical sound; it is also signaled in the facial expressions of performers (Livingstone *et al.* 2009, Thompson *et al.* 2005, Thompson *et al.* 2008). This paper concerns the nature and significance of facial expressions during sung music performance, focusing on expressions that occur immediately following the cessation of vocal production.

Effective singing requires a stage in which plans for vocal and emotional expression are created, coordinated, and implemented. Vocal planning facilitates accurate production of pitch, timing, intensity, and vocal quality (timbre). It recruits a range of muscle groups including the vocal cords, throat, face, and other parts of the body that support vocal production. The nature and time course of vocal planning can be inferred by examining subtle movements in these muscle groups that occur prior to sound production. Such movements reflect a dynamic process in which action and decision-making are tightly coupled (McKinstry *et al.* 2008).

Muscular activity associated with emotional communication overlaps with muscular activity used for effective singing, but it is not identical. While a performer is singing it may be difficult to disentangle movements that support accurate vocal production from those that support emotional communication. Similarly, movements that occur immediately prior to vocal production combine plans for accurate vocal production with plans for emotional communication.

Once vocal production has terminated, however, the bodily movements and facial expressions that persist cannot be interpreted as a reflection of vocal production mechanisms. Emotional facial expressions linger beyond the time it takes to deactivate muscular activity, often lasting several seconds or more. Such activity can only be interpreted as a constituent of emotional communication and is referred to as *emotional lingering*.

Emotional lingering can be investigated in both production and perception studies. First, facial expressions and other movements that occur following the cessation of vocal production can be captured and analyzed using technologies such as motion capture and electromyography. These strategies can be used to confirm the existence of emotional lingering and determine its properties and time course. Second, perceptual studies can be used to determine how perceivers are affected by emotional lingering phenomena. Do facial expressions that persist beyond the termination of sound provide reliable emotional information, and do they influence emotional interpretations of the music?

Livingstone *et al.* (2009) confirmed that singers maintain emotional facial expressions beyond the cessation of vocal production. Participants were recorded with motion capture or electromyography (EMG) as they watched and imitated phrases of emotional singing. All were shown audiovisual recordings of sung phrases performed with happy, sad, or neutral emotional expressions. Their task was to imitate the target stimulus, emphasizing the emotion expressed. Facial expressions for happy and sad sung phrases were significantly different from facial expressions for neutral sung phrases. However, these differences were observed not only during the imitation, but also before and after vocal production. The authors concluded that facial expressions not only support music performance during vocal production, but also reflect processes of emotional *planning* and *lingering*.

In the current investigation, we examined whether the facial expressions that occur after vocal production provide reliable emotional information to listeners. If so, it would support the notion that such expressions can be used to clarify, underscore, or modify emotional intentions. A full description of the investigation will be described in a forthcoming publication.

METHOD

Participants

Seventeen first year psychology students took part in the experiment in return for course credit. All had normal or corrected to normal vision.

Materials

Stimuli were excerpts of video recordings of facial expressions used by four singers (Livingstone *et al.* 2009). Stimuli were presented as full video or point-light display (13 markers). Full videos were recorded using a Sony DV camera, positioned roughly 45 degrees to the right of participants at a distance of 2.5 m. Motion capture data were collected from 13 markers on the face using an 8-camera Vicon optical motion capture system (Oxford Metrics), calibrated to less than 1 mm error. Six stimuli were chosen from each singer, depicting two sung phrases for each of three emotions: happy, neutral, and sad. Clips from three time periods or *epochs* were excerpted from each trial: pre-production (three beats prior to vocalization, or 2.4 s), production (the middle three beats during vocalization), and post-production (the first three beats after the singer stopped singing). Each epoch was depicted in two formats: video and point-light display. Videos were edited in *Final Cut Pro* (Apple) to reveal only the face and shoulders of the singer on a neutral (beige) background. Point-light displays were produced by processing motion capture data for each trial in *Matlab* (Mathworks) and consisted of black dots on a white background.

The experiment was run on a *MacBook Pro* laptop, using *Experiment Creator 1.4* (available from WFT's website). Stimuli were presented on a 24" Samsung monitor. Participants were seated roughly 50-100 cm from the screen.

Procedure

Each participant completed 144 trials (4 singers, 2 phrases, 3 epochs, 3 emotions, 2 display types). Display type (video or point-light display) was blocked and counterbalanced and the order of presentation within blocks was ran-

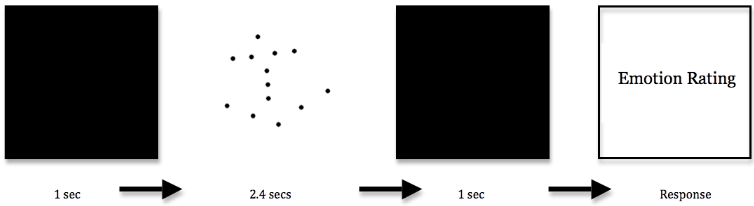

Figure 1. Timeline of a trial involving point-light display. Each black dot represents a marker used to track facial motion. Markers were placed on the forehead, temples, nose-bridge, nose-tip, eyebrows (2 each), and lips (upper, lower, and corners).

domized. Participants completed six practice trials for each display type before completing each block. Illustrated in Figure 1, each trial began with 1 s of black screen, followed by the 2.4 s stimulus and then another 1 s of black screen. Participants then rated the emotion perceived on a scale from -3 (very sad), to 0 (neutral), to +3 (very happy). A computer mouse was used to select ratings displayed on the monitor. Once participants rated the stimulus they could progress to the next trial when ready.

RESULTS

Preliminary analyses revealed significant interactions involving display type, motivating separate analyses for video and point-light display conditions. For each, an Analysis of Variance (ANOVA) was conducted with repeated measures on "emotion" (happy, sad, neutral) and "epoch" (pre-production, production, post-production).

For full video trials, there was a main effect of emotion ($F_{2,32}$=235.82, $p<0.001$) with high ratings assigned to happy trials (M=1.59, SE=0.10), intermediate ratings assigned to neutral trials (M=-0.47, SE=0.06), and low ratings assigned to sad trials (M=-1.29, SE=0.11). Although this general pattern was observed in all three epochs, there was a significant interaction between emotion and epoch ($F_{4,64}$=20.48, $p<0.001$). This interaction is illustrated in Figure 2 (left panel), which displays mean ratings of emotion for each of the three epochs. Analysis of data for the lingering epoch separately revealed a main effect of emotion ($F_{2,32}$=177.31, $p<0.001$), and planned comparisons verified that ratings for the three emotions differed significantly from each other. Thus, facial expressions that lingered beyond song production provided reliable emotional cues.

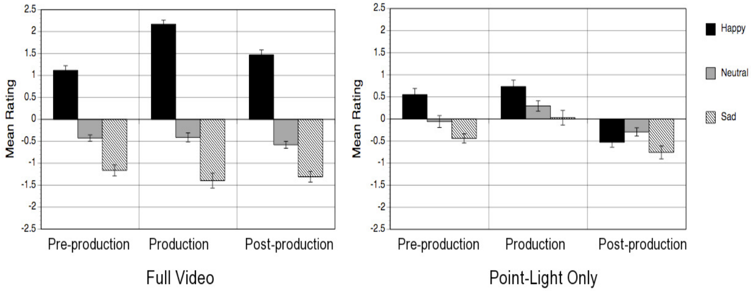

Figure 2. Mean emotion ratings for full video (left panel) and point-light display (right panel), and standard error bars.

For point-light display, there was a main effect of emotion ($F_{2,32}$=25.05, p<0.001), with highest ratings assigned to happy trials (M=0.25, SE=0.09), intermediate ratings assigned to neutral trials (M=-0.02, SE=0.08), and lowest ratings assigned to sad trials (M=-0.39, SE=0.11). There was also a significant interaction between emotion and epoch ($F_{4,64}$=4.60, p<0.01), illustrated in Figure 2 (right panel). Analysis of the post-production epoch separately revealed a main effect of emotion ($F_{2,32}$=5.38, p<0.05). However, planned comparisons indicated that only the neutral and sad conditions differed significantly in emotion ratings. During the post-production epoch, point-light display did not provide participants with sufficient information to differentiate happy facial expressions from other facial expressions.

DISCUSSION

Results confirm that facial expressions that linger beyond the cessation of vocal production contain reliable emotional cues. Indeed, when full video was available, discrimination of emotional facial expressions was observed prior, during, and after vocalization. Such facial expressions of emotion may function to shape a listener's interpretation of the music (Thompson *et al.* 2008).

When only point-light display was available, discrimination was observed prior and during vocalization, but participants could not discriminate happy expressions from other emotional intentions in the post-production epoch, indicating that marker movement alone carried insufficient information for decoding happy expressions in that epoch. It is possible that isolated happy emotional expressions are ambiguous in the lingering epoch because they begin with raised lip corners and end with a neutral expression, implying movement away from a positive emotional expression. Alternatively, in the absence of recognizable facial expressions, movement that comes to a stop may generally have negative connotations.

Facial expressions of emotion are likely to be integrated with auditory signals of emotion, yielding audiovisual experiences of music. Such experiences are consistent with current understandings of multisensory integration in the central nervous system, and underscore the importance of considering facial expressions and other performance gestures in studies of music and emotion.

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Pianists with carpal tunnel syndrome: Conservative versus surgical treatment

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We studied retrospectively 18 patients, all professional pianists or advanced piano students, who had presented with carpal tunnel symptoms in the past and had undergone surgical or conservative treatments. We found that delayed diagnosis was more likely to lead to surgical treatment and that fear of diagnosis and fear of surgery prevented early treatment. Although surgical release was successful in 50% of the patients, re-education was essential to maintain good results according to long follow-up. Finally, medical practitioners are in a better position to help pianists when they make consideration of the demands and technical peculiarities of this profession.

Keywords: carpal tunnel syndrome; pianists' hand pain; pianists' finger numbness; pianists' finger weakness; nerve entrapment

Carpal tunnel syndrome is the most common cause of entrapment neuropathy in the upper limb. Compression of the median nerve within the carpal tunnel may be caused by an increase in the volume of its contents either due to local events such as tenosynovitis of the tendons within the tunnel or due to general disease such as diabetes, myxoedema, or rheumatoid arthritis. Compression of the median nerve gives rise to symptoms of numbness, pain, or weakness (clumsiness) in the affected hand. When a patient visits the medical practitioner complaining of symptoms suspicious of carpal tunnel syndrome, the clinical examination—comprising of specific diagnostic tests—may be able to confirm the condition and to some extent its severity. In cases of doubt, further electrophysiologic tests (electromyography and nerve conduction studies) may become necessary, where the prolongation of distal motor latency will confirm the presence of median nerve compression. It is, however, worth mentioning that a normal result on electromyography does not rule out the diagnosis.

The treatment of carpal tunnel syndrome has been traditionally either conservative (rest, splints, oral or injectable anti-inflammatories), surgical (division of flexor retinaculum with or without neurolysis or tenosynovectomy), or both, depending on the severity of the symptoms. There is, however, a natural progression of the condition, with deterioration over time, and this becomes essential in the awareness that the patient should have in order to identify the early symptoms. Particularly for pianists—who are among the professionals more prone to develop carpal tunnel syndrome due to the repetitive tasks they perform—early diagnosis is crucial for the successful outcome of their treatment. In this study, we tried to detect how the time of diagnosis affected the treatment and outcome of carpal tunnel syndrome in the pianists studied. We also aimed to examine the progress of the condition in the pianists who received conservative treatment and the pianists who received surgical treatment. The surgeon-patient relationship was studied in an effort to establish potential correlation between the medical approach to the condition and the awareness of the particular technical issues of the pianist when making management decisions.

METHOD

Participants

Fifteen female and three male pianists, aged between 17-57 years, participated. They all studied or worked at the National Music Conservatory in Athens and their treatment—surgical or conservative—was also provided in Athens. The diagnosis had been made on the basis of clinical presentation, and on six patients, nerve conduction and electromyographic studies were also performed. Twelve patients had undergone surgical decompression and six had had non-surgical treatment with a combination of advice on modifying their practice, physiotherapy, splints, local anti-inflammatory injections, and oral anti-inflammatories.

Procedure

To assess the patients' follow up we distributed medical as well as practice questionnaires to collect information on pre- and post-treatment symptoms. In the pre-treatment period, the time of initiation of symptoms was studied in relation to the subsequent type of treatment and the relation of patterns and habits of practicing, as well as adverse psychology in relation to carpal tunnel symptoms. In the post-treatment period (follow-up 4-14 years), the results of the pianists' progress were grouped into poor, good, and excellent according to specified criteria and assessed in relation to the treatment received.

RESULTS

In the pre-treatment period, our results showed that the early diagnosis was followed with relief of the symptoms without the need for surgery. Most delayed diagnoses were either due to fear of diagnosis or due to fear of potential surgical treatment (see Table 1). We found a correlation between symptomatology and technical difficulties in practice or occasions where low morale and social or career pressures were prominent (see Table 2).

In the post-treatment period, we defined our results according to the outlined criteria (poor: no change/possible deterioration, good: improvement/possible relapse, excellent: improvement/no relapse) for both conservatively and surgically treated pianists (see Table 3) and found that although surgical treatment had been of good initial relief in 50% of the patients, a further re-education of practicing was essential in order to maintain the outcome.

In the evaluation of this result, it is difficult accurately to detect retrospectively the surgeon/physician's familiarity/awareness with the particular technical issues that affect the pianists. In our questionnaire, we asked whether the patient felt that "the medical practitioner was able to discuss and understand the pianistic demands and peculiarities of their technique," and we based our results on their replies (see Table 4). It could be said that, the less aware the surgeon, the more his/her inclination toward surgical treatment.

DISCUSSION

Peripheral nerve entrapment syndromes of the upper extremities are well documented in musicians. Lederman (2004) evaluated 226 instrumentalists for playing-related disorders and found that 29% had a peripheral nerve disorder. Gohl *et al.* (2006) studied 19 pianists and concluded that 16% had early evidence of median neuropathy and that by completing a thorough medical history, good physical examination, and nerve conduction testing, early neuropathy may be detected.

In our present study, we found that the early diagnosis was followed with relief of the symptoms without the need for surgery. Most delayed diagnoses were either due to fear of diagnosis or due to fear of potential surgical treatment. It is essential that the pianists learn to identify early symptoms. During the early stages one can reflect upon the actual technique and postural ad-

Table 1. Pre-treatment period: time of diagnosis and subsequent treatment.

	Diagnosis <3 months	*Diagnosis 3-6 months*	*Diagnosis >6 months*
Conservative	1 (5.5%)	5 (27.7%)	0 (0.00%)
Surgical	2 (11.1%)	2 (11.1%)	8 (44.4%)
Fear of diagnosis	1 (5.5%)	2 (11.1%)	6 (33.3%)
Fear of surgery	2 (11.1%)	0 (0.00%)	7 (38.8%)

Table 2. Pre-treatment period: symptoms and associated circumstances.

	Pain	*Weakness*	*Paresthesiae*	*Other*	*Total*
No technical difficulties	2	2	2	1	7 (38.8%)
No adverse psychology	0	0	1	1	2 (11.1%)
No career pressures	1	1	1	0	3 (16.6%)
Technical difficulties	4	2	3	1	10 (55.5%)
Low morale	4	2	4	2	12 (66.6%)
Career pressures	4	3	4	4	15 (83.3%)

Table 3. Post-treatment period: outcome of treatment.

	Poor	*Good*	*Excellent*
Conservative	2 (33.3%)	2 (33.3%)	2 (33.3%)
Surgical	3 (25.0%)	6 (50.0%)	3 (25.0%)

Table 4. Post-treatment period: patient/surgeon relationship.

	Surgeon aware	*Surgeon unaware*
Conservative	3 (50%)	3 (50%)
Surgical	3 (35%)	9 (75%)

justments in order to reverse and further prevent compression of the median nerve in the carpal tunnel. Early signs should not be neglected by pianists as during these times one may not seek medical help; it relies on the musician to consider modification in their practice. If, however, symptoms and signs deteriorate, medical help should be sought without delay. Conservative treatment may come to benefit and treat the condition without need for surgery. It is also recognized that from some point onwards the damaged median nerve will not recover with conservative means and surgery will become unavoidable.

We also found a correlation between symptomatology and technical difficulties in practice or occasions where low morale and social or career pressures were prominent. It has been discussed that misuse of the tendons and/or excessive wrist flexion are contributing factors to the development of carpal tunnel syndrome. It may also be the case that psychological matters that give rise to tension in the upper limbs play some role in this or other conditions that affect piano players. Further studies should be conducted to determine the statistical significance of the psychological effects.

We found that although surgical treatment had been of good initial relief in 50% of the patients, a further re-education of practicing was essential in order to maintain the outcome. This is either because the pianist had not modified their practice during the earlier stages of the condition or because the relief from the acute symptoms following surgery gave the freedom and reassurance to the pianist to practice without deliberating their technique. It is therefore essential for any re-education to happen soon after the operation and to be maintained during the rehabilitation period and beyond in order to prevent reoccurrence.

It could be said that, the less aware the surgeon, the more his/her inclination toward surgical treatment. This we cannot prove with this study, as due to its retrospective nature it cannot reflect accurate assumptions. However, we do take the opportunity to highlight this issue and emphasize that as the pianist needs to be aware of the early warnings of a possible carpal tunnel syndrome, the surgeon should be also aware of the possible technical aspects that can contribute to this condition and be in a position to discuss them with his patient before applying treatments.

We conclude that it is of major importance to maintain the clinician's awareness of the particular demands that the pianists have from their hands all the way through the diagnostic and treatment process. The debate of surgical versus conservative management still remains open, as there are cases that do equally well with either type of care. Carpal tunnel syndrome should be broadly made known to piano players, and the early clinical symptoms should be highlighted and possibly taught to the pianists early in their studies and careers. Whether the symptoms are due to wrong technical habits or whether they are due to unavoidable pathologies, it is crucial to understand that early diagnosis and management can relieve the pianist from the anxiety that carpal tunnel syndrome may cause.

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Musical training facilitates brain plasticity: Short-term training effects on sensorimotor integration

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Efficient sensorimotor integration is essential for music performance. Previous research has indicated that auditory-motor associations form not only as a result of long-term training but after a very brief period of training. After short-term training, it has been demonstrated that premotor areas are recruited during passive listening of trained music, suggesting that these mappings can rapidly become automatic. It has been argued that these mappings rely on activity in mirror neuron systems (involved generally in imitating and learning actions). Action-observation studies in this field have associated changes in EEG mu-rhythm activity with the mirror neuron system. We utilized this technique in our action-listening study in order to detect involuntary motor co-activation during passive listening to melodies and rhythms. We investigate whether motor co-activation during passive listening occurs specifically for newly acquired sound-action mappings after training. Subjects participated in a short-term training scheme in which they were trained to accurately play back randomly generated basic piano melodies. Preliminary results show changes in the mu-rhythm activity in post-training EEG recordings. These initial findings support the hypothesis that sensorimotor experience is important for the mirror neuron system. This study demonstrates that musical training research can make a valuable contribution to brain plasticity research.

Keywords: sensorimotor training; brain plasticity; neuroimaging; EEG; audio-motor

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Symposium:
Musician’s dystonia: New aspects in pathophysiology and treatment

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Is musician's dystonia an inherited condition?

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Musician's dystonia (MD) is generally considered a sporadic disorder that presents with loss of voluntary motor control of extensively trained movements. To test the hypothesis of a genetic etiology in at least a subset of MD, we initiated a large clinical genetic study. The families of 28 index patients with MD, 14 with a reported positive family history of focal task-specific dystonia (FTSD) and 14 with no known family history (FH-), underwent a standardized telephone screening interview using the Beth Israel Dystonia Screen. Videotaped neurological examinations were performed on all participants who screened positive, and consensus diagnoses were established. All patients were investigated for the GAG deletion in DYT1; suitable families were tested for linkage to DYT7. A diagnosis of dystonia was established in all 28 index patients and in 19 of 97 examined relatives (MD: n=8, other FTSD: n=9, other dystonias: n=2), 5 of whom were members of FH- families. In total, 18 families were multiplex with 2-4 affected members. The GAG deletion was not present in any of the tested patients. Linkage to DYT7 could be excluded in one of the 11 informative families. Our results suggest a genetic contribution to MD with phenotypic variability including FTSD.

Keywords: musician's dystonia; focal task-specific dystonia; genetics; movement disorders; DYT1 gene

Musician's dystonia (MD), a type of focal task-specific dystonia (FTSD), presents with painless muscular incoordination or loss of voluntary motor control of extensively trained movements when a musician is playing the instrument (Altenmüller 2003). While the pathophysiology remains largely elusive, MD has been associated with intensive training regimes and thus been considered a form of occupational cramp. However, the epidemiology also suggests a possible hereditary component: 10% of MD patients report a positive family history of dystonia (Altenmüller 2003). In rare cases of focal dystonia, a hereditary component has been demonstrated, such as the GAG deletion in the DYT1 gene (Defazio *et al.* 2007). However, this mutation was excluded in a small group of MD patients (Friedman *et al.* 2000). In two families, focal dystonia has been linked to a specific gene locus on chromosome 18 (DYT7) (Defazio *et al.* 2007). More recently, the report of three families with putative autosomal dominant inheritance of FTSD in relatives of patients with MD has lent support to the concept of a genetic contribution to MD (Schmidt *et al.* 2006). To test the hypothesis of a genetic etiology in at least a subset of MD and to explore a possible relationship between MD and other forms of FTSD, we initiated a large clinical genetic study of MD based on systematic examination of 28 families (Schmidt *et al.* 2009).

METHOD

Recruitment of study sample and onsite examination

After approval of the study by the local ethics committee and obtaining informed consent, we included 28 professional musicians diagnosed with focal dystonia at the outpatient clinic of the Hanover Institute of Music Physiology and Musicians' Medicine (index patients). Based on history and clinical features, all were classified as having likely primary dystonia. Fourteen of these index patients had a reported positive family history (FH+) of FTSD and were matched to 14 patients with no known family history (FH-) for age, sex, instrument group, and type of dystonia (limb versus embouchure). In a first telephone contact, all index patients were asked to report known cases of dystonia in their families (family history interview). All available first- and second-degree relatives with no known dystonia underwent a standardized telephone screening interview using a modified version of the Beth Israel Dystonia Screen containing additional questions screening for MD (BIDS, adapted from Saunders-Pullman *et al.* 2005). Videotaped neurological examinations were performed at a home visit by the same examiner (AS) in all 28 index patients, in all 15 relatives with a known or reported form of FTSD, and in all 11 relatives who screened positive for dystonia in the BIDS.

Diagnostic criteria, video rating, and consensus diagnosis

A diagnosis of dystonia was made following previously published criteria (Altenmüller 2003, Bressman *et al.* 2002):

- Definite: muscle contractions producing characteristic twisting, flexion, or extension movements and postures consistently present
- Probable: movements and postures of insufficient intensity or consistency to merit classification as definite
- Possible: muscle contractions not considered abnormal but remotely suggestive of dystonia
- No dystonia

All examined family members were diagnosed in a three-step process: first, by onsite examination including information about pedigree structure and medical history (AS); second, by blinded independent video review by four movement disorders specialists (EA, JH, CK, and AM), one of whom is an expert in MD (EA); third, by evaluation of questionable cases by two blinded external collaborators (SB and RSP). Finally, a consensus diagnosis was established.

Molecular analysis

Peripheral blood samples were collected from all probands, and DNA was extracted and screened for the known three-nucleotide (GAG) deletion in the DYT1 gene. To test for a possible involvement of the DYT7 locus, suitable families were investigated for linkage using the following six DNA microsatellite markers: D18S481, D18S54, D18S976, D18S452, D18S843, and D18S1153.

RESULTS

Consensus diagnoses

The study procedure and main results are illustrated in Figure 1. MD was established by onsite examination and videotape review in all 14 FH+ (definite: n=13, probable: n=1) and in all 14 FH- (definite: n=14) index patients. In total, 97 (56 FH+, 41 FH-) first- and second-degree relatives of these index patients were examined. Seventeen of the 56 FH+ relatives had a previously known FTSD (MD: n=7, writer's cramp (WC): n=10), two of these relatives were deceased. Family history interview revealed another two deceased relatives with MD, one FH+ and one FH-. Using the BIDS in 78 putatively unaf-

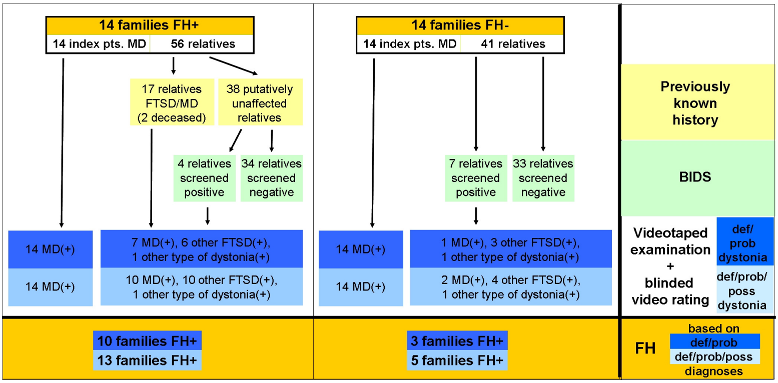

Figure 1. Flow chart of the study displaying study procedure and results. FH+=reported positive family history of FTSD, FH=no known family history, pts.=patients, MD=musician's dystonia, FTSD=focal task-specific dystonia, BIDS=Beth Israel Dystonia Screen, def=definite, prob=probable, poss=possible, (+)=additional dystonias or additional other movement disorders in some individuals definitely, probably, or possibly present. (See full color version at www.performancescience.org.)

fected family members, an additional 11 individuals screened positive for dystonia, 7 of whom were members of FH- families.

A type of dystonia was confirmed as definite or probable in 19 of the 26 relatives who had a previously known form of FTSD or screened positive with the BIDS. Fourteen of these 19 probands were members of FH+ (MD: n=7, other FTSD: n=6, other dystonias: n=1) and five of FH- (MD: n=1, other FTSD: n=3, other dystonias: n=1) families. In 27 of the 47, FH+ and FH-family members with definite or probable dystonia one (n=18), two (n=8), or three (n=3) additional forms of dystonia were present at least possibly—i.e. these patients were not only affected with one dystonia type (e.g. MD) but also with another FTSD (e.g. WC) or additional other dystonias (e.g. cervical dystonia). In 23 of the aforementioned 47 family members, one (n=20), two, (n=2), or three (n=1) additional other movement disorders or movement abnormalities were diagnosed as definitely or probably present, including tremor (n=6), tics (n=4), chorea (n=2), involuntary perioral movements (n=2), athetosis (n=1), mirror movements (n=8), and parkinsonian features (n=4). In total, 18 (13 FH+, 5 FH-) of the entire set of 28 families were multiplex families (based on definite, probable, and possible diagnoses of dystonia) with two to four affected family members in one (n=6), two (n=10), or three (n=2) generations, compatible with autosomal dominant inheritance in at least 12 families.

Molecular findings

The DYT1 GAG deletion was not present in any of the tested patients. Due to the small number of affected family members, linkage to the DYT7 locus could not be excluded in 10 of the 11 informative families. In one family, affected offspring did not share a common DYT7 haplotype with their affected father. Therefore, linkage to the DYT7 locus could be excluded in this family.

DISCUSSION

The present study expands previous findings of the presence of dystonia in a considerable number of relatives of index patients with MD with an autosomal dominant pattern of transmission (Schmidt *et al.* 2006). Affected relatives were identified both of index FH+ and FH- patients. Although none of the 14 FH- index patients reported any cases of dystonia in their families, five of them (36%) had affected relatives with dystonia on clinical examination. MD, however, has long served as a textbook example of a purely occupational dystonia, even more so than other forms of FTSD such as writer's cramp (WC). Due to the large number of familial cases observed also in MD, the concept of MD as a sporadic and solely "environmentally" acquired type of dystonia needs to be reconsidered. Surprisingly, a considerable number of identified patients with MD or WC displayed additional types of dystonia. In addition, an unexpected number of other hypo- and hyperkinetic movement disorders, some of them unusual, were present in a considerable number of participants. As a broad intra- and interfamilial phenotypic spectrum is known for many genetic movement disorders, it is tempting to speculate that at least part of the observed additional movement disorders in our patients are due to a shared underlying genetic cause. Not surprisingly, none of our patients carried the GAG deletion in the DYT1 gene that has only rarely been linked to focal dystonia (Defazio *et al.* 2007). Due to relatively small number of affected family members, linkage to the DYT7 gene locus that has been described in two families with focal dystonia (Defazio *et al.* 2007) could not be definitively excluded in all but one family. Based on the results of the present study, our main hypothesis is that at least some cases of MD, other forms of FTSD, and possibly even other types of movement disorders may have a shared underlying genetic cause. The genetic factors that cause or contribute to focal dystonia still have to be identified.

Acknowledgments

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New aspects in action planning and execution in musicians with dystonia

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Recent neurophysiological studies have associated focal-task specific dystonia (FTSD) with impaired inhibitory function. However, it remains unknown whether FTSD also affects the inhibition (INH) of long-term overlearned motor programs. Consequently, the question whether or not musician's dystonia (MD) affects the inhibition (INH) of long-term overlearned motor programs was addressed. By means of electroencephalography (EEG), the neural correlates associated with INH of long-term overlearned motor memory traces were investigated in MD and healthy pianists in a Go/NoGo paradigm. The findings support the hypothesis of a deficient phase coupling between the neuronal assemblies required to inhibit motor memory traces in patients with MD. Furthermore, in NoGo trials, the movement related cortical potentials showed a positive shift after the NoGo signal related to inhibition and was significantly smaller over sensorimotor areas in musicians with MD. Lastly, EMG recorded from the right flexor pollicis longus muscle confirmed that patients with MD had a disrupted INH in NoGo trials.

Keywords: music; performance; dystonia; inhibition; EEG

Musician's dystonia (MD), a form of focal task-specific dystonia (FTSD), is characterized by a degradation of these motor memory traces. MD is a movement disorder, which occurs while a musician is playing the instrument, and is marked by the painless loss of voluntary motor control of extensively trained movements (Altenmüller 2003). Recent neurophysiological studies have provided evidence for the hypothesis that musician's dystonia is associated with impaired inhibitory function and abnormal movement preparation (for a review, see Lim *et al.* 2001). The latter has been reported, for instance, in data of the Bereitschaftspotential (BP) (Deuschl *et al.* 1995) and the contingent negative variation (CNV) (Lim *et al.* 2001). Furthermore, in a recent study (Hummel *et al.* 2002), deficient inhibition of simple motor patterns was demonstrated in six patients with FTSD using transcranial magnetic stimulation (TMS) and EEG-alpha oscillatory activity. However, it remains unknown whether FTSD also affects the inhibition (INH) of long-term overlearned motor programs. Consequently, the aim of the present study was to investigate, using a Go/NoGo paradigm, the neural correlates associated with the activation (ACT) and inhibition (INH) of motor memory traces in pianists with MD during a pianistic motor task under constraint timing conditions with multichannel EEG. Our main hypothesis was that the functional coupling during INH is impaired for pianists with MD compared with healthy pianists.

METHOD

Participants

Nine healthy pianists (8 males, age range=26-47 years, mean=36.5 years) and nine pianists with MD (8 males, age range=27-50 years, mean=35.3 years) participated in this study. In all patients, the right hand was affected. All participants were professional pianists (with accumulated practice time over 10,000 hours). Eight of the nine participants in each group were right-handed, according to the Edinburgh Inventory (Oldfield 1971).

Procedure

Participants were seated at a digital piano (Wersi Digital Piano CT2). The keyboard and the right hand of the participant were covered with a board to prevent participants from visually tracking hand and finger movements. In a modified Go/NoGo study, the task was to play upward C-major scales over two octaves. Scales were played as sixteenth notes, and the tempo was standardized at 80 beats/min for a quarter note (one key stroke every 187.5 ms) and paced by metronome-like auditory cues. Scales were played using the conventional C-major fingering: 1,2,3,1,2,3,4,1,2,3,1,2,3,4,5 (the fingers 1-5 refer to thumb, index, middle, ring, and little finger, respectively). The specifications of the Go/NoGo study were as follows: a first visual cue (S1) indicated that participants should be prepared to start playing. The metronome was started 2,750 ms after S1. Participants were instructed to play the first note of any scale coinciding with the third metronome beat. A second visual cue (S2) was presented 250 ms before the third metronome beat, indicating that the participant should either execute (Go, green ellipse) or not execute (NoGo, red ellipse) the motor sequence. Continuous EEG was recorded from 22 electrodes placed over the scalp according to the extended 10-20 system referenced to linked mastoids. Data were sampled at 500 Hz; the upper cutoff was 100 Hz, and the time constant was set to DC (DC amplifiers and software by NeuroScan, Herndon, Virginia, USA). One bipolar EMG channel was recorded from surface electrodes positioned over the right flexor pollicis longus muscle, located 6 cm apart. The bandpass filters for EMG were set to 5 Hz (highpass) and 100 Hz (lowpass).

We performed the following analyses of the EEG signals: (1) standard time averaging technique to analyze the slow shift of movement-related cortical potentials (MRCPs), (2) wavelet based time-frequency representations (TFR) to analyze (3) the spatiotemporal dynamics of the inter-electrode phase coupling. All statistical tests were performed by means of nonparametric univariate permutation tests and multivariate synchronized permutations (Good 2005).

RESULTS

EMG analysis

The amplitude mean value in the analysis interval and the EMG peak were selected as EMG activity parameters. In NoGo trials, the selected time window was 0-350 ms to detect whether pianists initiated a movement around 250 ms in spite of the NoGo signal. Burst of EMG activity showed that participants initiated movements of the thumb in some NoGo. Interestingly, however, the first key of the MIDI piano was not actually pressed. This result confirmed that inhibition in our paradigm demanded active suppression of the motor program. The EMG peak was found significantly higher in pianists with MD (mean=14 μV, range=5.2-50 μV) than in healthy ones (mean=5.5 μV, range=3.1-16 μV).

Movement-related cortical potentials

Both groups showed similar pre-movement activity over the sensorimotor cortex, characterized by the slow negative MRCP termed as CNV (Figure 1). In our paradigm, the CNV reflected the maintenance of a motor response in readiness (Haider *et al.* 1981). In NoGo trials, the pre-movement negativity returned to baseline levels and later a positive shift post-S2 was observed. The positive peak after S2, which could be related to the inhibition of the

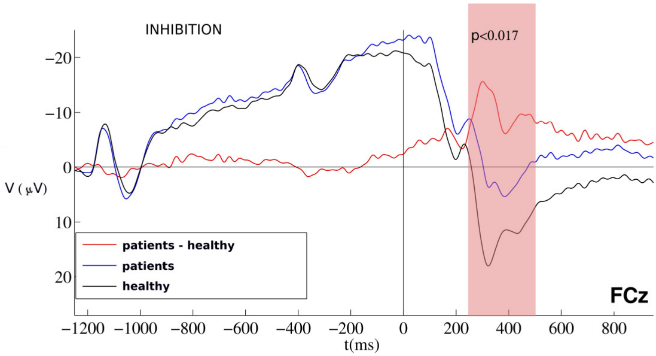

Figure 1. Movement-related cortical potentials (MRCPs) analysis. Grand average of the MRCPs at electrode FCz for NoGo trials in pianists with MD (blue line), healthy pianists (black line), and difference (MD minus healthy, red line). The temporal interval of statistical significance (p<0.0017, permutation test) in the between-groups difference is indicated by the pink region. (See full color version at www.performancescience.org.)

motor pattern, had a significantly larger amplitude across sensorimotor areas in healthy pianists than in pianists with MD (p=0.0016).

Inter-electrode cortico-cortical phase synchronization

NoGo trials were associated with a robust increase in the degree of global synchronization across the sensorimotor cortex in the theta (4-7 Hz) and lower alpha band (7-8 Hz) with a time span of 200-400 ms, hence coinciding with the latency when the participants were required to begin playing (Figure 2). This increase was significantly more enhanced between 230-330 ms for healthy pianists than for pianists with MD (p=0.004, permutation test, univariate test). This effect was due to a weaker phase synchronization in pianists with MD between electrode Cz, representing the supplementary motor areas (SMA), and left premotor and sensorimotor electrodes (FC3, C3, CP3). This result confirmed our main hypothesis, that the functional coupling during INH is impaired for pianists with MD compared with healthy pianists.

DISCUSSION

Our study focused on the execution and inhibition of long-term overlearned motor programs, due to its relevance in real playing conditions. Our assumption was that in the non-retrieval condition, motor memory traces, strongly activated after the first metronome beat, needed to be suppressed after S2

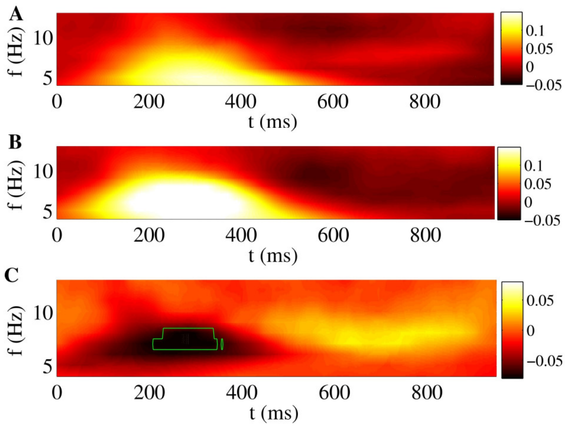

Figure 2. Phase synchronization analysis during INH. The time-frequency plots of the inter-electrode phase synchronization index, averaged across electrodes over sensorimotor and prefrontal areas, are presented for pianists with MD (A), for healthy pianists (B), and for the between-group difference (C, A-B). A pointwise paired permutation test between groups yielded significant differences (p=0.004) between 230 and 330 ms and at 7-8 Hz, due to higher global synchronization in healthy pianists than in pianists with MD in this time-frequency window. This region is indicated by the green contour. (See full color version at www.performancescience.org.)

(Hummel *et al.* 2002). Here, we aimed at studying a task that is close to naturalistic piano performance. Accordingly, we imposed high temporal constraints on the task, we used a large sample of patients suffering from MD, and we had healthy musicians as controls.

In this setting, (1) the role of the inter-electrode functional coupling in the sensorimotor integration of inhibitory processes turned out to be the most relevant physiological marker. Our study further showed that in pianists with MD, (2) the non-retrieval of the motor program was associated with a weaker positive shift after-S2 over cortical sensorimotor areas. Finally, (3) the EMG peak in NoGo trials was found to be significantly higher in pianists with MD than in healthy pianists. Our findings, thus, offer evidence that patients with MD, as compared with healthy pianists, have a significantly higher innervation input of the flexor pollicis longus during NoGo trials. This outcome supports the main hypothesis of deficient inhibition in pianists with MD.

The SMA is thought to play an important role in the functional control of movement in that it has direct projections to the primary motor cortex and the spinal chord (Matsuzaka *et al.* 1992). Recent data has proven the suppressive influence of SMA on the primary motor cortex (M1) in motor imagery, thus reflecting the inhibitory function of the forward connection between the SMA and M1 (Kasess *et al.* 2008). Hence, our results could be interpreted as a deficient higher order motor functioning in pianists with MD: the phase coupling between the SMA and the left premotor and sensorimotor cortex, which is required for the non-retrieval of the motor program, is weaker in pianists with MD. Consequently, these data can be regarded as an electrophysiological correlate of the impaired inhibition in pianists with MD.

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Functional and morphological changes of brain structures in patients suffering from musician's dystonia

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Focal hand dystonia has been associated with morphometric changes and distorted somatotopic representations in the putamen. Our objective was (1) to test for morphometric alterations of the putamen in pianists with musician's dystonia (MD) relative to healthy pianists without dystonia and (2) to identify structural changes in the basal ganglia that correlate with performance during piano playing. Eleven pianists with MD and 12 healthy pianists without dystonia underwent high-resolution T1-weighted MRI of the whole brain. Additionally, motor performance was investigated in a music-related task according to a protocol previously described as a valid and reliable method to assess motor control in pianists. When playing major scales on the piano, the timing of key strokes was more variable in patients with MD than in pianists without dystonia. Healthy musicians had a smaller grey matter volume in the right middle putamen compared with MD patients. In dystonic and non-dystonic pianists, the middle part of the left and right putamen was smaller in individuals with higher temporal accuracy during piano playing. A smaller associative territory of the motor putamen is a structural marker for manual skillfulness in highly trained pianists. Since this structure-function relationship is preserved in MD, we argue that the relative increase in grey matter volume in this region reflects impaired performance in dystonic musicians rather than a specific structural substrate of focal hand dystonia.

Keywords: focal dystonia; pianists; basal ganglia; morphometry; performance skill

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Setting the stage for prevention and treatment: New therapeutic approaches in musician's dystonia

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Musician's dystonia (MD) is probably the most challenging disorder in musicians' medicine. It has a tremendous negative impact on the careers of affected musicians and is difficult to treat. We have investigated treatment effects of established therapies and new approaches on playing-related motor control in pianists with MD.

Keywords: focal dystonia; musician's dystonia; retraining; botulinum toxin; transcranial direct current stimulation

Focal dystonia in musicians (MD) is a task-specific movement disorder which presents itself as a loss of voluntary motor control in extensively trained movements while the musician is playing the instrument (Altenmüller 2003). For those who are affected, the disorder is highly disabling, and in many cases, it terminates musical careers. According to estimations, 1% of all musicians are affected. Defective inhibition on different levels of the central nervous system is thought to be involved in the pathophysiology (Lin and Hallett 2009). Treatment of patients with MD is still a challenge. Therapeutic options include anticholinergic medication with trihexyphenidyl (Trhx), botulinum toxin (BT) injections, and pedagogical retraining (PR) (Jabusch and Altenmüller 2006). Transcranial direct current stimulation (tDCS) has been shown to modulate excitability of the motor cortex: anodal tDCS facilitated motor learning, and cathodal tDCS improved performance in overlearned tasks

(Nitsche *et al.* 2003, Antal *et al.* 2004). It may be hypothesized that tDCS facilitates retraining effects in musicians with dystonia. In this paper, we present outcome data in 33 pianists with focal dystonia after an average follow-up period of 24 months. Pianists were treated using BT, Trhx, or PR, either as monotherapies or in combination. Treatment monitoring was made using an established protocol that allows assessment of motor control in a relevant musical task. Additionally, short-term development after tDCS-supported retraining in a single patient is reported.

METHOD

Participants

Study 1: 33 pianists with MD (mean age=37 years, range=21-71 yrs, 24 men, 9 women) were included in the follow-up study. *Study 2:* the short-term follow-up study was performed in a 43 year-old male pianist suffering from MD. All patients were diagnosed at the Institute of Music Physiology and Musicians' Medicine, Hanover University of Music and Drama. The diagnostic procedure included a complete neurological examination as well as visual inspection while patients were playing the piano.

Procedure

Assessment of motor control: motor control at the piano was assessed in scale playing because this motor task is early affected during onset of MD. MIDI-based scale analysis was done according to the following protocol (Jabusch *et al.* 2004). Scales were performed with the affected hand on a digital piano that was connected to a computer. Sequences of 10 to 15 C major scales were played over two octaves in both playing directions. Scales were played using the conventional C major fingering. The tempo was standardized and paced by a metronome (one keystroke every 125 ms). The temporary unevenness of inter-onset intervals (IOI) has previously been identified as a valid, reliable, and precise indicator of the impairment of motor control in pianists with dystonia (Jabusch *et al.* 2004). For each participant, temporary unevenness of IOI was analyzed for the affected hand and for both playing directions by calculating the median standard deviations of IOI (mSD-IOI) of all scales. The mSD-IOI score of the more severely affected playing direction was used for further analyses. Motor control was assessed before and after follow-up in Study 1 as well as before and after each treatment condition in Study 2.

Treatment, Study 1: therapeutic approaches, as monotherapies or in simultaneous or successive combination, included the following options: PR was applied in patients who preferred a non-medication treatment approach. PR took place under the supervision of a piano instructor (LB) specialized in dystonia retraining. PR included elements based on the following principles reported previously (e.g. Boullet 2003): (1) movements of affected body parts were limited to a level of tempo and force at which the dystonic movement would not occur, (2) compensatory movements (e.g. of adjacent fingers) were avoided, partially under the application of splints, (3) instant visual feedback with mirrors or monitors helped patients to recognize dystonic and non-dystonic movements. BT injections were applied in patients in whom primary dystonic movements could be clearly distinguished from secondary compensatory movements. Target muscles were identified by visual inspection of the dystonic movement patterns while patients were playing their instruments. A lyophilized botulinum toxin A powder (Dysport®, Ipsen Ltd., Berkshire, UK) was injected using an EMG-guided technique. Trhx was applied as monotherapy when treatment with PR or BT was not desired or possible and no contraindication was present. Adjustment of the dosage was made depending on beneficial effects and side effects. Patients with little response during PR were additionally treated with BT or Trhx when no contraindications were present.

Treatment, Study 2: in a double-blind single case study, tDCS was combined with retraining on the piano that took place according to the aforementioned principles. The patient was treated with three stimulation protocols consecutively, with a minimum of 5 weeks between treatment sessions: anodal tDCS, cathodal tDCS, and placebo stimulation (3x5 days). In the verum stimulation conditions, tDCS (2 mA) was applied for 20 mins on the primary motor cortex contralateral to the affected hand. During stimulation, the patient practiced slow, non-dystonic movement patterns on the piano. Motor control was assessed before and 1 min, 60 mins, 120 mins, and 180 mins after the respective treatment session.

Statistical analyses: Mann-Whitney-U tests were applied to analyze performance differences. The alpha level was set at 0.05. In Study 2, alpha adjustment for multiple testing was made according to Bonferroni-Holm.

RESULTS

Study 1: monotherapies were applied in 23 patients: BT (n=8), Trhx (n=1), PR (n=14). Treatment combinations were applied in five patients: PR+BT (n=3), PR+Trhx (n=2). Five patients refused any treatment. Follow-up monitoring after an average period of 24 months (range=3-57) revealed the

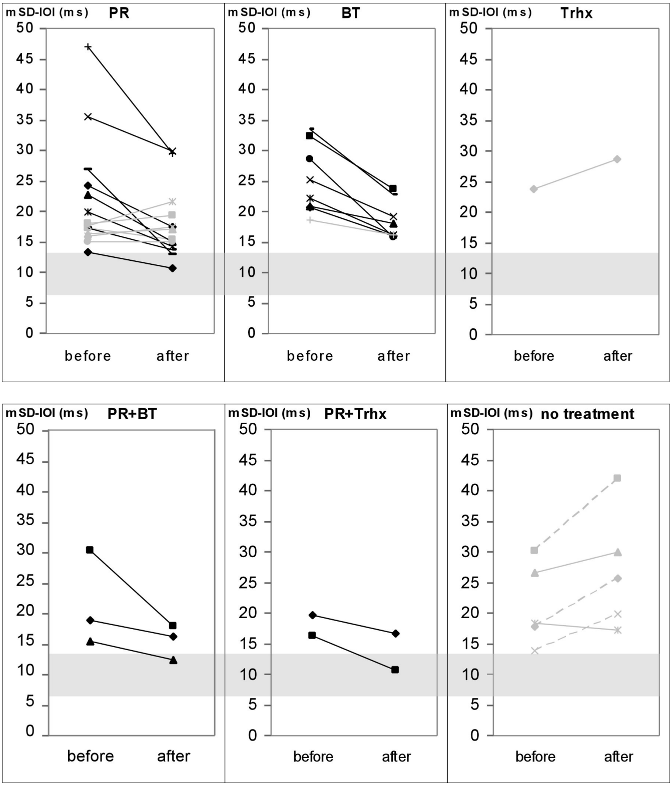

Figure 1. Study 1: each line indicates the mSD-IOI values of one patient before (left endpoint) and after follow-up (right endpoint). A high score for mSD-IOI denotes a high level of temporal unevenness in the scales (impaired motor control), while a lower score for mSD-IOI denotes a lower level of unevenness (less or non-impaired motor control). Solid black lines indicate significant improvement of motor control, solid grey lines indicate no significant change in motor control, dashed grey lines indicate significant deterioration in motor control. Gray window: range of motor control of healthy pianists.

following outcome. A significant improvement of motor performance was seen in 20 patients (71% of the 28 treated patients) after BT (n=7), PR (n=8), PR+BT (n=3), and PR+Trhx (n=2). Four of these patients (14% of all treated patients) returned to a level of normal motor control as seen in healthy pianists (PR: n=2, PR+BT: n=1, PR+Trhx: n=1). No change of motor performance was seen in 8 patients after treatment (BT: n=1, Trhx: n=1, PR: n=6). In the five untreated patients, motor performance remained unchanged (n=2) or deteriorated (n=3). Detailed outcome of individual patients is displayed in Figure 1.

Study 2: motor control at baseline did not differ between the stimulation conditions. In the placebo condition, motor control was improved 1 min ($p<0.001$) and 120 mins ($p<0.05$) after treatment as compared with before treatment. In the anodal condition, motor control was improved 1 min ($p<0.001$), 60 mins ($p<0.001$), 120 mins ($p<0.01$), and 180 mins ($p<0.05$) after treatment. In the cathodal condition, motor control was improved 1 min, 60 mins, 120 mins, and 180 mins after treatment (each $p<0.05$). Inter-treatment comparisons revealed a better performance outcome in the cathodal condition compared with placebo 180 mins after treatment ($p<0.001$).

DISCUSSION

The results underline the potential benefit of a behavioral approach in the treatment of pianists with MD. PR as a monotherapy resulted in improved motor control in the majority of patients after follow-up. This result indicates a beneficial effect of an active involvement of patients. As a limiting factor, PR requires patience and compliance of affected pianists. BT injections were successful in all but one of the patients treated with this option. When the muscles involved in the dystonic movements can be clearly identified, BT treatment may be recommended to patients, especially to those who are not able to invest the time and patience required for PR. A treatment attempt with Trhx was unsuccessful in the only patient treated with this option as a monotherapy. Other publications report an improvement rate of 33% in patients with MD who tolerated the medication (Jabusch and Altenmüller 2006). The applicability is, however, limited due to the frequent occurrence of side effects. Treatment combinations such as PR+BT or PR+Trhx are promising, especially in patients with little response to PR alone. In Study 2, retraining resulted in prolonged effects when combined with cathodal tDCS as compared to placebo stimulation. Further studies with large numbers of patients and longer follow-up periods are, however, required to determine the effects of (1) combination therapies based on PR and (2) tDCS-supported retraining. Our results show that the currently available therapies help to improve the situation in the majority of patients. However, they also demonstrate that only exceptionally, affected pianists return to normal motor control.

This observation underlines the crucial importance of a successful prevention. Previous findings suggest that different risk factors such as exaggerated perfectionism and anxiety can trigger the manifestation of MD (Jabusch and Altenmüller 2006) in predisposed musicians. These risk factors should be addressed in the musical education from the first lesson onward. Music teachers should strive to create a friendly, supportive atmosphere focusing on creativity, curiosity, and playful experiences in the world of sounds. We assume that the risk of MD may be reduced by including retraining principles even in the teaching process for healthy pianists and by the application of "healthy" practice strategies. Reasonable practice schedules, an economic playing technique, prevention of overuse and pain, mental practice, a variety of movement patterns, maintenance of motivation, avoidance of mechanical repetitions and frustration, sufficient breaks, warm-up and cool-down exercises, regular physical exercise, and sleep are the cornerstones of healthy musical practice. Future projects will have to investigate the preventive potential of these strategies.

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The effects of pianistic retraining via video conferencing as a means of assisting recovery from focal dystonia: A case study

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Focal dystonia (FD) is a devastating neurological condition that can result in the loss of a musician's playing ability. In pianists, involuntary muscle contractions can cause abnormal finger postures, making it impossible to play at concert level. It is a difficult condition to treat, and although some improvement has been reported with Botulinum toxin therapy, complete recovery is rare. Our study investigated whether retraining with the aid of video conferencing could be helpful in the treatment of a professional pianist resident in the UK with a six year history of focal dystonia. Quality of scales was assessed before and after pianism retraining and included assessment by a listener blinded as to which hand was dystonic and whether they were assessing playing pre- or post-retraining. Although full recovery was not seen, improvement was observed at slow tempi and the hand was visibly less cramped as training sessions progressed. We conclude that video conferencing could be an acceptable medium for pianistic retraining in pianists with FD when location prevents onsite retraining. However, in this study it did not seem as effective as one-to-one retraining in the same location.

Keywords: focal dystonia; pianism; piano technique; retraining; video conferencing

Focal dystonia is usually painless and most commonly affects only one hand, often involving involuntary flexion of just two or three specific fingers. The incidence may be as high as 1% of all professional musicians (Jabusch and Altenmuller 2006). In focal dystonia, the areas in the brain responsible for the movement of adjacent fingers have become enlarged, due to overuse, and can "overlap" (Elbert 1998). Treatment options have included administration of Trihexyphenidyl or Botulinum Toxin-A, splinting, and limb immobilization, but only exceptionally do musicians with focal dystonia return to normal motor control (Altenmuller and Jabusch 2007). Different methods of retraining alone without the above medical interventions have reported anecdotal success, but few have applied scientific method. We have previously reported successful treatment of FD with intensive one-to-one pianistic retraining without the use of Botulinum Toxin. The aim of the present research was to see whether it is possible to improve the condition of a pianist suffering from FD through pianistic retraining using the medium of video conferencing.

METHOD

Participants

A 65 year old male professional pianist with a five year history of FD affecting digits 3-5 (D3-5) of his right hand participated in a specific retraining program based on a biomechanically sound way of playing with minimal tension through the medium of video conferencing. Subject characteristics are shown in Table 1.

Materials

The following equipment was used: video conferencing facilities, two fixed and two mobile cameras, and two pianos.

Procedure

The subject underwent pianistic retraining using video conferencing technology. A collaboration was set up between the University of Auckland and the Royal College of Music, London. In each location, two cameras were used: one fixed and one mobile. Scales and test repertoire were recorded at the commencement of the study, after ten sessions within three weeks, and then after a further ten follow up sessions within the next year. The sound only of three different scales and a diminished seventh arpeggio at tempi ranging from 60-144 bpm (quarter note) was assessed by a professional pianist (the "blinded listener"), blinded to which hand was playing and whether the playing was pre-, post-ten sessions, or at the end of the retraining process. The assessment used a Scale Quality Evaluation (SQE) and a Dystonic Hand Identification Evaluation (DHIE) where the listener was asked to identify

Table 1. Subject characteristics.

Characteristic	*Data*
Age	65 years
Sex	Male
Level of performance	Professional soloist
Years of playing	60
Duration of dystonia	Six years
Hand dominance	Right
Hand affected	Right
Digits affected	D3-D5

whether the hand playing was dystonic or not. The above evaluation scales have been previously described by the author (de Lisle *et al.* 2006). Statistical analysis was carried out using Generalised Linear Models in SAS v9 for Windows. Estimates are the change in SQE from the initial assessment to the end of the three week 10 session end point or the end of one year endpoint. Seven months following commencement of retraining the author had two face-to-face retraining sessions with the subject in London, but otherwise all training sessions were carried out via video conferencing.

The subject had been used to playing with a very curved hand position and had trained using finger independence exercises involving antagonistic muscle movements simultaneously (e.g. Pischner exercises). The excessively rounded hand position had caused the subject to play at the edge of the white keys with the thumb over the key surface, and D2-5 rarely played between the black keys. An ascending scale passage revealed radial deviation and any upward movement of the wrist caused D3-5 to curl excessively. Descending scale passages involved shoulder abduction when crossing over the thumb, causing the elbow to elevate away from the body and the hand and wrist to pronate while pivoting on the thumb. Therefore, the initial aim was to lower the wrist and to use a flatter hand position and play with fingers less flexed. In scale passages, the subject was instructed to avoid lifting the wrist when passing over the thumb and instead to ride forward on D3, moving the arm toward the fall of the piano.

Particularly challenging was any tremolo movement using rotation, where D5 became stuck to the keys and the wrist would flex excessively. The subject had a lack of freedom in forearm rotation and tended to direct the movement from the wrist. This was corrected by reducing wrist palmar flexion and in-

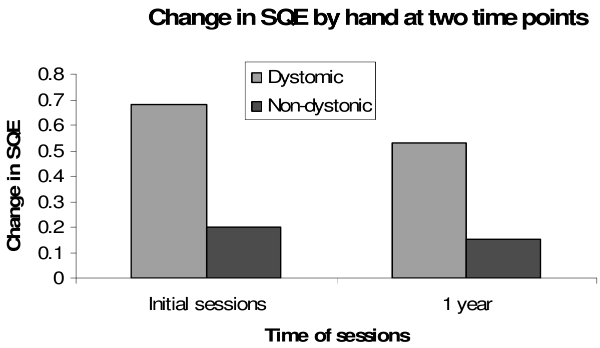

Figure 1. Change in SQE by hand at two time points.

creasing the rotation of the forearm (pronation and supination). Lifting the fingers simultaneously from the metacarpophalangeal (MCP) joints was problematic when pivoting on D2 because D5 tended to lag behind the other fingers and this was given as a specific exercise. This lagging was also apparent in descending scales but could be prevented if the movement of crossing over the thumb was directed from D5 without flexing the wrist. In ascending broken chord playing, passing from D5 to D1 caused excessive curling of D5, but this was preventable at a slow tempo by actively extending D5 away from the cramping movement. Passing from D2-D3 caused cramping of D5, but this could be prevented by a downward convex movement of the wrist to align the fingers with the keys. Chord playing using D1,3,5 was difficult, but D1,4,5 was accomplished with ease.

RESULTS

The analysis showed a significant improvement of the SQE from the pre-assessment to the point in time of the three week, 10 session intensive retraining of 0.46 points [95% CI=(0.11,0.81), p=0.01], after controlling for dystonic/ non-dystonic hand, this effect remained statistically significant. An analysis of the effect by hand showed a small non-significant improvement in the non-dystonic hand of 0.20 points [95% CI=(-0.13,053), p=0.23], while the dystonic hand showed a statistically significant improvement of 0.68 points [95% CI=(0.20,1.17), p<0.01]. When the blind assessor was assessing the playing, they correctly identified the non-dystonic hand 85% of the time with the pre-assessment and 95% of the time at the end of the 10 sessions; this was not statistically different (p=0.29). Whereas with the dystonic hand the assessor was able to detect the dystonic hand 95% of the time at the pre-assessment, this decreased significantly to 44% after training (p=0.0006).

When we compared the data from the pre-assessment to the end of year assessment (see Figure 1), we again found an overall improvement, in this case of 0.35 points [95% CI=(0.11,0.59), p=0.0044]. After controlling for the effect of hand, this again remained significant. Similarly, analysis by hand found a small but non-significant improvement in the non-dystonic hand of 0.15 points [95% CI=(-0.07,0.36), p=0.17] but a significant improvement in the SQE for the dystonic hand of 0.53 points [95% CI=(0.24,0.82), p=0.0004]. Again, assessment of the non-dystonic hand was successfully assessed 81% of the time at the pre-assessment, and this improved slightly to 91% and the end of training (p=0.26). As before, the dystonic hand was accurately detected 91% of the time at the pre-assessment, and this decreased significantly to 69% at the end of training (p=0.03).

DISCUSSION

We have previously shown that it is possible to treat FD effectively in pianists with intensive retraining (de Lisle *et al.* 2006). The novel finding of the present study is that this retraining can be undertaken using video conferencing technology. Although full recovery was not seen, improvement was observed at slow tempi, and the hand was visibly less cramped as training sessions progressed. We conclude that video conferencing could be an acceptable medium for pianistic retraining in pianists with FD when location prevents on-site retraining. However, in this study, it did not seem as effective as one-to-one retraining in the same location. Many factors influenced this. First, technical problems often meant that the sessions were shorter than the planned time of one hour. Also apparent was the fact that when retraining sessions were too far apart, movement patterns were not easily maintained, and it was difficult to maintain the motivation of the subject. Another distracting factor was that this subject did not stop other concert playing during the retraining process, and this tended to interfere with new movement patterns being strongly established. The clearest understanding of the process occurred when the sessions were close together (e.g. 10 sessions within three weeks). A greater improvement in this process may have been possible had the following sessions been at more regular intervals and if the subject had ceased all other playing during the retraining process. However, feedback at distance to both retrainer and subject lacks the element of touch, which is the most immediate way of conveying the fine technical adjustments that are necessary for recovery from focal dystonia. While video conferencing may be useful in establishing new movement patterns the results are probably slower than those possible in the same location. However, it could be an effective tool to supplement and monitor progress after an initial period of onsite retraining.

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Doing without thinking? Aspects of musical decision-making

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When asked to explain their processes of musical decision-making, musicians attribute their behavior to various causes. This paper explores how musical decisions are made. A semi-structured interview was conducted with a Baroque violinist about her interpretation of the violin line in the aria *Ich bin vergnügt in meinem Leiden* from J. S. Bach's Cantata BWV 58. Using interpretative phenomenological analysis (IPA), the interview was coded to create categories describing differing influences on the performer's musical interpretation: feelings, score analysis, research, technical considerations, and specific experiences. A second analysis identified intuition and analysis as contrasting approaches to musical decision-making. This paper focuses on the nature of intuitive methods of making interpretative choices with reference to the interview data and psychological literature on intuition.

Keywords: music performance; interpretation; decision-making; intuition; phenomenology

Musicians are involved in complex and often rapid processes of decision-making when preparing and performing a musical work. This paper explores how musical decisions are made, focusing on the experiences of an individual musician to identify influences on their artistic practice. Within this framework of musical decision-making, this paper aims to distinguish between intuitive and non-intuitive methods of making interpretative choices, focusing on the nature of intuitive processes in particular.

Intuition has been conceptualized and defined in many ways (see Sprenkle 2005). Betsch (2008) identifies three differing approaches to understanding the concept and how it may operate:

> Some scholars focus on intuition as a *source* of knowledge. Accordingly, intuition is what we know without knowing how we learned it. Others suggest a *process* view by equating intuition with automatic or implicit processes of thinking. Finally, one spots proponents of a *system* view claiming that intuition is a distinct faculty of the human mind (p. 4).

This paper takes a process view of intuition based on dual process theories of cognition that distinguish between processes that are unconscious, rapid, and automatic (System 1), and those that are conscious, slow, and deliberative (System 2) (see Hammond *et al.* 1987, Epstein 1991, 1994, 2003, Hogarth 2001, Evans 2008). Many of the characteristics of System 1 can be found in definitions of intuition:

> Intuition is a process of thinking. The input to this process is mostly provided by knowledge stored in long-term memory that has been primarily acquired via associative learning. This input is processed automatically and without conscious awareness. The output of the process is a feeling that can serve as a basis for judgments and decisions (Betsch 2008, p. 3).

METHOD

Procedure

A semi-structured interview was conducted with Baroque violinist Alice Evans in January 2009. Evans chose to discuss a piece by J. S. Bach with a prominent violin line: the soprano aria *Ich bin vergnügt in meinem Leiden* from Cantata BWV 58. The interview questions were designed to elicit reflection on the interpretative choices involved in performing the piece. The interview began with a hypothetical masterclass scenario asking Evans how she would teach her interpretation of the piece and progressed to broader questions about musical decision-making.

Analytical framework

The interview transcript was analyzed using interpretative phenomenological analysis (IPA) within the qualitative data analysis software program Atlas.ti (version 6). IPA studies explore the meaning of a particular experience for the participant by focusing on the participant's views and perceptions of the topic being investigated (see Landridge 2007, Willig 2008). IPA is a version of the phenomenological method that does not separate description and interpretation; instead, it acknowledges that the researcher's own conceptions are re-

Table 1. Influences on musical decision-making.

Category	*Discussion points*	*Language examples*
Feelings	Musical characters	I feel
	Tempo choice	You get the sense
	Ornamentation	
	Baroque bow and instrument	
	Bass line	
Score analysis	Harmony	I look for
	Beat hierarchy	Be aware
	Placement of rests	Noticing
	Chord position	
	Articulation markings	
	Clarity of different parts	
Research	Text of cantata	I learned
Technique	Intonation	Basic things
	Producing good tone	
	Rhythm	
Experiences	Playing other pieces by Bach	I played
	Playing from different editions	He said
	Using first Baroque bow	
	Rehearsals with Sigiswald Kuijken	

quired to make sense of the participant's life world through a process of interpretative activity (Smith *et al.* 1999, pp. 218-219).

RESULTS

During the interview, Evans discussed 20 different influences on her musical decision-making in relation to interpreting the piece. Analysis of the transcript resulted in the creation of five thematic categories: feelings, score analysis, research, technical considerations, and experiences (see Table 1). The language used to discuss an aspect of the piece—for example, "feel," "sense," "look," or "learn"—informed this process of categorization. Based on the definition claiming that the output of intuition is a feeling (Betsch 2008), 5 of the 20 elements of Evans' interpretation could be classed as operating via intuition, while the categories score analysis and research demonstrate more conscious, controlled decisions. The categories technique and experiences

Table 2. Discussion of decision-making processes.

Category	*Discussion points*	*Language examples*
Intuition	Instinct Subconscious realization	Accumulative learning Thoughtlessness Absorption Innate sense Reaction
Analysis	Taste Consciousness	Thoughtfulness

seem to influence decision-making at varying levels of conscious awareness. For example, Evans recalled some specifics from influential rehearsals and performances but suggested that knowledge gained through experiences usually took place at a more general, less explicit level.

Although the categorization process demonstrates a mixture of influences on her musical decision-making, Evans labeled herself an "instinctive" rather than a predominantly "learned" player. This distinction is similar to Dunsby's (2002) differentiation between "performers who are more inclined to the intuitive approach, and those who feel that some kind of thorough cognitive underpinning yields better results" (p. 226). Concepts related directly to intuitive and non-intuitive or analytical methods of decision-making discussed during the interview were identified and categorized through a second analysis of the transcript (see Table 2).

DISCUSSION

While Evans frequently referred to "instinct" during the interview, instinct is not guided by deep knowledge structures, prior learning, and expertise (Carlson 2004), and what Evans described could perhaps be more accurately termed intuition:

> For me there is an aspect in music which is accumulative learning and so you do something automatically that is sort of the culmination of what you've learnt up until that point and so you don't make a conscious decision about what you're doing. You do it completely without thinking. So for me instinct, whether or not semantically that's correct, for me instinct includes partially reacting without thought using the knowledge that you've had up until that point. Therefore it can change, so the more you

> learn, your instincts towards something can change. But for me, I use instinct as the opposite of thoughtfulness, consciousness, so that you do something without being conscious of why you're doing it in the moment.

Evans' description of intuitive processes as being automatic, having low conscious awareness, and being based on accumulated knowledge corresponds to the characteristics of intuition as defined by Betsch (2008) and other authors (see Hodginkson *et al.* 2008). These characteristics result in decisions that "make sense" or "feel right" and cannot be readily explained by a specific reason.

According to Weber and Lindemann (2008), the lack of conscious access associated with expert intuition is either because "previously conscious, analytic processes have become automated to a point in which conscious attention is no longer necessary or as the result of cumulative, associative learning that has never been conscious" (p. 191). The interview data suggests that for Evans, much of her knowledge was not gained consciously, but through experience and what she termed "absorption." The automation of analytic processes on the other hand is similar to Simon's (1987) definition of intuition as "analyses frozen into habit" (p. 63), which in musical contexts could apply to learning technical skills or the activity of practicing in general.

This preliminary study has attempted to present a framework of decision-making through which intuitive and non-intuitive processes involved in interpreting a musical score can be identified. The study concentrates on the subjective experience of musical intuition while acknowledging that self-report data can present difficulties for the researcher. For example, musicians may inaccurately attribute their behavior, certain processes may not be introspectively available to them, or they may be "anxious, defensive, or unaware of what they do" (Chaffin and Crawford 2007, p. 156). The author intends to develop an understanding of how musical intuition is experienced by period instrument string players through further interviews in combination with other approaches to data collection.

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Applications of formal analysis: Musical comprehension and memory consolidation in performance

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This paper reflects principally on the perception of musical form and its dependence on the temporality in front of the conceptual system, related to the nominalizations and numerical groupings of the theoretical representation of the structure. Through the assumption of practice as the only way to experience music, this paper calls for sensations and emotional intelligence with regard to musical appreciation, including form as one of the most important elements of musical comprehension. The capacity of the performers for evoking musical form, through its knowledge synchronically to its temporal experience, is defended as a potential tool for consolidating memory due to the security it provides in performance.

Keywords: formal analysis; memory; musical comprehension; time; performance

Independent of the consideration of music as a language and consequently a communication system (Maconie 1990), or as an abstract expression of "something" not related to the will of meaning, a structure exists that defines it in length and articulates the presentation of its sonorous content. Considering music as a language or a discourse the form refers to its syntax (Vega-Rodríguez and Villar-Taboada 2001) and, taking into account the exclusiveness of its abstract expression, avoiding a semantic quality, and noticing its ineffable condition (Jankélévitch 1983), the form constitutes the design of those presented. In both cases, the complex organizational analysis of the developed elements in a composition fosters the comprehension, apprehension, and assessment of its contents by the performer. The knowledge of the form of a piece, through its analysis, allows the performer to connect the synchronic relationship of execution and aural capacity with the prevision or, as

Huron (2006) explains, with a *sweet anticipation* that makes possible the evocation/recovery (the last period of memory capacity after appropriation and storage) of that which is to be played. It is absolutely feasible to play, even by heart, ignoring the formal dimension of a piece, although it is not possible to "perform" (Stravinsky 1942) a musical work without a solid assumption of its form. Tovey reminds us that "players should understand what they play" (Lester 1995), and formal analysis is a relevant tool for connecting the multiple musical elements (values, frequencies, rhythm, melody, nuances, tempo, agogic, harmony, motives, cadences, etc.) for this purpose.

Performing from memory can trigger fears or insecurity about final results in live performances. But at the same time, playing by heart awakens in players a sensation of freedom with regard to the musical appropriation which provides a very convenient state of introspection and individuality (Delannoy 2008) with the support of the "emotional intelligence" (Goleman 1995). While in theory the formal analysis rests on the *number* (number of sections, phrases, motives, measures, notes, etc.), the execution embraces *time* as the perception of form. Music is a temporal artistic representation, and this is the crucial point through which a performer may transcend what he or she appreciates at a cognitive level to the experience of practice (Elliot 1995). Rousseau (1760) explained that "only through our own movement we acquire the idea of extension" (p. 82). In a parallel way, it is possible to affirm that only through the *experience of time* can we acquire the final idea of musical form. Intellect and perception (Renaud 1999) plus imagination are the keys for consolidating musical memory (Snyder 2000, Barbacci 1987) in order to attempt a "rhetoric expression" of structure.

MAIN CONTRIBUTION

To know the limits of the musical form does not mean to understand it. The border that divides the knowledge and the comprehension of the musical structure can be as wide or as narrow as the capacity of the performer for letting himself or herself be attracted by the temporal experience. For a theoretical analysis of the structure of a piece it is indispensable to develop "logical-mathematical" and "spatial" intelligences (Gardner 1993). Logical-mathematical intelligence is required for synthesizing, through the *number*, a piece's parts and limits, while spatial intelligence is required as a visual help for speeding up the logical-mathematical intelligence in the preliminary stage of a piece's progress. Perhaps both intelligences were considered by Gardner as constituent parts of another of his defined intelligences: the "musical intelligence." However, for transcending the results of the theoretical recognition of the form to the practical perception, it is necessary to turn to the "emotional intelligence" bonded to the physical sensations. Goleman (1995, p. 15) insists on the *experience* as the "basic vital attitude" in front of the "concept" in a proper free flowing "emotional intelligence."

What is the route of experience? The route of experience is *time*. But the perception of *time* is evidenced only through the experience. In this process of complicities, the experience of the physical/vital movement in performance is essential in order for the performer to be conscious synchronously to the execution of the start and ending of the frequencies, musical cells, phrases or sections of a composition. This is just what form represents. Because of past assumptions this reflection focuses the attention on the comprehension of music, including its form or structure, as an "act." Elliot asserted that "the aesthetic concept of music-as-object obscures the more fundamental reality of 'music' as a form of deliberate doing and making" (Elliot 1995, p. 49). The musical comprehension through the perception of form via *time* illuminates a very important demand in professional performance: memorization.

The duration: The formal essence of music

The form is what defines, configures, or holds up an *object* due to the limits that it imposes on the matter of which they are made. In *music*, once it is transcended from the score/object to the sonorous world thanks to practice, the only way to appreciate its form is hearing it attentively and letting the time occur, trying to perceive *when* the sound and the multiple associations that the composer establishes with it start and end. This is the perception of the sound *duration*. Kivy (2001) affirms:

> That musical form is spatial I can only take to be a claim based on the conflation of musical form with its mode of representation. It is an unfortunate choice of words to have started calling sonata, variation, rondo, and so forth "forms"·at all, for the obvious reason that "form" is a word more closely connected in our common usage with two-dimensional or spatial images. But musical forms are not, except metaphorically (although the metaphor is ubiquitous) musical shapes. They are *temporal patterns* (p. 211).

Similarly Tarchini (2004), pianist and formal analyst, affirms that:

> The possibility of a conscious monitoring of the temporal progress implies a great capacity for compiling, synthesizing, associating and under-

> standing the obtained data from the score. This capacity allows us to corroborate with certainty the perceptive and formative unities, their functions, hierarchies and the different levels of tension-rest (p. 311).

What is important in Tarchini's words for this study is the acceptance she assumes of a temporal awareness in performance and its connection with the musical form.

The number: The organizer concept of the musical form for theory

Although for the performers and the audience the musical form is essentially perceived "in time," in theory the form is conceptually measured in the number of figures and silences, measures, cells, semi-phrases, phrases, themes, motives, sections, or movements registered through a graphic code in a particular space: the score. The resultant quantities of all the elements of the musical form are, in theory, as static and tangible as the paper's fragments that contain them. Musical theory has named some of the most common musical forms throughout history. Sonata, lied, or fugue are some of these standardized forms. But, obviously, they do not represent the "fingerprint" of any particular piece. When theory wants to recognize and describe a specific piece, it uses the *number* to elaborate the exhaustive and individual structure of its content. As an example, the formal "fingerprint" at the beginning of Chopin's *Scherzo* Op.20 is represented in Table 1. Evidently, the names *motif, exposition, section, introduction*, or *transition* that appear in the analysis-table are valid for many other masterpieces, usually in the same order, but what is almost impossible—or would be the result of chance—is that the sequences that conform to the different named parts are the same in other pieces regardless of the number and the association with the measures they have.

Strategies of musical memory: Formal evocation

Through the formal analysis of a composition (theoretical and temporal-perceptive), the musical contents remain mentally delimited. The resultant compartments of the contents' delineation depend, among other aspects, on the "meaning," inspiration, aesthetic, harmony, style, syntax, rhythm, melody, musical prosody, expressiveness, or technical exigencies that affect them; *qualias*—"inherent proprieties of sensorial states" (Delanoy 2008, p. 111) and so on. The order imposed by performers to these formal compartments demands of the musicians a volatile impulse of *interaction* and *expectation* of their elements, which represents in a hypothetical memorized performance,

Table 1. Chopin's *Scherzo No.* 1 Op. 20 in B minor for piano.

Section	*Measures*
Introduction	1-8
Section A	9-68
Exposition Theme A-1	
Motif A-1	9-16
Presentation motif A-1	9-11
Transport motif A-1	11-13
Conclusion motif A-1	13-16
Motif A-1 transported	17-24 etc.

two important resources for avoiding the so feared lapse. Even when a slip emerges, the "musical mind" tries to reconstruct the material with reference to the specific details of the general elements. Form is essentially a general element so, if performers remember it, the "last" opportunity to reconstruct the musical material is in some way guaranteed. Memory survives partially thanks to the growth of security; when a commanded formal evocation begins, the consciousness of the musical content is more effective and the performance evolves synchronically from a passive verification of audition synchronically to a simple and physical execution to a controlled mental complex. This is thanks to the re-creative intention, which in symbiosis with the bodily experience provides a sensation of pleasure and security in practice.

IMPLICATIONS

The benefits of involving formal analysis in performance as a memory resource include: (1) the potential for music comprehension, (2) the evidence of the acquired knowledge as a tool for continuing to learn from it, (3) the cultural information that it provides about structural models, (4) the mental appropriation of musical content, (5) the effective use of practice and teaching hours, (6) the prevention of lapses due to the effort of construction and de-construction of musical material, (7) the knowledge of formal patterns useful for improvising and composing, (8) the attention to the musical breath and musical discourse apart from technical necessities, and (9) the mathematical stimulus of mental processing. To resort to the formal analysis represents an exercise of compromise and faithfulness to the composer and his or her creation, which forms the basis of a "possible" performance.

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That blissful feeling: Phenomenological conceptions of music performance from one performer's perspective

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Inspired by the small amount of relevant past research available (Berger 1999, Berliner 1994, Monson 1996, Sudnow 1978), this paper focuses on the type of performance experience an individual musician views as worthy of striving toward (and avoiding) and the possible way(s) in which this can be accomplished. Using Strauss and Corbin's (1998) take on Grounded Theory (GT) as a methodology, data obtained from a semi-structured, in-depth interview with Jeremy Kelshaw (JK), a professional musician, are examined. JK's subjective, phenomenological experience of music performance comprised a detailed understanding of an ideal performance which emerged from JK's understanding of excellence and the uniquely uncertain nature of music performance. Also important in this experience were a number of strategies implemented by JK and his band Cloud Control in an attempt to establish, maintain, and regain vibe, the mysterious key ingredient of a desirable performance experience. Alongside the implications it holds for music education, this research also provides a unique insight into an individual musician's understanding of an ideal performance experience and the strategies used to achieve this.

Keywords: phenomenology; experience; interview; idiographic

The bulk of past studies examining music performance within the discipline of psychology have utilized an experimental research paradigm centered on the music listener. These studies have particularly focused on the relationship between music and the listener's emotion experience (Gabrielsson and Juslin 1996, Huron 2006, Minsky 1982, Sloboda 1991, Waterman 1996). In comparison to the music listener, the perspective of the music performer has been relatively underrepresented in this literature. The majority of studies have used an experimental research paradigm to examine the importance of performer-related factors such as emotion and memory (Dunsby 2002, Palmer 2005, Williamon 2002). The specific nature of these studies restricts the amount to which they are able to contribute to an understanding of a musician's gestalt experience of performance.

A handful of studies have examined a musician's broader experience of music performance using self-report and in-depth interviews. One difficulty among many when discerning the relevance of this research to the current research project is that different genres make different use of a large number of variables including musical form, convention, and performance setting. These variables must have an impact at the level of phenomenology. In this way, work by Berliner (1994), Monson (1996), and Sudnow (1978) examining the experience of performance for jazz musicians is valuable, but naturally cannot apply across all genres. Aligning more closely with the aims of our research, Berger (1999) investigated the musician's experience of performance across three genres, discovering a close link between performer affect, music structure, and aspects of the performer's social life. However, noticeable researcher bias, coupled with the strong historiographical and ethnomusicological foci of Berger's work, limits the relevance of its results to our research. We aim to allow the "data to speak" by being more exploratory in our focus and choice of methodology.

Arising from this context, the main objective of our research is to ascertain which sort of performance experience, if any, a musician views as worthy of striving for (or avoiding) and the possible way(s) in which this is accomplished. By conducting and analyzing semi-structured, in-depth interviews with professional musicians, this research aims to build a Grounded Theory (Strauss and Corbin 1998) of the musician's performance experience. An interview with a single musician, the first in this program of research, forms the basis of this article.

MAIN CONTRIBUTION

Research methodology and background

Strauss and Corbin's (1998) reworking of Glaser and Strauss's (1967) Grounded Theory (GT) is the ideal methodology for this research program due to the paucity of past research available in the subject area and the aforementioned difficulties associated with attempting to investigate phenomenology and experience. Rather than demanding example verification or perfect description, GT calls for bottom-up theory building derived from strict adherence to data. To aid theory building, GT employs theoretical sampling, a piecemeal approach in which "sampling, rather than being predetermined before beginning the research, evolves during the process" (Strauss and Corbin 1998, p. 202).

The data on which this article is based are drawn from a semi-structured interview carried out with Jeremy Kelshaw (JK), an experienced bassist currently playing in Cloud Control, a moderately successful self-described indie, alt-folk, pop band. It was initially thought that JK's interview would serve as a pilot study. However, the data emerging from this interview were rich and substantial enough to allow the interview to be included as the first in a program of research involving interviews with professional musicians. The unpredictability of theoretical sampling and the incomplete nature of this research make it important to stress the preliminary nature of findings reported in this article.

The interview

Excellence and the blissful moment

In describing his ideal performance experience, JK not only spells out the specific type of performance experience that he aims to create but also reveals his understanding of excellence:

> If you're not nervous and [the] crowd is already into it…and if it's a song that you know backwards…you just go into a little bit of a zone…. In that blissful moment it's the same feeling you have when you really enjoy anything I think…. Your body knows what to do, and you just go into this trance…. You just enjoy yourself, and you don't have to think…. It's that feeling of success and a feeling of accomplishment and privilege at the same time…. It's just bliss.

Phenomenologically, excellence in performance for JK comprises feelings of bliss, success, accomplishment, and privilege. "Trance" and "zone" are used by JK in an attempt to convey the other-worldly nature of this experience, amplified by the high level of intensity and extreme pleasure accompanying these feelings. Csíkszentmihályi's (1990) notion of "flow" is helpful here. Just like one experiencing flow, JK's experience is characterized by concentration, absorption, and reward.

Vibe

Although the word was originally introduced into the interview by the researcher (AG), JK demonstrates a predilection toward using vibe in his description of performance experience. Closely linked to JK's ideal performance experience, vibe approximates to an emergent something that binds the blissful moment together. Its nexus between individual band members, vibe can expand to fill the space between band and audience and band and song, with all three of its manifestations being interrelated:

> It is the four of us, first and foremost, trying to create a connection with each other and then that being broadcast to the audience.... In the same way that you can't force a vibe with an audience, you can't force a vibe with a song.

A fleeting uniqueness

JK's understanding of the unique nature of music performance underpins the performance experience that JK aims to create:

> A live performance is unique in that it happens once and then it's gone.... [It] is unique to you and unique to the people that you're playing with.

The inherent uncertainty in music performance resulting from its vulnerability to temporal and contextual specificity is, ironically, of greatest threat and value to JK. Feelings of exclusivity, privilege, success, and accomplishment stem from the informed yet inevitable gamble with uncertainty JK must take during performance and the sense that it has, on this occasion, paid off. Yet uncertainty also serves as the biggest obstacle to JK's desired experience, with performance being a fleeting, nonreplicable creative experience. A certain quality of performance then, a specific type of experience, a particular type of vibe, can all be aimed for but can never be taken for granted nor guaranteed.

Indefinable connection

Like vibe, there is also an element of uncertainty in the connection to audience. Although vital to a successful performance, the way in which a dynamic and reciprocal connection to the audience emerges seems unable to ever be completely fathomed:

> So much of a successful performance is a connection with the audience... We can't pin it down but I think...the better performers still look for that connection, look for that connectivity.

Although partially reliant on variables such as audience expectation, genre, and location of performance space, the unpredictable elements of a connection to the audience, just like those in an ideal music performance, guarantee against its certainty. As a result, performance for JK must always involve working hard to establish, maintain, and prevent the loss of both connection and vibe.

The shaping of a successful performance

Cloud Control implement a number of tactics in an attempt both to prevent an undesirable performance experience and to increase the likelihood of a desirable performance experience. Among pre-performance strategies such as ensuring familiarity with a piece of music and thinking thoroughly about a set list, Cloud Control carry out a pre-performance routine. Prior to performance, the band finds a physical space in which they can sit, collecting their thoughts, singing together and listening to a motivational speech delivered by JK. This routine ensures band members are on the same wavelength before performance. Cloud Control also execute a number of strategies onstage. The most important of these strategies for JK centers on his notion of intention. For JK, performance is never a haphazardly random occurrence into which the performer is thrown but is rather a planned experience over which the performer can exercise control:

> I think you've gotta be intentional.... You can actually choose to have a good time.... You just have to give it your best, and people will respect that.... If it's out of your control then that's fine.... How you respond to that is in your control.... That is all you can do really.

Although some variables may be out of a performer's control, for JK, the amount of enjoyment derived from a performance and the amount of effort put into a performance are not. Even if other factors are less than ideal, intention seems conducive to establishing vibe.

IMPLICATIONS

Analysis of an in-depth interview with a single professional musician provides a unique insight into the particular meaning that excellence holds for JK in the context of performance. Using conceptual variables as units of comparison, the iterative nature of theoretical sampling in GT will allow this picture to expand continually over the course of the research project. It is hoped that dissemination of the results of this project might also renew appreciation for the amount of work and talent the intricacies of successful music performance demand. This work also holds potential implications for the ways in which music is learned, taught, and performed.

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Thematic session:
The perception of technique

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Left-hand expression in cello playing: Exploring approaches to shifting

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This investigation explores aspects of musical interpretation in relation to left-hand cello technique. It focuses on how listeners, performers, and teachers approach shifting, both in terms of its functionality and its expressive use in portamenti. The method involved appraisal of five selected interpretations through listening experiments with cellists and other instrumentalists, analyses of portamenti, and interviews. The results revealed that listeners generally preferred contemporary recordings with less obvious use of portamenti and that cellists tended to rate the use of portamenti higher than other instrumentalists.

Keywords: performance; expression; string playing; shifting; preferences

During Pablo Casals's 97 years (1876-1973), the cello emerged from reclusion to take its place alongside other popular solo instruments. Major additions to the repertoire presented cellists with new challenges, and advances in recording possibilities ensured that technical proficiency became the norm. Although much has been written about string technique, there is no detailed study of the expressive characteristics of *shifting*. Pleeth (1982) suggests that the "feel" for distance in movement and the variety of tension in the left-hand are essential in creating good shifts. He also links portamenti to singing and states that "it is the notes that give birth to the slide, not the other way around" (p. 37). However the study of such a technical, yet expressive, tool can be problematic. Mantel (1975) suggests that "technique cannot be separated from the experience of making music. For practical purposes [however] we can separate technique from interpretation…a point of departure for the analyses of this technique" (p. XV). Although such separation may be possible in order to refine technique, there seems to be little point in practicing technical movements without relating them to a musical objective. Nonetheless, in the mechanical sense, musicians have been the object of study for quite some time, as examples of practitioners with highly skilled sensorimotor coordination in terms of precision, speed, and dexterity (e.g. Kay 2003). The relationship between mental representations and motor actions in pianists has also been studied (e.g. Drost *et al.* 2005). However, studies on the relationship between musical understandings and ways of shifting are nonexistent. Music performance research often considers expressive intonation, vibrato, dynamics, and timing, but with the exception of a few studies on the violin, expressive shifting is rarely mentioned.

This investigation examines expressive shifting from both technical and interpretive angles, exploring approaches to portamenti from the perspectives of the listener, the performer, and the teacher. This article reports on the first two perspectives: (1) listeners' evaluations of portamenti and impact on interpretation and (2) cellists' individual approaches to shifting and portamenti in performance.

METHOD

Participants

Thirty-eight listeners were recruited: cellists (n=27) and other instrumentalists (n=11). The 27 cellists comprised undergraduate (n=14) and postgraduate (n=8) students of the Royal College of Music and Trinity College of Music, amateurs (n=2), and professional performers (n=3).

Materials

Five recordings by distinguished cellists (see Table 1) of the *Finale* from *Don Quixote* by R. Strauss were selected. This excerpt was chosen for its extensive potential for expressive portamenti.

Procedure

All recordings were analyzed and compared focusing on portamenti. For the purposes of homogeneity, recordings were normalized and noise reduction filters were applied. The participants were asked to evaluate an extract of the *Finale* (see Figure 1), with the five recordings played in a random order, using a scale of 1 to 7 and to provide the reasons for their ratings. Subsequently, the participants were required to listen to the same extract a second time, rating the use of portamenti for the following categories: (1) quality (QP), (2) appropriateness for the interpretation (HA), and (3) overall importance (OI). Semi-

Figure 1. Cello part of the extract played from the *Finale of Don Quixote* by R. Strauss.

Table 1. Cellists, recording labels, and dates of the five recordings, as well as the estimated onsets, offsets, and durations of the selected portamenti.

Recording	*Cellist*	*Label*	*Onset-offset (s)*	*Duration (ms)*
R1 (1976)	M. Rostropovich	EMI 4-76903	19.07-19.18	~120
R2 (1969)	P. Fournier	CBS 61110	16.62-16.79	~160
R3 (1938)	E. Feuermann	IGI-372	17.08-17.31	~240
R4 (1958)	P. Tortelier	HMV ASD-326	18.96-19.11	~150
R5 (1953)	G. Piatigorsky	HMV ALP-1211	18.87-19.18	~200

structured interviews were carried out with the cellists, probing their approaches to shifting, including practice strategies, decisions about choices of portamenti, relationship with stage fright, and training received.

RESULTS

In order to determine whether there were differences in the listeners' evaluations of interpretations and *portamenti*, repeated measures Analyses of Variance (ANOVA) were conducted separately for each type of rating. The within-group variable was the recording, and the between-group variable was cellist/non-cellist. Mauchly's tests of sphericity were significant for each test and, therefore, F values are reported with the Greenhouse-Geisser correction. Thee main points arose.

Firstly, significant between-group differences were found. Cellists' ratings of interpretations and portamenti were generally higher than non-cellists.

The differences between the two groups were significant in QP ($F_{1,35}$=8.55, p<0.05) and HA ($F_{1,35}$=6.57, p<0.015). Since all recordings were by eminent cellists, it is perhaps expected that cellists, most of them students aiming to acquire the technical and musical skills present in the recordings, would indeed rate QP and HA higher than non-cellists. However, evaluations of OI seemed to reflect simply the amount of portamenti employed (i.e. the more portamenti, the higher the rating).

Secondly, the analysis revealed significant within-group effects across all performances for all four outcome measures: PE ($F_{2.86,99.95}$=4.32, p<0.05), QP ($F_{3.06,106.92}$=2.98, p<0.05), HA ($F_{2.68,93.87}$=7.20, p<0.05), OI ($F_{3.16,110.8}$=9.45, p<0.05). Although the exact pattern of differences varied between the four outcome measures, inspection of the marginal means (see Figure 2) suggested that R3 was generally least preferred in terms of PE, QP, and HA. However, the profile for OI was reversed, indicating that the importance of portamenti was high in R3. This seems to suggest that participants found the portamenti particularly striking in R3, but they did not generally like it. The preferred interpretations (PE) were R4 and R5, and the highest ratings for QP and HA were for R1.

Thirdly, the only significant interaction between recording and group was for PE ($F_{2.86,99.95}$=3.48, p<0.05). As can be seen in Figure 3, while the general between group effect (cellists rating higher than non-cellists) was maintained for recordings 1, 2, and 4, the difference disappeared for R3 and R5. This may be due to the fact that most cellist participants are students used to contemporary styles and, hence, more biased in their appreciation of interpretations set in a different era than other instrumentalists (i.e. the lower ratings may reflect their lack of familiarity with older styles of interpretation).

A preliminary analysis of the recordings was also carried out, and as expected, a variety of approaches to portamenti was found. For example, the number of portamenti heard varied considerably for each recording (R1 n=22, R2 n=18, R3 n=28, R4 n=22, R5 n=16), and there were only two places where all cellists commonly produced portamento (see Figure 4): third to fourth beat of bar 4, and last beat of bar 15 to first beat of bar 16.

The analysis of shifts in bar 4 also highlights the individual approaches adopted. Although spectrograms cannot offer a clear representation of portamenti due to the presence of orchestral accompaniment, it is still possible nevertheless to identify some of the partials of the most salient pitches (F# and D) as well as changes in frequency. Spectrograms were, therefore, created using 512 points Fast Fourier Transforms with 87.5% overlap. The approxi mated durations (see Table 1) are based on the steady state of pitches since the presence of vibrato and interference of orchestral sounds hindered the

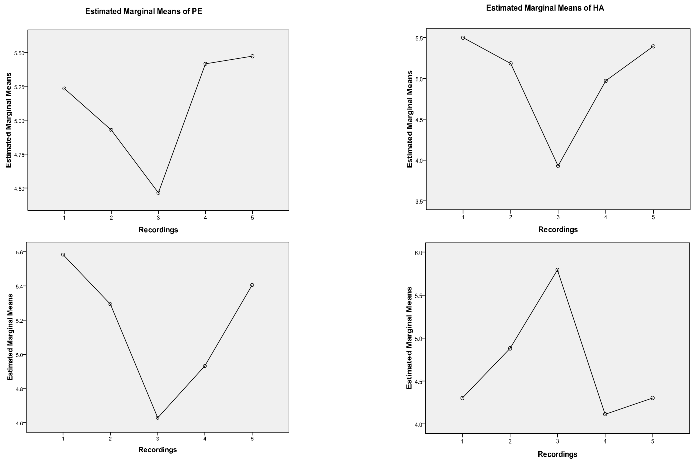

Figure 2. Listeners' mean ratings (cellists and non-cellists) for PE (top left), HA (top right), QP (bottom left), and OI (bottom right).

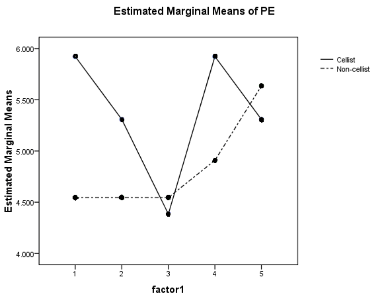

Figure 3. Graph of interactions (mean ratings for cellists and non-cellists) for PE.

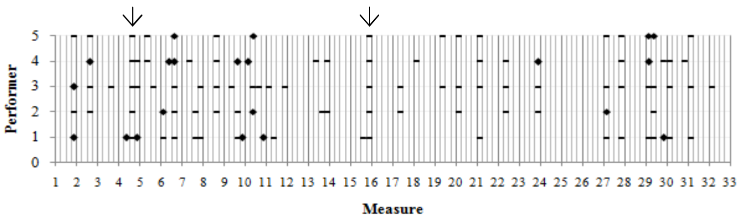

Figure 4. Places of portamenti in each recording. Pronounced portamenti are shown by the segmented lines and less pronounced portamenti shown by the diamond shapes. Arrows indicate common places of portamenti for all cellists.

precision of the estimation of onsets and offsets. The spectrograms showed that portamenti differed not only in their duration but also in the vibrato employed at the beginning of the shift; their speed from the departure to the arrival pitch, and the changes in loudness.

DISCUSSION

This exploratory study shows that (1) approaches to portamenti are highly individual and (2) this plays an important role in listeners' preferences for certain interpretations. The results of the evaluations highlight the preferences for contemporary styles with fewer expressive shifts as well as the higher ratings by cellists when asked to focus upon specific technical and musical aspects of shifting.

This preliminary study will be further developed by focusing on teaching. Observations, interviews, and intervention studies will provide insights into contemporary and artistic approaches involved in shifting that may have an impact on how cellists prepare for performance. In these ways, the continuation of the research will have implications for performing, teaching, and learning, stimulating performers toward more creative and artistic approaches to the role of the left-hand in cello playing.

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Fingering force in violin vibrato

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This study investigated the spatio-temporal features of the longitudinal ("shaking") and normal ("press") string clamping forces by the left hand during vibrato sound production. A violin installed with a 3-D force transducer was used for the measurement of the force at the D5 tone position. Twelve trained violinists produced an A (open) tone for 2 s followed by a D (vibrato and force measurement) tone for 30 s at different vibrato rates (4.5 and 6 Hz, and no-vibrato), dynamics (*p, mf,* and *f*), and with the use of different fingers (index, middle, ring, and little fingers). The average, amplitude, and peak-to-peak time of shaking, and press forces, and the longitudinal-lateral shear force relationship were evaluated. During vibrato, an oscillated pattern was observed in each of the three forces, while the longitudinal component demonstrated the largest periodic oscillation. The average press force and the amplitude of shaking force significantly increased with the rate of vibrato as well as dynamics of the sound generated. These force variables did not differ among the four fingers. The shaking force showed considerable inter-player difference (1.0-4.2 N). The feedback training was found to help in some reduction of the force.

Keywords: violin; vibrato; fingerboard reaction force; acoustic parameters; finger difference

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Fluctuation strength of tremolo played on the mandolin: How is tremolo evaluated as good?

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The tremolo played on the mandolin is a continuous sound produced by the repetition of attenuating sounds. The amount of acoustic amplitude of tremolo is usually fluctuated in terms of time. Therefore, the tremolo is assumed to give a listener the feeling of fluctuation, which is thought to be concerned with subjective evaluation for performance proficiency. Introduced here is an evaluation method that strongly depends on the "fluctuation strength" (FS), which has been suggested as an index for evaluating the feeling of fluctuation for fluctuating sounds at low frequencies. Past studies have investigated the index for modulated pure tones and broadband noise. In this study, tremolo fluctuations are described by FS, and the relation between FS and tremolo proficiency was investigated through evaluation experiments. Specifically, we conducted four studies using performance sounds and two kinds of synthesized sounds. As a result, highly rated tremolos had a relatively low physical FS and were correlated with highly subjective evaluations. Therefore, we confirmed that skilled tremolos satisfied both playing restrictions and psychoacoustical criteria.

Keywords: mandolin; tremolo; feeling of fluctuation; fluctuation strength; subjective evaluation

The tremolo is one of the popular ways of playing the mandolin (Fujita 2005). Though there is almost no agreement concerning the physical characteristics of tremolo played by experts, the feeling of fluctuation on tremolo is thought to be concerned with subjective evaluation for performance proficiency. The "fluctuation strength" (FS) has been suggested as an index for evaluating hearing sensation in fluctuating sounds at low frequencies, and past studies have investigated that of modulated pure tones and broadband noise (Terhardt 1968, Fastl 1982, Fastl and Zwicker 1990). However, few have reported on the FS of fluctuating musical sounds produced by musical instruments and proficiency. In addition, there are no suggestions for an index corresponding to their proficiency.

Therefore, tremolo fluctuations are described by FS, and the relation between FS and tremolo proficiency was investigated through evaluation experiments. The plucking rate, onset deviation, and amplitude deviation are set on the basis of our assumption that they affect the hearing sensation and subjective evaluation for tremolo more strongly than the other factors. Here, both onset and amplitude deviation are called "irregularity on tremolo." Aesthetic performances of tremolo are said to be "smooth" or "not fluctuating" by trained players, so the amount of FS for tremolo is originally calculated by extracting a fluctuation component of about 4-8 Hz from acoustic data. The procedure for objectively calculating the amount of FS is designed based on facts reported by past studies (Terhardt 1968, Fastl 1982, Fastl and Zwicker 1990) and an assumption that the characteristics of the tremolo are somewhat similar to the AM SIN at slow speeds (Roads 2001).

Therefore, we hypothesized that the fluctuation components extracted originally from a tremolo influences the feeling of fluctuation (or an aesthetic evaluation). Here, the calculated FS is called "physical FS," while the FS proposed by Fastl *et al.* is called "psychological FS." We conducted four studies using performance sounds and two kinds of synthesized sounds. In Study 1, the region of plucking rates used in actual tremolo performance was investigated. In Study 2, in order to describe tremolo fluctuation by FS, the relation between feeling of fluctuation, and physical FS was investigated using synthesized sounds that have just a feeling of fluctuation without tremolo proficiency, played at several plucking rates (2-16 Hz). In Study 3, the relation between physical FS and tremolo proficiency was investigated using performance sounds played at three plucking rates (6, 8, and 9 Hz). However, factors that affect the feeling of fluctuation and subjective evaluation for tremolo proficiency are not only plucking rate but also onset deviation and amplitude deviation. The unified irregularity on tremolo is rarely found by simply observing actual performance. So, in Study 4, the relation between physical FS and tremolo proficiency was investigated using other synthesized sounds by controlling three parameters that have both tremolo proficiency and feeling of fluctuation. Here, synthesized sound used in Study 2 is called "imitated sound," while the sound used in Study 4 is called "simulated sound."

METHOD

Participants

In Study 1, four mandolin players with over two years of experience were used as listeners. In Study 2, two of the listeners were mandolin players, and three of the listeners had no experience of playing the mandolin. In Study 3, seven mandolin players (P1-P7) with over three years experience were used as mandolin players. Six other mandolin players with over a half year of experience were used as listeners. In Study 4, five other mandolin players with over a year of experience were used as listeners.

Materials

In Study 1, simulated tremolo sounds with onset deviations and amplitude deviations on each plucking were used, 60 in total (3 deviation patterns and 20 plucking rate patterns). In Study 2, imitated tremolo sounds with onset deviations and amplitude deviations on each plucking were used, 45 in total (3 deviation patterns and 15 plucking rate patterns). Those sounds have just a feeling of fluctuation without tremolo proficiency. It Study 3, 21 tremolo sounds played by 7 players were used (i.e. 3 plucking patterns times 7 players). In Study 4, simulated tremolo sounds with onset deviations and amplitude deviations on each plucking were used, 27 in total (3 deviation patterns and 9 plucking rate patterns).

Procedure

In Study 1, participants were asked to evaluate whether or not stimuli were significantly perceived as tremolo sounds. In Study 2, an experiment using the method of magnitude estimation was conducted to subjectively evaluate the magnitude of fluctuation for imitated sounds synthesized at several plucking rates (2-16 Hz) under three deviation patterns by five listeners. In Studies 3 and 4, the two tremolo sounds were presented one immediately after the other, and listeners were asked to subjectively select the better one.

RESULTS

The result of Study 1 is shown in Figure 1; it was found that simulated sounds synthesized at plucking rate of 6-13 Hz were evaluated as tremolo sounds. The result that compared FS with amplitude-modulated pure tone (Terhardt 1968, Fastl 1982, Fastl and Zwicker 1990), as well as comparing to physical FS, is shown Figure 2. The magnitude of fluctuation for imitated sounds in

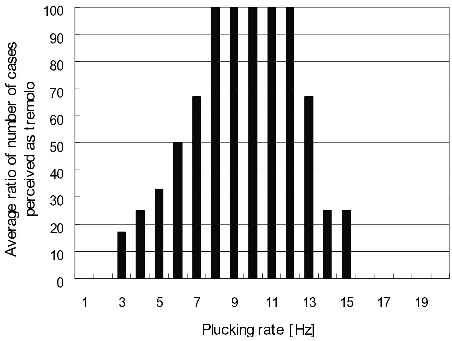

Figure 1. Results of investigation of the region of plucking rates.

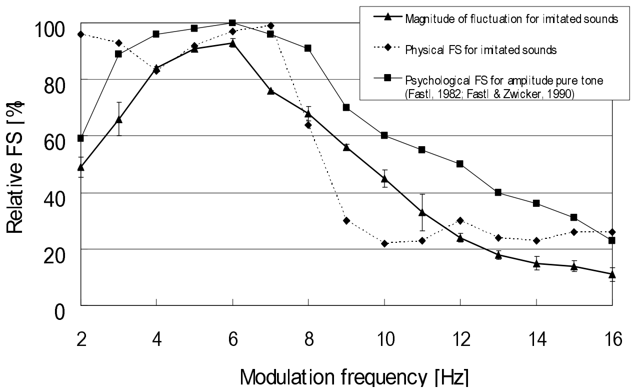

Figure 2. Results of investigation of feeling of fluctuation.

Figure 2 is the average of all results, represented as a percentage. Percentages were obtained by assigning the number 100 to the maximum value of each listener's answer. As can be seen in Figure 2, it was confirmed that magnitude of fluctuation for imitated sounds is high at plucking rate of 4-8 Hz and low at plucking rate of 10-16 Hz. It revealed that the feeling of fluctuation for simulated sounds has a strong positive correlation with a high FS of amplitude-modulated pure tone and physical FS ($0.81 \leq r \leq 0.98$, $n=15$).

As a result of Study 3, it is confirmed that tremolos performed at plucking rates of 8 or 9 Hz were evaluated as good. Also, it is confirmed that faster rates correspond to smaller amounts of physical FS.

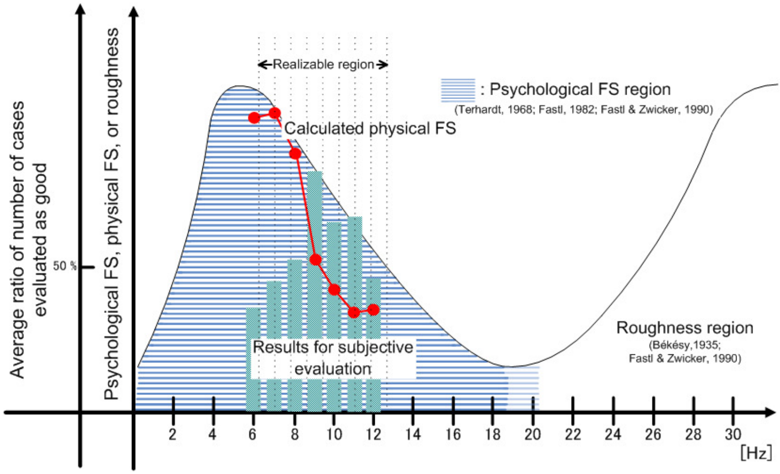

Figure 3. Relation between our results and psychological FS. (See full color version at www.performancescience.org.)

As a result of Study 4, it was found that the tremolos synthesized at plucking rates of 8-11 Hz were evaluated as good. Also, it was found that a plucking rate of 7 Hz corresponds to larger amounts of physical FS, and one after 7 Hz corresponds exponentially to smaller amounts of physical FS.

DISCUSSION

As seen from Study 4, highly rated tremolos had a relatively low physical FS. Furthermore, the physical FS has a strong negative correlation with a high subjective evaluation ($r=-0.60$, $n=27$). Therefore, this shows that physical FS can be used as an evaluation index of the tremolo performance proficiency played on the mandolin.

The relation between results obtained in this study and psychological FS is shown in Figure.3. The “realizable region” is obtained from the results of Study 1. As can be seen in Figure 3, two strong relations were confirmed among the calculated physical FS: the subjective evaluation results and the psychological FS.

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Thematic session: Emotion in performance

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The effects of musical syntax on perception of music performance

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The focus of this study is to examine the effects of social interaction and musical syntax in a music performance with emphasis on emotion perceptions. The syntactical elements that were analyzed during the course of these experiments included pitch, tuning, and timing. Two experiments were conducted to examine the relationship of syntax and performance. In the first experiment, subjects were asked to state preference between altered stimuli with higher levels of expressivity and unaltered stimuli with lower levels of performer expressivity. In the second experiment, subjects were asked to sing familiar or traditional songs in social and individual settings. Results confirm that participants demonstrated a definitive preference toward social interaction when actively engaged in embodied musical performance. However, the outcome was less definitive in passive listening environment of the first experiment.

Keywords: music perception; syntax; musical embodiment; music performance; social interaction

Musical performance situations provide opportunities for social interaction and joint attention (Baldwin 1995). Musical enjoyment in a performance setting often relies on the communicative interaction of participants and the transmission of the musical messages may impact the enjoyment of the participants. According to the “shared affective motion experience” (SAME) model developed by Overy and Molnar-Szakacs (2009), music perception is a process of interactive social communication involving neural processing of pitch and time dimensions that result in complex action sequences involving the perception and/or agency of another person, whose actions are interpreted, imitated, and predicted. While accuracy of musical syntax is generally considered a critical feature of emotional perception of music, in many performance situations the quality of syntax may be secondary to social interaction and group attuning (Leman 2008). De Bruyn *et al.* (2009) found that social interaction between music listeners affected music perception and musical meaning formation processes. Participants in a social setting were better able to synchronize with music and responded with increased intensity of corporeal articulations in social conditions.

The purpose of the present study was to explore the settings in which the importance of syntax is undermined by the context in which the music is performed. The first experiment measured the effect of changes in syntax of the music on listener's preferences and perceptions. The second experiment measured the effect of changes in syntax of the music on subjects' preferences in musical performance environments. In both experimental settings, we examined methods to measure the elements involved in embodied music cognition when syntactical elements are altered.

METHOD

Participants

Thirty-two subjects, aged 20-26 years, participated in each experiment. Participants were from different sample populations. Background data regarding the participants' musical experience were collected through the use of pre-surveys and groups were divided to include musically experienced participants and less musically experienced participants.

Materials

In the first experiment, video/audio segments of approximately one minute in length were recorded with singer and piano. Syntax alteration was introduced through audio software and included tonal changes varying the sharpness or flatness of pitch of approximately 0.67 semitones and timing changes to the piano accompaniment gradually increased through the duration of the musical piece. Survey data was used to collect participant responses after each two excerpts.

In the second experiment, four songs were recorded approximately two minutes in length (two Dutch, two English). Audiovisual excerpts were then altered to include syntactical alteration in timing and pitch. Pitch was gradually altered to -6 semitones. Sliders, which consisted of a scale of 1-10, recorded participant responses while stimulus was played and were interconnected to collect data for both group and individual settings through an *Arduino* interface. A *Max Patch* allowed for data to be recorded along a timeline for each song. Participants were asked to reflect their musical enjoyment using the slider as part of the experimental task, allowing for the collection of data that reflected changing musical preference during active participation in the performance. Data were analyzed according to a timeline corresponding with video data.

Procedure

In Experiment 1, all participants listened to stimuli with and without syntactical alteration, together in a group setting. Subjects were then divided into two groups based on musical experience. Each group was presented a set of four musical excerpts performed in two modes of expressivity. Group A was presented stimuli in the original syntax. Group B was presented all stimuli with an altered syntax. Subjects were asked to state their musical preferences through the use of a survey. Responses were compared in all listening conditions.

In Experiment 2, all participants performed stimuli together in a group setting and individually. Lyrics of the songs were presented simultaneously with visual stimuli and participants were asked to sing along. Stimuli consisted of the same pieces in both performance situations. Subjects were asked to state their musical enjoyment simultaneously while performing experimental tasks. This data was collected through the use of multiple sliders (scaled 1-10) connected through an *Arduino* interface and through the use of a post-survey.

RESULTS

Experiment 1

In Group A, stimuli were presented with unaltered syntax. According to data based in participant responses, the majority of subjects preferred the more expressive performance (see Figure 1). Of the musically experienced participants, 66.7% on average preferred the more expressive performance throughout the musical excerpts. Of the less musically experienced participants, 85.7% preferred the more expressive performance on average throughout the excerpts. This data confirmed that a more expressive performance is preferred when syntax is unaltered.

Group B was presented stimuli with altered syntax. The majority of participants preferred the less expressive performance (see Figure 2). Of the musically experienced participants, 70.8% preferred the less expressive performances throughout the excerpts on average. Of the less musically experienced participants, 72.5%preferred the less expressive performance on

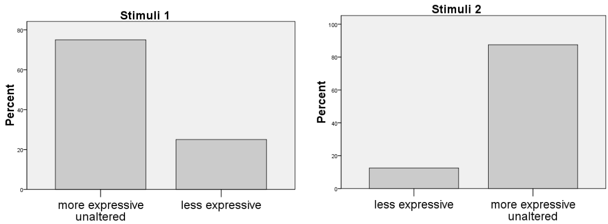

Figure 1. Statistical analysis of syntax perception Group A.

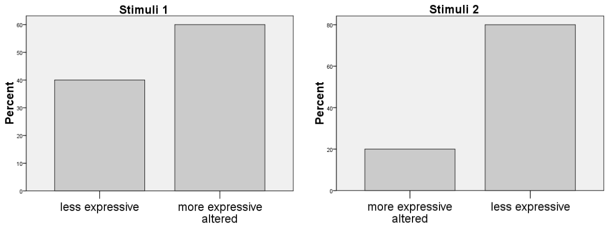

Figure 2. Statistical analysis of syntax perception Group B.

average throughout the musical excerpts. These data demonstrated that a less expressive performance is preferred when syntax is altered in a passive listening situation.

Experiment 2

Subject responses demonstrate a significant preference toward group performance over individual performance. Sixty-six percent of participants responded that the group performance situation appealed to them more than the individual performance situation. Fifty-six percent of respondents mentioned they were most comfortable when singing together in the independent responses. When describing the group experimental setting, 47% of participants responses could be organized into two categories specifying the appealing aspects of the group situation: the social interaction (including "not singing alone," "listening to each other," "feeling supported," and "group/social feeling") and that the atmosphere was more enjoyable or "fun." Of our subjects, 70% said that singing in the group setting was easier because of appreciable differences between their individual and group performance.

In the group setting, subjects responded that it was easier to keep the right tone, there was more fun of singing together and the combination of the voices was more aesthetically pleasing. The altered syntax was not mentioned as a factor in responses for the group singing evaluations. Seventy-five percent felt uncomfortable in their individual performance. In addition, sharing difficulties when performing music increased the enjoyment of some 19% of participants, who stated that sharing of the experience made them "happy" and "comfortable."

Slider data confirmed the overall preference for the group setting when syntax was altered in a musical performance setting. Fifty-nine percent of participants had a greater number of increases in "enjoyment" along the scale when performing stimuli in the group setting. Twenty-two percent had more increases of "enjoyment" in the individual setting. Instances where the degree with which increases in enjoyment were more substantial than decreases in enjoyment occurred for 46% of participants in the group setting and 15% of participants in the individual setting. Instances where the degree with which decreases in enjoyment were more substantial than increases in enjoyment occurred for 12% of participants in the group setting and overall 38% of participants in the individual setting. Fifty percent of participants spent more time at higher levels of enjoyment in the group, as opposed to 9% who spent more time at higher levels of enjoyment in the individual setting.

DISCUSSION

Analysis of data facilitated the observation of the cultural and social dynamics influencing music performance. In Experiment I, participants preferred the more expressive performance overall when syntax was unaltered. However, fewer participants with musical experience preferred more expressive performances than those without musical experience. In situations where the syntax was altered, the majority of participants selected the less expressive performance. The introduction of an additional level of expressivity may influence experimental results. In Experiment 2, participants preferred social interaction in the group setting, as it allowed them to form a common understanding regarding music perception. In future research, it may be possible to integrate syntax alteration through a more ecological approach. Ideally syntax change would be introduced through the performance of participants or performers themselves. A more nuanced distinction between corporeal and cerebral understanding of music and an implementation of a taxonomy of structural cues to analyze movement data in relation to syntactical change may assist researchers to further understand the impact of behavioral resonance with corporeal articulations.

The study effectively quantified subjective musical understanding in social and individual environments. The majority of participants also indicated that a social interaction condition was preferred. Participants' responses demonstrated that they actively attempt to construct an understanding of each other's intentional actions when performing musical stimuli in a group setting. Results may indicate the effect of corporeal articulations in influencing musical and syntactical perception. In support of the findings of Overy and Molnar-Szakacs (2009), music functioned as social activity where perceptual activities of participants were integrated and interdependent.

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Emotional arousal and the automatic detection of musical phrase boundaries

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This study investigated correspondences between listeners' emotional responses to an orchestral work and the underlying phrase structure. An algorithm for the automatic detection of musical phrase boundaries was developed, based on listeners' continuous ratings of perceived emotion with a two-dimensional tool (valence and arousal). Rates of change in arousal (velocity) and change in change in arousal (acceleration) for each musical phrase were combined into a single metric. Similarity in listeners' responses for musically related phrases was higher than those for musically contrasting phrases. Based on listeners' responses to identical sections, a recursive algorithm identified all phrase boundaries. These findings indicate novel measures of change in listeners' emotional arousal that correspond with musical phrase structure.

Keywords: emotional response; arousal; phrase structure; automatic boundary detection; similarity metric

Emotional response to music is influenced by contributions of both the composition and performance (Kendall and Carterette 1990, Livingstone and Thompson 2009). Although significant research has investigated the role of musical cues such as tempo and articulation on emotional response (Gabrielsson and Lindstrom 2001), fewer studies have investigated the role of phrase structure. Recent work (Krumhansl 2002, Vines *et al.* 2005) found that listeners' tension ratings coincided with the phrase structure, suggesting that listeners' emotional responses could be used for the computational (automatic) detection of phrase structure (Cambouropoulos 2001).

We investigated listeners' emotional responses to an orchestral work to identify response patterns across phrases that varied in melodic and harmonic context. Two measures of emotional response were analysed: velocity (first derivative) and acceleration (second derivative) of arousal (amount of emotional activity). These instantaneous measures reduce effects of the preceding musical context. The velocity-acceleration arousal responses were compared with the theoretical phrase structure. Based on the recurrent nature of listeners' responses, a detection algorithm was developed to identify segment boundaries, which confirmed that listeners' emotional arousal reflects musical phrase structure.

METHOD

Participants and materials

Sixty-seven adult listeners with varied amounts of musical training (9 had no training, 19 had 1-10 years, 39 had 10+ years), most of whom were undergraduate music education students participated (further details in Schubert 1999). An orchestral recording of the *Pizzicato Polka*, Op.234 (J. and J. Strauss), length 2:37 mins, was used, which contains the following phrase structure: introduction (4 bars), phrase A (8 bars), B (12 bars), A' (8 bars), followed by a middle section (32 bars), and a repeat of the introduction, phrases A, B, and A', followed by a coda. The A, B, A' section that occurred twice within the composition was the focus of the analyses; the two occurrences are referred to as section 1 and section 2. Phrases A and A' had related melodic and harmonic content, whereas Phrase B was not related to A or A'. Sections 1 and 2 were further subdivided into 4-bar sub-phrases: a1, a2, b1, b2, a'1, a'2, as shown in Figure 1.

Procedure and analysis

Listeners continuously reported their emotional response using Emotion-Space Lab, a two-dimensional tool that records valence from positive (100) to negative (-100) and arousal (amount of emotional activity) from strong (100) to weak (-100), sampled at 1 Hz (Schubert 1999). Listeners' valence responses did not correspond to the phrase structure, and therefore we focus on arousal responses. Responses were smoothed with *functional data analysis* (Ramsay and Silverman 2005). Listeners' mean arousal responses and their velocity (first derivative) and acceleration (second derivative) values are shown in Figure 1. Phase-plane plots that combined velocity and acceleration were generated for each sub-phase (for an example, see inset of Figure 1). Similarities

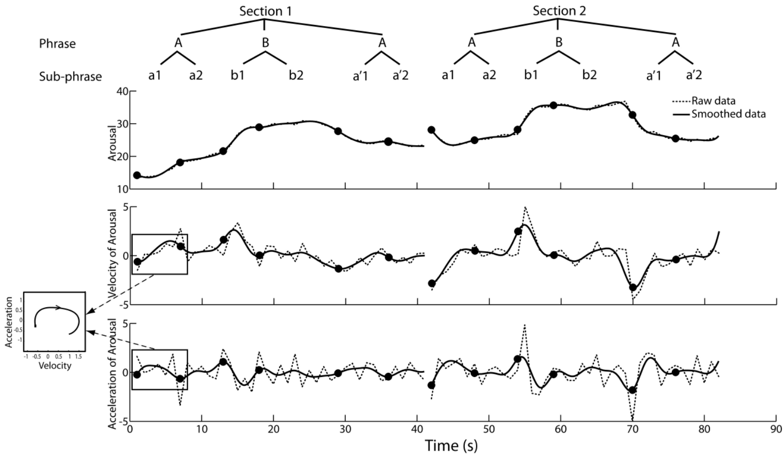

Figure 1. Phrase structure of sections 1 and 2 of the *Pizzicato Polka*, with listeners' mean arousal, velocity, and acceleration values. Theoretical phrase boundaries indicated as dots. Phase-plane plot for sub-phrase a1 in section 1 (inset) shows velocity and acceleration values and begins at the filled square.

between phase-plane plots, which reflect the 2-dimensional responses to arousal, were evaluated with procrustes analyses (2-dimensional measure of similarity).

Listeners' responses to different sub-phrases were divided into three groups: repetition, within-category, and between-category. The repetition group contained pairs of responses to the same sub-phrase from section 1 and section 2 (n=6). The within-category group compared all musically related sub-phrases (same letter, e.g. a1 to a2) in and across both sections, excluding repetition pairs (n=28). The between-category comparisons contained pairs of responses to musically unrelated sub-phrases (different letters, e.g., a1 to b1) in and across both sections (n=38).

RESULTS

Listeners' mean emotional arousal values across the entire section 1 were highly similar to those for section 2, which occurred later in the musical context (mean arousal: $r=0.84$, $p<0.01$, mean velocity: $r=0.70$, $p<0.01$, mean acceleration: $r=.69$, $p<0.01$). Next we measured response similarity among the 2D phase-plane plots, shown in Figure 2, at the level of individual sub-phrases. The procrustes similarity values for repetition pairs (Table 1, first column) indicated that listeners' emotional responses to individual sub-

Table 1. Procrustes similarity values for repetition, within-category, and between-category sub-phrase comparisons for original and new phrase structures. All p<0.01.

	Original phrase structure	*New phrase structure (with B3)*
Repetition	0.75	0.81
Within-category	0.69	0.75
Between-category	0.63	0.77

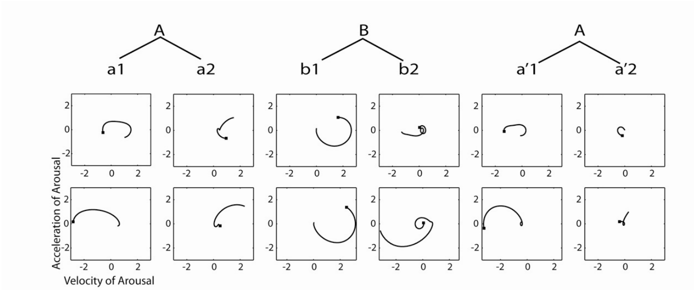

Figure 2. Phase plane plots for sub-phrases sections 1 (top row) and 2 (bottom) of the *Pizzicato Polka*. Sub-phrases begin at the filled squares and possess a cyclical structure.

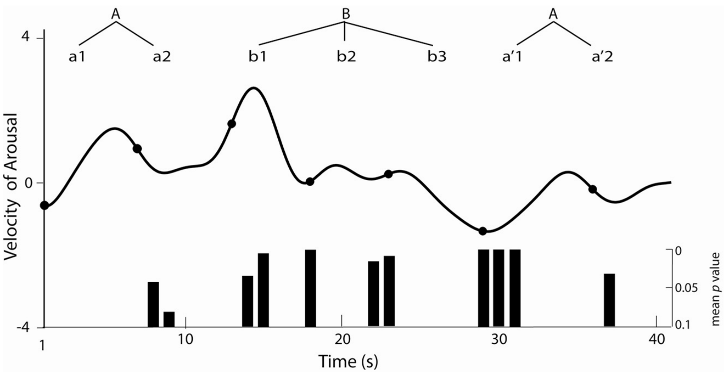

Figure 3. Automatic phrase detection outcomes aligned with listeners' mean arousal responses (velocity) for section 1. Filled circles indicate theoretical phrase boundaries. Bars indicate points in time at which a phrase boundary was algorithmically detected (taller bars=smaller p-values).

phrases in section 1 reheard in section 2 were highly similar. Furthermore, emotional responses for within-category sub-phrases were perceived as next most similar and responses to between-category sub-phrases as least similar.

The phase-plane plots in Figure 2 show a cyclical structure to listeners' emotional responses; each sub-phrase generated semi-elliptical responses that shifted clockwise around the midpoint. However, b2 sub-phrase responses possessed an unusual double swirl. These phrases were also considerably longer in duration than other sub-phrases (see Figure 1). Therefore, b2 sub-phrases were subdivided into 2 sub-phrases (b2 and b3) and procrustes analyses were recalculated for the new phrase structure (Table 1, second column). The similarity values based on the new phrase structure were higher than those based on the original phrase structure, suggesting that the new phrase structure is a more accurate representation of listeners' emotional responses to the *Pizzicato Polka*.

The high similarity in listeners' emotional responses to repeated phrases suggests that this information may benefit the automatic detection of phrase boundaries in this piece, which has a simple harmonic structure. A recursive algorithm was developed which takes as input the listeners' velocity responses for sections 1 and 2. Beginning with a window size of 2 s, responses for sections 1 and 2 were correlated and the window length grew iteratively (+1 s) up to the entire 41 s response. The resulting correlation function was used to identify peaks of most similarity, for comparison with locations of sub-phrase boundaries. Peaks in the correlation function were defined by two successive increasing values followed by two successive decreases. The algorithm was then reiterated once at each value, with the new window onset time equal to the sequential location of the peak. To evenly distribute the effect of sequence beginnings and endings on window lengths, the algorithm was run in both sequence directions (forward/backward) and the outcomes averaged. Figure 3 shows the p-values associated with each detected boundary. All six boundaries were correctly identified automatically within two seconds of the hypothesized phrase boundaries, and no false positives.

DISCUSSION

Listeners' emotional arousal responses to repeated musical sections were highly consistent. Similarity analyses revealed that the first and second derivatives of emotional arousal were more similar for repeated musical sub-phrases than for musically related or less related sub-phrases. These findings indicate that listeners had distinct arousal responses at the 4-bar sub-phrase level in the *Pizzicato Polka* and these patterns recurred during musical repetitions.

The phrase boundary detection algorithm used the similarity in listeners' responses to repeated musical sections to identify all phrase boundaries successfully. The algorithm operates under the premise that listeners' responses to identical musical sections are most similar at phrase boundaries. Phrase boundaries are points of perceptual salience, and listeners' emotional responses may accelerate at these locations. Use of the first and second derivatives of emotional arousal helped to provide a more precise temporal marker of change in listeners' responses. This research demonstrates novel analytic techniques for measuring listeners' emotional responses and their correspondence with the underlying phrase structure of music.

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Communicating emotion in piano performance

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Music expression involves tacit knowledge, an elusive and frequently lacking aspect of music education. This paper considers activities related to learning new repertoire. In a supervised performance lab at the Federal University of Rio Grande do Sul, students gather weekly to play and discuss the results of their practice activities and performances. Building on two previous studies (conducted in 2007 and 2008) wherein students were introduced to Russell's "circumplex model" in order to establish a common vocabulary, they were encouraged to label both intended and perceived emotions. In the present study, we present data on the preparation of a lesser-known piece by Schumann without guidance from their piano teachers. After nine weeks, participants were encouraged to discuss their level of achievement by listening to the results of three recording sessions. Parameters such as contour, articulation, tempo, timing, dynamics, movement/gesture, and global coherence were evaluated in order to assess their performances. Two independent referees also graded the third recording session, and these results were quantitatively and qualitatively compared with those of the students. The results suggest a lack of correlation among the parameters. After two more weeks of practice, there was no significant increase in the level of ability and there was also a low degree of correlation between intended and perceived emotions among participants.

Keywords: expression; piano performance; communication; circumplex model

A relevant issue to the study of music performance and perception concerns the ability of players to express emotional intentions and the ability of listeners to recognize them. This subject has already been investigated from several different points of view. For instance, Timmers (2007) investigated the relationship between vocal expression, musical structure, and emotion in recorded performances by famous singers of three Schubert songs. Timmers observed that variations in tempo, dynamics, and pitch were systematically related to music structure, emotional activity, and valence. Several experiments have dealt with the encoding and perception of emotional intentions in music performance with different musical instruments (e.g. Gabrielsson and Juslin 1996, Juslin 2003, Juslin and Person 2002). From a strategic point of view, Hultberg (2008) recently observed in two case studies that the process of music interpretation is characterized by complex strategies, based on individual familiarity with the conventions of musical expression.

From the music education point of view, Juslin and Persson (2002) claimed that instrument teachers lack a guiding theory of expression in performance. Karlsson and Juslin (2008) have recently investigated instrumental teaching with a focus on expression and emotion, suggesting that the focus of teaching was mainly on technique and on the written score. Although there were differences among teachers, common features pointed to lack of clear goals, specific tasks, and systematic teaching patterns.

As part of the present study, the piano laboratory at the Federal University of Rio Grande do Sul (UFRGS) promotes discussions of multifaceted aspects of performance. We provide an environment in which students are free to explore their attitudes and beliefs about music expression, to reflect upon their own performances, and to gauge the achievement of their peers. In a previous study, we investigated the emotion that undergraduate and graduate students intended to communicate through the piano and the emotions perceived by the musically educated audience (Gerling and Santos 2007). Unknown to the participants, the chosen piece was based on a ratio of shorter and longer note values devoid of time or dynamic signatures. In order to follow up on our exploratory research, another study considered the case in which Russell's circumplex model (1980) was employed as a guide for describing intended and perceived emotions in the performance of a well known Baroque work (Gerling *et al.* 2008). In the present study, we discuss the preparation by undergraduate and graduate students of a lesser-known Schumann piece without guidance by their music teachers.

METHOD

Participants

A semester-long course with one two-hour weekly meetings and a laboratory was set up for undergraduate and graduate piano students at UFRGS. For this activity, four males and two females participated as performers and listeners.

Materials

Students received a romantic score (Schumann's *Anhang* discarded from Op.12) without the composer's name. All but one recognized the author and was asked not to divulge the information.

Procedure

The student's preparation of the music was monitored in three phases. The first phase comprised nine weeks of practice without guidance. The performances and interviews were recorded in weeks 2, 5, and 9 of the student's work. Complementarily, the students at the laboratory (1) watched videos of professional pianists playing Brahms, Liszt, Schumann, and Chopin works (week 3), (2) discussed the relationship between bodily expression and performance (e.g. Maria João Pires's masterclass) (week 6), (3) received tips from a professional pianist concerning practical ways to achieve sound effects as indicated on the score (week 7), and (4) discussed the structural characteristics of the score among themselves (week 8).

In the second phase, a sample from the third recording session was evaluated by two referees who focused on contour, articulation, tempo, timing, dynamics, movements/gesture, and global coherence. A "stimulated recall" interview was conducted after each student watched and graded his or her individual recorded sample. Before entering the third phase, the German terms present in the score (*feurigst* and *rascher*) were again discussed with the student without reference to actual playing.

During phase three, students practiced for a further two weeks, at the end of which there was another recording session. Students were then requested to reveal the emotion they had intended in their performance, making use of terms defined in Russell's circumplex model.

RESULTS

Grades were assigned by two independent piano teachers, who acted as referees (R1 and R2), and by each student after analyzing the third recorded performance on video in terms of phrase contour, articulation, tempo, timing, dynamics, movements/gestures, and global coherence on a scale from 1-10, with 10=highest.

The accuracy for the mean grade and standard deviation (SD) attributed by the two referees, as well as those given by the student himself or herself, was calculated for each parameter. Results (see Figure 1) express the degree attributed by the student himself/herself with the corresponding SD. The

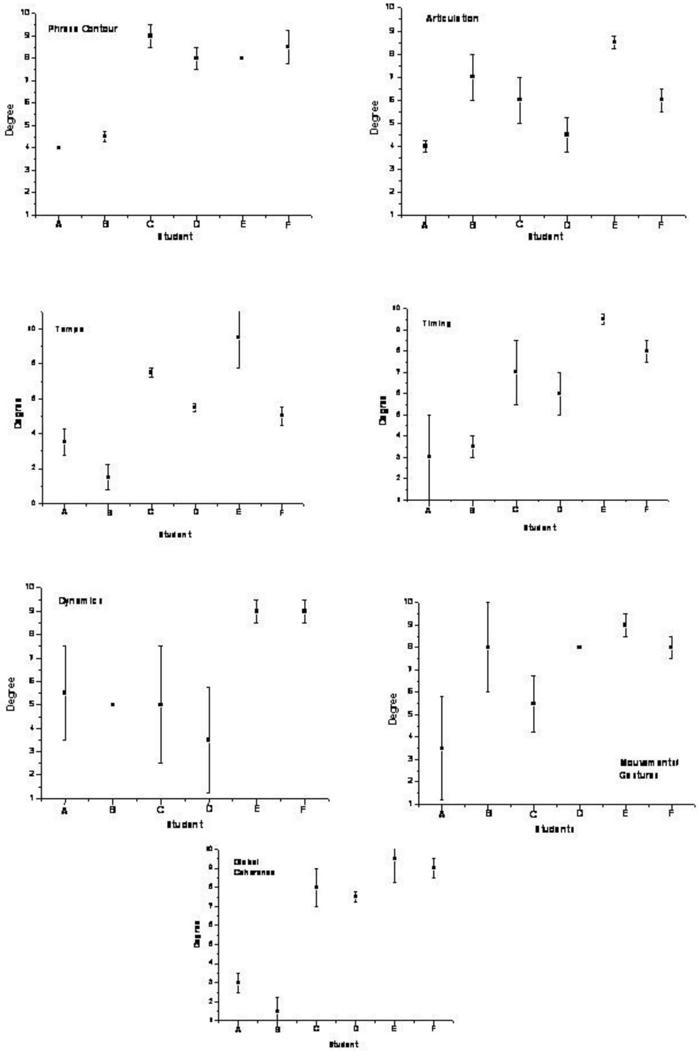

Figure 1. Mean score assigned in each category by each student and respective SD in comparison to the mean grades assigned by the two referees. Students A, B, and C are freshmen, D and E are juniors, and F is a graduate student From top left, the graphs indicate phrase contour, articulation, tempo, timing, dynamics, movements/gestures, and global coherence.

students were then requested to express their intended emotion in a recorded performance. All participants including the performer evaluated audio and audio/video samples using the terms from Russell's circumplex model. The results contradict previous observations both in the case of Bach's *Prelude* (Gerling *et al.* 2008) and in similar discussions, such as that in Vines *et al.* (2006). In this study, the limits imposed by the aural channel improved the correlation between intended and perceived emotion.

DISCUSSION

Juslin and Madison (1999) used a combination of analysis and synthesis afforded by the ability to "resynthesize" human performance by means of computer technology. This approach was employed in the investigation of the relative importance of timing patterns in the communication of emotions through musical performance. The authors gradually removed different expressive cues (tempo, dynamics, timing, articulation) from piano performance played with various intended expressions (anger, sadness, happiness, fear) to see how such manipulations would affect a listener's ability to decode the intended emotional expression. The results indicated that (1) removing the timing pattern yielded a decrease in the listener's decoding accuracy, (2) timing patterns alone were capable of communicating at least some emotions with high accuracy, and (3) timing patterns were less effective in communicating emotions than were tempo and dynamics.

According to these authors, listeners can use timing patterns to decode the emotional expression of a performance. In our present study, the low degree of correlation between intended and perceived emotion may be associated with a high SD in scores of timing, dynamics, and movement/gesture. The results suggest that in their practice our participants neglected some if not many of the most fundamental means for achieving global coherence in terms of the demands of the score and its expression in their musical performances.

Our results suggest that the students have to be made aware of the importance of choosing a tempo (speed, pacing) in the planning and enunciation of all other parameters evaluated in this study in order to convey their intended expressive qualities in their performances. Furthermore, timing and movement/gesture seem to develop along and to increase with expertise and maturity (see Figure 1). For this particular study group, contour was shown to be well assimilated and less dependent on students' level of expertise. We conclude that expertise in the establishment and manipulations of tempo has been an aspect largely overlooked in a musician's instruction, and this will be the focus of our future research. It seems that the appropriate preparation of a score depends fundamentally on the articulation of all parameters. It is our hypothesis that the deliberate choice of tempo sets a precedent in which other parameters such as contour, articulation, timing, and dynamics will be proportioned, thus fostering global coherence and the expression of the intended expressive qualities during performance.

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Workshops

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Hearing and the noise of performance: Solutions for sound monitoring

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Performing artists must be able to practice, rehearse, and perform safely. With respect to hearing and the "noise" of performance, however, the delicate nature of their work and the dedication of performers themselves may mean that they—as well as their employers, educators, and managers—are placed in a difficult position when complying with new international noise at work regulations. This workshop showcases recent initiatives that have brought together artists and scientists to generate practical solutions and new technology for monitoring noise and protecting hearing, while having little or no impact on the quality of performers' work. The workshop consists of the following demonstrations: "Improving noise exposure during practice: The sound absorbing mirror" (Dance and Zepidou), "The use of the iPhone as a sound meter: A cheaper noise badge" (Dance and Zepidou), and "The E-meter: A new noise badge designed for the entertainment industry" (Backus and Williamon). In each, new devices and technology are demonstrated alongside in-depth discussion of the research underpinning their development, as well as their cost and application across a wide range of performing arts contexts. The workshop also considers avenues for future research and the artistic, cultural, and scientific requisites that must be met in pursuing them.

Keywords: hearing; noise; sound meter; acoustics; regulations

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Taking microtonal composition and performance from the periphery into the mainstream

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This workshop seeks to bring some technical and expressive aspects of microtonal singing from experimental approaches (e.g. those represented by the music of Harry Partch) into mainstream vocal performance. *Sacred Songbook* is a collection of “lieder” by the first author, set to texts of Abrahamic (Christian, Jewish, Islamic) provenance, using the microtonal scale with 19 equal steps to the octave. The third author will demonstrate (live) the preparation for performance of selections, using machine-assisted rehearsal, performance, measurement, and analysis techniques developed by the second author. The workshop will showcase: (1) machine-assisted practice techniques, (2) score-based versus aural-based rehearsing techniques and feedback, (3) post facto empirical (machine-based) measurement, analysis, and interpretation, (4) use of techniques of microtonal melodic ornamentation and gesture to blend expressive and technical means, and (5) the relationship between the meaning, character, and aesthetic qualities of the texts and the musical expression and structure of the performance. The workshop draws on a number of sources from experimental composition and performance traditions, and harnesses, develops, and extends them to invigorate mainstream approaches to vocal performance and to achieve performances that reflect something of the ecstatic mysticism of texts from the different traditions represented in the *Sacred Songbook*.

Keywords: microtonal; practice; feedback; machine-assisted; voice

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The art and science of historical performance

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Daniel Türk's *Klavierschule* (1789) makes the important observation that "some musical effects cannot be described; they must be *heard*." Evidence for the art (as opposed to the science) of historical performance remains elusive, deliciously inexact, but potentially inspirational. Clearly, C. P. E. Bach's remarks about the importance of moving an audience are of special value; and no clarinettist can afford to ignore the reviewer who described Anton Stadler's clarinet as having "so soft and lovely a tone that no-one with a heart could resist it." Modern "period" performers each occupy a position on the spectrum from historical accuracy to practical expediency, not least in their choice of original instruments, copies, or replicas. "Authentic" performers have sometimes denied any form of glorifying self expression, but acted in the service of the composer by following "textbook" rules, with a strictly empirical program to verify historical practices. With no reference to personality, this was somehow magically transformed into a composer's intentions, with the performer dangerously close to infantile dependency. This workshop deconstructs period performances of music for clarinet and fortepiano by Mozart, Stadler, and Vanhal, distinguishing historical elements from those aspects of art and science that are arguably rooted in the twenty-first century.

Keywords: historical performance; original instruments; personality; clarinet; fortepiano

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Friday
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Symposium:
Student musicians' motivation, learning, and performance

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Multiple motives: Profiles of young Australians' reasons for musical engagement

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Self-determination theory conceives of motivation as lying along an intrinsic-extrinsic continuum and has been investigated extensively in school learning, but less in performance domains. This paper investigates the ways that students manifest multiple motives for striving in the demanding field of musical performance. Performance examination candidates (n=677) aged 8-19 years completed questionnaires. Factor analysis produced five motives lying along the internal-external continuum. Cluster analysis then generated four groups of participants: (1) a group reporting high levels of internal motives and low levels of external motives, (2) a group reporting high levels of all five motives, (3) a group reporting low levels of internal motives and high levels of external motives, and (4) a group reporting low levels of all five motives. Results showed that both groups with high levels of internal motives achieved higher performance results than the two groups with low levels of internal motives. The high-external/low-internal group did not differ in performance achievement from the group reporting low levels of all motives. The study confirms prior research in suggesting that high levels of internalized motives can work together with high levels of external motives to produce excellent performance, but external motives alone are insufficient.

Keywords: music education; motivation; self-determination theory; self-efficacy; self-regulated learning

Large-scale studies in the 1990s (Ericsson *et al.* 1993, Sloboda *et al.* 1996) demonstrated the crucial role of deliberate practice in the acquisition of expertise in musical performance, and more recently, researchers (e.g. Austin *et al.* 2006) have discussed the need for powerful motivational resources to sustain such work, which by definition is not inherently enjoyable. Intrinsic motivation is one construct that has been invoked to account for the developmental shift toward sustained and more self-controlled engagement in the learning of musical performance skills (Renwick and McPherson 2009, Sloboda and Davidson 1996). According to self-determination theory, intrinsic motivation is "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" (Ryan and Deci 2000, p. 70), whereas people are extrinsically motivated when they engage in an activity such as musical practice in order to obtain a separate outcome, such as a reward, or to avoid punishment or a sense of shame.

The present study builds on our earlier work examining young musicians' motivational beliefs in light of self-determination theory (Renwick 2008, Renwick *et al.* 2002, 2009) by investigating the possible existence of motivational profiles consisting of different combinations of intrinsic and extrinsic motives. Such multiple goal profiles have been documented in terms of achievement goal theory in academic learning contexts (Meece and Holt 1993, Seifert 1995, Valle *et al.* 2003), and also in terms of self-determination theory in physical education (Boiché *et al.* 2008) and athletics (Gillet *et al.* 2009). Such findings show that high levels of intrinsic motivation (or mastery goals) can coexist with high levels of extrinsic motivation (or ego goals) to predict high levels of achievement. To our knowledge, this possibility has not been investigated in the domain of music performance training; hence, this paper aims to extend our prior variable-centered approach to a person-centered one, by using cluster analysis to identify groups of individuals sharing similar motivation beliefs.

METHOD

Participants

We recruited 753 candidates enrolled in a performance examination administered by the Australian Music Examinations Board [AMEB (NSW)]; 677 of these fit our sampling frame of students enrolled in Grades 1 to 8 of the performance syllabus, aged between 8.0 and 19.1 years (mean=13.25), and completed sufficient items for the present analysis. Females comprised 65% of the sample of young people, who undertook the examination on keyboard (55%), woodwind (21%), brass (12%), string (9%) instruments, or voice (3%).

Materials

The Academic Self-Regulation Questionnaire (Ryan and Connell 1989) was adapted to the music-learning context. This scale assesses students' motiva-

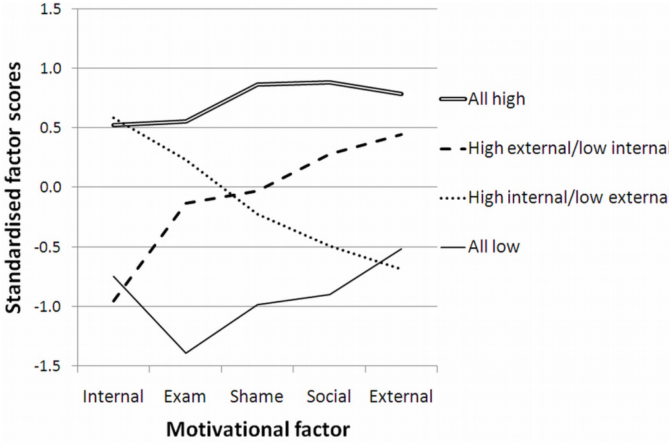

Figure 1. Mean standardized factor scores for each cluster on each motivational factor.

tion to strive in achievement settings in various ways along the intrinsic-extrinsic continuum proposed by self-determination theory. The questionnaire was subjected to exploratory factor analysis and congeneric modeling (Jöreskog 1971), producing five measures of motivation along the following continuum: internal motivation, exam-related motivation, shame-related motivation, social motivation, and external motivation (see Renwick 2008).

Procedure

Participants completed the questionnaire the night before their examination and delivered it to the reception desk on the day of their examination. Performance grades (ranging from D=1 to A+=7) were obtained from the AMEB (NSW) in the days following the examinations. Following the computation of individual factor scores for the five motivational factors described above, these factor scores were subjected to K-means cluster analysis and differences between cluster groups were computed with analysis of variance (ANOVA).

RESULTS

Cluster analysis identified four groups of students with distinct motivational profiles (see Figure 1). There were 240 participants reporting high levels of the more internal forms of motivation and low levels of the more external forms (the dotted line on Figure 1); 169 participants reported the opposite pattern: high levels of the more external forms of motivation and low levels of the more internal forms (the dashed line); 174 respondents reported above-average levels of all five forms of motivation (double line), while the remaining 94 showed below-average levels of all five motives (unbroken line).

A one-way ANOVA was used to test for differences between the cluster groups in terms of their results in the AMEB examination. Achievement differed significantly between groups ($F_{3,668}$=5.13, p<0.01, η^2=0.02). Post-hoc comparisons using the Bonferroni adjustment revealed that the "all-high" group (mean=4.87, SD=1.25) achieved significantly (p<0.05) higher results than both the "all-low" group (mean=4.37, SD=1.44) and the "high-external/low-internal" group (mean=4.43, SD=1.46). In addition, the "high-internal/low-external" cluster (mean=4.79, SD=1.38) achieved significantly (p<0.05) higher results than the "high-external/low-external" group. Other comparisons were non-significant.

DISCUSSION

The results of the cluster analysis showed a remarkably clear pattern (although given the exploratory nature of cluster analysis, this finding should be treated with some caution). The four groups were strongly differentiated into (1) a large group reporting mostly internal motivation, (2) a group reporting mostly external motivation, (3) a group reporting high levels of all five types of motivation, and (4) a group reporting low levels of all five types. This finding is consistent with prior research in self-determination theory (Boiché *et al.* 2008, Gillet *et al.* 2009): because researchers have typically found that internal motivation and external motivation are only weakly related (r=-0.20 in the present study), a pattern of motivation whereby students can sustain high levels of a range of motives along the continuum is to be anticipated. Thus, even though research has shown that the provision of extrinsic rewards can undermine intrinsic motivation (Deci *et al.* 1999), it would appear that as part of long-term motivational profiles, extrinsic and intrinsic motives can coexist in a complex interplay.

The study found that high levels of internalized motives (sometimes called mastery goals) can work together with high levels of external motives (sometimes conceptualized as ego goals) to produce excellent performance, but external motives alone are insufficient.

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Playing together in ways that cater for and fulfill student musicians' psychological needs

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This study applied Self-Determination Theory to study the psychological needs of a sample of 34 highly involved year 11 and 12 student musicians in a large Midwestern state of the United States who possessed the ability to become professional musicians. Content analysis of survey responses and face-to-face interviews sought to clarify how the psychological needs of relatedness, autonomy, and competence were being met by the musicians' musical engagement in and outside of school. Results demonstrate complex motivational forces in action during this key stage of development. Being around like-minded peers, supportive teachers, and an environment that was conducive challenged them to achieve at a constantly higher level. Many were agonizing with personal and external influences however, which left them with self-doubts about whether they should go on to become a professional musician, whether they would still feel the same way about music in the years to come, and whether they felt capable of obtaining a position in music that would provide sufficient satisfaction for them personally and professionally.

Keywords: self-determination; psychological needs; self-beliefs; motivation; musical development

In the psychological literature on motivation, studies concerned with self-beliefs are so prevalent that they dominate the field. Yet the powerful explanations that arise from close examination of this literature have rarely been explored as these relate to learning music. Because music is a subject that involves a high level of personal choice, students are influenced by their own and others' beliefs about and valuing of music perhaps more than in other areas of learning.

Among the most prominent motivation theories is Deci and Ryan's (2002) Self-Determination Theory (SDT). This organismic, dialectical perspective is built around the central premise that "all individuals have natural, innate and constructive tendencies to develop an ever more elaborated and unified sense of self" (Deci and Ryan, p. 5). SDT is concerned with the choices people make on their own and how they choose to behave in a manner that reflects their autonomy and their behavior, free of the need to receive an external reward. In this way, SDT is used to examine the degree to which an individual's behavior is self-endorsed and self-determined. A key component of SDT is the three innate and universal psychological needs which Deci and Ryan state are essential to an individual's psychological health and wellbeing. The need to feel competent underpins our desire to believe that we are capable and competent and in control of our environment. When we feel competent, we are better positioned to seek further challenges and to engage in an activity at a more concentrated level. According to Deci and Ryan, when autonomous, "individuals experience their behavior as an expression of the self, such that, even when actions are influenced by outside sources, the actors concur with those influences, feeling both initiative and value with regard to them" (p. 8). Finally, people also have a need for relatedness, to be connected with and cared for by others. The sense of belongingness that can come from participation and involvement in a musical ensemble, for example, is one way this psychological need can be met, especially given that this dimension "concerns the psychological sense of being with others in secure communion or unity" (p. 7). In summary, SDT proposes that individuals are active in their pursuit to satisfy these three psychological needs and is being applied in various disciplines to explain why people become sufficiently intrinsically motivated that they will engage in an activity for its own sake and at a level that becomes fully internalized and autonomous.

The purpose of this study was to clarify the degree to which 34 highly involved young school-aged musicians believed that their personal learning agenda was being fulfilled, and the ways in which the teaching and learning process to which they were exposed satisfied their psychological needs as defined by Deci and Ryan's (2002) SDT.

METHOD

Participants

The study involved individual interviews with 34 musicians during their last two years of high school (years 11 and 12). All were identified by their teachers as among the most dedicated and highly involved in a large Midwest state in the United States. The musicians ranged from those who were section leaders in one of the most prominent youth symphony orchestras in the country, to students in school music programs that have received national and international recognition for the quality of their program, through to others who were performing and composing for highly regarded folk ensembles and rock groups.

Materials

All students completed a background questionnaire to gather preliminary evidence concerning the level of their involvement and commitment to music, and then face-to-face interviews that lasted between 60 and 90 minutes in order to understand more precisely how they felt about music, the support systems which facilitated their progress, and the beliefs they held about their capacity as musicians. Emergent themes were identified after a content analysis of full transcripts of the interviews for each participating musician.

Procedure

As shown in Figure 1, key issues covered in the interviews focused on how the three psychological needs were being met, the quality and quantity of involvement and engagement with music, the types of networks (such as peers, social groupings, parental support) which facilitated the musicians' interest in music, their sense of purpose as a musician, and the degree to which their involvement in music both socially and personally was a valued part of their lives. Additional issues concerned what these students hoped to accomplish in music both now and in the future, and the extent to which their personal musical learning agenda was being met through their participation in formal and informal learning processes, plus whether any of these might complement or conflict with other aspects of their learning. To clarify this last issue, questions were asked about the musicians' short and long-term goals in music, and the influences that were impacting on their decision whether to choose music as a career beyond high school.

RESULTS

As confirmed by their teachers, all of the musicians had the potential to become professional musicians. Most felt comfortable with their school or community music experiences, where like-minded peers, supportive teachers, and an environment that was conducive to their needs challenged them to achieve at a constantly higher level. Others had ceased participating in certain musical activities that they felt were not at the level of their own musical skills, while others were agonizing with personal and external influences

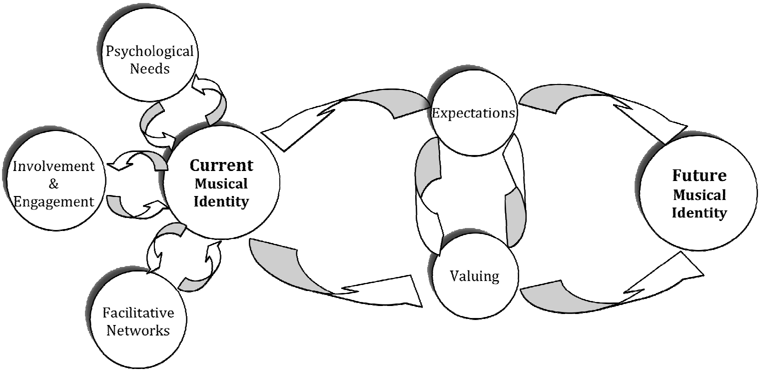

Figure 1. Flow of influences for current and future "musical" identity.

which left them doubting whether they should go on to become a professional musician, whether they would still feel the same way about music in the years to come, or whether they felt capable of obtaining a position within the profession that would provide ongoing satisfaction for them personally and emotionally.

Comments of a 17 year old flutist, who reported doing at least 24 hours of practice each week and spending every weekend rehearsing in ensembles (one of which is among the most prestigious youth orchestras in the nation) provide evidence of the complexity of these young musicians' personal beliefs. In her case, feelings of relatedness and competence impacted on how she viewed music both now and into the future:

> Music motivates me. It consoles me and excites me. It's an intangible means of improving my life; it gives my life more glory than it often deserves.... It's important to me because I enjoy it so much. I love the challenge. My entire weekends are eaten up by music. The kids I meet in the youth orchestra are amazing people. I love that companionship. To experience music with others is divine! It's the most special thing I have.

As the only musician in her family, and recognizing also the commitment her parents had made to supporting her musically, this young musician worried that she takes "the limelight" away from her other two sisters. As one of the best flutists in the country for her age, there can be no doubt about the intensity and level of her current musical engagement. Digging more deeply to compare her current and future self however, revealed many niggling worries and self-doubts about whether she wanted a career in music, whether she would still feel the same way about music in the years ahead, and whether a career in music was worth the effort, given the possibility that she may be separated from her family and the city she loved. Many of these worries and self-doubts were perceptions about music and musicians that she had picked up from others, with many of the more important coming from her mother:

> I remember my sophomore year of high school. I started thinking about applying to music schools. My mom said "You know you'd be just as happy being an English major or a history major, and you'd be much more secure." I was like, "OK, that's fine".... I still don't know what to do. I'm still applying to music schools, but it's hard to make a choice and I don't want to make a choice. My mum is supportive but worried. I think she just wants me to be happy. She likes security. She's worried that I won't have a secure position, or my life will be sort of all over the place. She hates that.... I'd love to play in a great orchestra. But there is an opening once every seven years, and thousands of people are trying for that one shot. You have to move somewhere. My mom made me promise that I won't leave [name of city]. She left her parents, and she doesn't want me to do the same to her. I can always break my promise, but I would like to have options. And I think with music, you are very much bound to who wants you and if they will, whether they will have you.

For another student, a vocalist, guitarist, and composer who performs in three rock groups, strong competence and autonomy perceptions impacted on how he was preparing for his musical future: "it was so nice when we won the Battle of the Bands. The next day we played again, and I just remember looking out there. The entire front two rows were singing along to a song I wrote.... I must have smiled for like a week and a half after that." These and other comments give a clear sense of what this young man wanted to do with the rest of his life, possibly in part because he came from a wealthy family that made it easier than might otherwise be the case to take more chances and to try out a lifestyle that may well end in disappointment. He reported that when he first told his parents that he wanted to be a musician "they were horrified.... They thought that I was losing valuable time." Despite this, he regarded music as "the truest expression of my soul. The expression of my own feelings and stuff. Even if I don't make it and I'm stone-broke somewhere, it will be OK. If I don't give it my all, it will haunt me for the rest of my life. That's what I need to do. It's not like I *want* to be a musician. I *need* to be a musician."

DISCUSSION

Email correspondence 18 months later revealed that the flutist decided to pursue a double degree in music and English but was considering dropping English "because I have since discovered that it is unrewarding and unsatisfying." She was also "still not entirely sure that I will become a professional musician, but for now it makes me happy." The guitarist/composer on the other hand, was pursuing a path to becoming a professional musician and songwriter. Results such as these demonstrate the effectiveness of SDT for contextualizing the key transitional stages of development, such as in this study of young musicians who were devoting huge personal and physical resources to their musical development while learning how to cope with a demanding, competitive learning environment, overcome periods of self-doubt and performance slumps, and develop a tool kit of psychological and behavioral skills that would enable them to manage the many obstacles they will encounter along the journey to fulfilling their own personal dreams.

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Focus, effort, and enjoyment in chamber music: Rehearsal strategies of successful and "failed" student ensembles

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Different chamber ensembles take different approaches to individual practice and ensemble rehearsal; in this study, we investigated the approaches of three student groups who could be described as successful and "failed." The members of two string quartets, one newly-formed and one established, and a newly-formed wind quintet kept practice and rehearsal diaries for six months. There were significant differences between what and how they practiced and rehearsed and between their ratings of their own and their colleagues' focus, effort, and enjoyment, although these three dimensions were correlated in several ways. The members of the successful established ensemble enjoyed practicing more than rehearsing, while the reverse was true for the members of the successful new ensemble. It is also clear from the ratings that participants were realistic about the efficacy of their practice and rehearsal strategies. These findings have implications for theories of motivation and practical applications for the teaching of chamber music.

Keywords: effective; group; rehearsal; practice; students

Strategies for ensemble rehearsal have been explored via studies of duos (e.g. Williamon and Davidson 2002, Ginsborg and King 2007), string quartets (e.g. Davidson and Good 2002), and wind quintets (Ford and Davidson 2003, Burt-Perkins and Mills 2008), suggesting the importance of clarity as to ensemble members' roles in order to reduce potential conflicts and effective verbal and non-verbal communication in relation to social as well as musical issues. Ericsson *et al.* (1993) and Lehmann (2002) found that positive correlations exist between concentration and effort, and concentration and enjoyment, but negative correlations between effort and enjoyment. The present study investigated the extent to which successful ensemble rehearsal (defined by the relative success of the ensemble over time) is influenced by performers' ratings of their own and their colleagues' focus, effort, and enjoyment.

METHOD

Participants

Three student ensembles were recruited: one newly-formed (SQ1) and one established string quartet (SQ3) and a newly-formed first-year wind quintet (WQ1). SQ1 comprised two male and two female first year students "matched" on the basis of their performance in college entrance auditions. SQ3 was formed by its members—three male third year students and one female student—two years before the present study began. WQ1 comprised a "mixed" group of four first year students and one second year female student, selected on the basis of the instruments they played.

Materials and procedure

Printed diary templates were devised for ensemble rehearsals and practice sessions in which music for ensemble rehearsals was prepared. The ensemble rehearsal diaries requested information including date, place, time, overall duration, and content/duration of each activity within the rehearsal; with reference to up to five activities, what participants thought their ensemble's goal was, how they went about achieving it, to what extent their strategy was effective, using a rating scale (1="useless" to 10="achieved goal 100%") and what their goal would be next time they engaged in this activity; ratings of their own and their peers' focus (1="very distracted" to 10="completely focused"), effort (1="just went through the motions" to 10="worked really hard), and enjoyment (1="not at all" to 10="had a great time"). Finally, participants were asked to describe any performance they had given that day and nominate "one thing [they] were really happy about" and "one thing [they] would like to do better in [their] next performance." The practice diaries used similar wording, adapted for individuals, and rating scales but did not ask about performance. During the first two terms of the academic year participants were asked to complete diaries whenever they had undertaken individual practice on material for ensemble rehearsals and, as individuals, after each rehearsal.

RESULTS

At the end of the academic year, WQ1 won a major prize. At the time of writing, its members are still performing together: it can be considered a "successful" ensemble. SQ1 agreed to disband after their end-of-year assessment and can therefore be considered to have "failed," in comparison with WQ1. SQ3 had been extremely successful for three years although ultimately it split up, and its members formed new ensembles.

Each of the participants' reports, in the form of diary entries relating to practice session or rehearsal content, goals/strategies/plans for each activity within the practice session or rehearsal, and comments on performance, was numbered. As shown in Table 1, SQ3 provided more than twice as many reports as SQ1 and WQ1. They reported preparing five quartets, while SQ1 spent nearly two terms on one quartet and learned a new work. In comparison, WQ1 reported preparing and performing three substantial quintets. SQ3 reported more than twice as much individual practice on quartet repertoire as WQ1, and half as much again as SQ1. SQ3 reported 22 quartet rehearsals, including one coaching session, and four performances. They rehearsed three times as long as SQ1, who reported ten rehearsals, including two coaching sessions, and two performances; by contrast, WQ1 reported 17 rehearsals of which more than half were coaching sessions, and two performances.

Examples of practice strategies rated high by members of each ensemble include: "Slow practice of solo passage for intonation (keeping as many fingers down for accuracy); focusing and right arm/wrist/hand for string crossing and building up tempo to play up to speed" (SQ3); "played through music putting fingerings and bowings in" (SQ1); "thought about sound and where to breathe" (WQ1). Examples of highly-rated rehearsal strategies include: "Repetition of phrases (maybe only a couple of bars) gradually elongating the passage until we could confidently play through the section" (SQ3); "stricter, stronger feel for pulse, simpler approach, more effect" (SQ1); "We worked out who we play the scales with. We realised the timing was out because of a semiquaver rest at the beginning of each scale. So we played a note on the rest and then did the scales until they were perfectly in time. Then we took out the extra note" (WQ1).

Numbers of and mean ratings for practice and rehearsal strategies are shown in Table 2. ANOVA revealed a main effect of ensemble on practice strategy rating ($F_{2,79}$=4.78, p=0.011); post-hoc tests showed significant differences between SQ1 and WQ3. There was also a main effect of ensemble on rehearsal strategy rating ($F_{2,237}$=31.42, p<0.0001); post-hoc tests showed significant differences between all ensembles.

Mean ratings for focus, effort, and enjoyment are shown in Table 3. The correlation between participants' ratings of focus and effort in individual practice (r_{42}=0.62, p<0.0001) was stronger than that between focus and

Table 1. Practice and rehearsal reports.

	WQ1	*SQ1*	*SQ3*
Repertoire	Nielsen, Reicha, Verdi	Mozart, Dance Project	Schumann, Mozart, Matthews, Schubert, Brahms
Reports	278	274	587
Individual practice (hrs)	6.5	9.25	14+
Rehearsal hrs (sessions)	23.3 (17)	11.3 (10)	38 (22)

*Table 2.*Practice and rehearsal strategies

	WQ1	*SQ1*	*SQ3*
Practice strategies rated (reported)	26 (26)	26 (26)	30 (30)
Practice strategy mean ratings (SD)	7.12 (2)	7.54 (1.2)	8.25 (.81)
Rehearsal strategies rated (reported)	44 (50)	49 (50)	147 (150)
Rehearsal strategy mean ratings (SD)	8.57 (1.28)	6.6 (1.52)	7.98 (1.17)

Table 3. Mean ratings (and SD) of focus, effort, and enjoyment.

			WQ1	*SQ1*	*SQ3*
Practice	Self	Focus	7.07 (1.86)	7.86 (1.10)	8.78 (0.70)
		Effort	6.64 (2.21)	7.64 (1.22)	8.43 (0.85)
		Enjoyment	5.64 (1.95)	5.86 (2.14)	7.64 (0.93)
Ensemble	Self	Focus	8.77 (1.33)	6.92 (1.52)	8.12 (0.90)
		Effort	8.71 (1.38)	7.05 (1.76)	8.43 (0.96)
		Enjoyment	9.31 (0.90)	6.26 (2.37)	7.50 (1.04)
Ensemble	Other	Focus	8.54 (1.72)	6.76 (1.76)	8.02 (1.00)
		Effort	8.80 (1.32)	6.96 (1.56)	8.24 (0.95)
		Enjoyment	9.17 (0.92)	6.76 (2.26)	7.79 (1.03)

Table 4. Ratings of own focus, effort and enjoyment in ensemble rehearsals.

N=135	*Focus*	*Effort*
Effort	0.83	
Enjoyment	0.57	0.55

Table 5. Ratings of others' focus, effort, and enjoyment in ensemble rehearsals.

N=135	*Focus*	*Effort*
Effort	0.83	
Enjoyment	0.41	0.46

enjoyment (r_{42}=0.39, p=0.01). There was no correlation between effort and enjoyment.

The correlations between ratings of participants' own and others' focus, effort, and enjoyment in ensemble rehearsal are shown in Tables 4 and 5. There were also significant correlations between participants' ratings of their own and their colleagues' focus (r_{134}=0.67), effort (r_{134}=0.70), and enjoyment (r_{133}=0.74), all significant at $p<0.0001$.

There were main effects of ensemble on focus ($F_{2,39}$=6.00, p=0.005), effort ($F_{2,39}$=4.76, p=0.014), and enjoyment in individual practice ($F_{2,39}$=5.48, p=0.008) such that the ratings of SQ3 were the highest; post-hoc tests showed significant differences between SQ3 and WQ1 on all three dimensions, and between all three ensembles on enjoyment. The main effects of ensemble on self-ratings were all significant at $p<0.0001$—focus ($F_{2,131}$=22.1), effort ($F_{2,131}$= 17.04), and enjoyment ($F_{2,131}$=37.44)—as were their ratings of their colleagues' focus ($F_{2,132}$=15.02), effort ($F_{2,132}$=21.61), and enjoyment ($F_{2,132}$=24.76). There were significant differences between all ensembles' self-ratings on all three dimensions, except SQ3 and WQ1 on effort, and on ratings of others between WQ1 and SQ1 on focus, SQ3 and SQ1 on effort, and all three ensembles on enjoyment.

DISCUSSION

Lehmann's (2002) findings were confirmed for individual practice by positive correlations between focus and effort, and focus and enjoyment. No negative correlation was found, however, between effort and enjoyment, and all three dimensions were correlated for rehearsals; there were also positive correlations between participants' rating of their own and their colleagues' focus, effort, and enjoyment. The members of the successful string quartet (SQ3) both practiced and rehearsed considerably more than their younger colleagues, although this is not surprising given that they had much more repertoire to perform. On the other hand, they enjoyed their individual practice more than did the other groups and more than their ensemble rehearsals, although they attributed higher levels of enjoyment to their colleagues. They also identified more sophisticated practice and rehearsal strategies, rating their own practice strategies higher than did the less advanced students. Although the members of WQ1 carried out the fewest individual practice hours—and indeed both WQ1 and SQ1 reported least enjoyment from practicing—they had a great deal of coaching from a range of tutors, and this, together with their ratings of their rehearsal strategies as even higher than SQ3 and the "failed" SQ1, may in part account for their success; SQ1 took part in just two rather unsuccessful coaching sessions early in the first term. Furthermore, WQ1 reported the highest levels of focus, effort, and enjoyment in rehearsal both for themselves and their colleagues. It may thus be possible for student musicians to do less individual practice if they have plenty of, and enjoy, ensemble rehearsal, although this is, of course, dependent on their role within the group. A final contrast is between SQ1, who rated focus, effort, and enjoyment for individual practice higher than WQ1 but provided the lowest ratings on all three dimensions for ensemble rehearsal—it was perhaps inevitable that they would "fail" as a group.

Further analyses of the participants' goals, strategies, and plans remain to be carried out; nevertheless, the findings of the present study have implications for theories of motivation in relation to practice versus rehearsal, as well as practical applications for those engaged in the teaching and coaching of chamber musicians.

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What predicts performance excellence in tertiary level music students?

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Performance quality should be the dependent variable in studies of music performance anxiety (MPA), as improvement in performance quality, as opposed to greater subjective wellbeing or altered physiological states, is the desired outcome for performing musicians of any intervention to reduce their arousal/anxiety during skilled performance, although the former factors may be necessary to achieve the latter. A predictive model of performance quality was developed for empirical assessment using tertiary level flute students. Hierarchical regression analyses tested the hypothesis that the specified variables (level of accomplishment on instrument, performance preparation, psychological and physiological measures) would predict expert ratings. The model accounted for 72.8% of the variance in expert ratings. Three variables contributed most—highest achievement as a soloist (0.91), minutes spent practicing the test piece (0.39), and music performance anxiety (0.38). These results indicate that some arousal during skilled performance in skilled performers is necessary to achieve a standard of performance that receives a high rating from an expert listener. Fear of negative evaluation (FNE) had negative beta weights in the predictive equation, showing that FNE is not helpful for skilled performance, as it is likely to distract the performer from the task and introduce irrelevant cognitions that would be likely to interfere with performance. Musical aptitude and achievement are clearly critical factors that are often neglected in models of both performance anxiety and performance enhancement.

Keywords: music performance anxiety; skilled performance; practice; expert ratings; prediction

Improved performance quality is the desired outcome of any intervention to reduce cognitive or somatic arousal/anxiety during skilled performance, although the reduction in the latter factors may be necessary to achieve the former. In this paper, we assessed factors (technical mastery, specific task mastery, quality and amount of practice, musical achievement, and psychological and physiological characteristics) associated with performance quality in a unified model to determine their relative influences and hence to inform pedagogy, self-management, and treatment.

METHOD

Participants

Participants were tertiary students of flute currently studying in the Bachelor of Music (with a major in flute performance) in any of the four years of that undergraduate degree, or Master of Music (Performance), or who had graduated from either of these courses in the previous year. A recruitment circular was distributed to 30 eligible flute students by post, of whom 24 expressed interest and were subsequently provided with the participant information statement. In addition, signs were located at the Conservatorium, Flute Society meetings, and orchestral rehearsals, which generated additional enquiries. There were 20 flute players in the final group of participants.

Materials

Participants provided details about their highest level performing experience as a soloist. A rating scale ranking *solo performance achievement* was developed and participants were awarded points on a ten-point scale from "musical achievements below grade 8" (1-2) to "played as soloist with a professional symphony orchestra" (e.g. ABC Young Performer's Awards, 10).

The *State-Trait Anxiety Inventory* (STAI, Spielberger *et al.* 1983) consists of two 20-item scales that measure state and trait anxiety. Internal consistency of the state (Cronbach's α=0.90) and trait scales (α=0.82) in the present sample was strong.

The *Kenny Music Performance Anxiety* (K-MPAI, Kenny 2004) was developed to assess the emotion-based theory of anxiety proposed by Barlow (2000) as it applies to anxiety in the context of music performance; it assesses uncontrollability, unpredictability, negative affect, situational cues, attentional shift (e.g. task or self-evaluative focus, fear of negative evaluation), physiological arousal, and memory. Questions are answered on a 7-point Likert scale ranging from 0 (strongly disagree) to 6 (strongly agree).

Higher scores indicate greater anxiety and psychological distress. This scale demonstrated excellent internal reliability (α=0.94, Kenny *et al.* 2004).

Fear of Negative Evaluation (FNE, Watson and Friend 1969) assesses expectations of being evaluated negatively and consists of 30 items that are answered either "true" or "false." The FNE has high internal consistency (α=0.94-0.96), strong one-month test-retest reliability (r=0.78-0.94), and criterion validity (Watson and Friend 1969).

Surface *electromyography* (EMG) is a safe and non-invasive method for measuring the nerve activation that occurs in a muscle as a result of voluntary or reflex activation (Turker 1993). Stress levels and occupational loads are two factors that influence surface EMG output readings, with particularly responsive sites for these measures in the upper trapezius and frontalis muscles (Westgaard 2000, Attebrant *et al.* 1996). Ten-second window measurements were taken from the EMG recording of the upper left trapezius muscle of the flute players in this study. A ratio of the maximal contraction from the EMG (in Hz) to a reference voluntary contraction was recorded.

A silver chloride electrode was used to measure *heart rate* (ECG). Maxima from the heart rate trace were averaged over blocks of time immediately before performance to achieve a resting heart rate and during performance of the musical item.

Till Eulenspiegels Lustige Streiche (R. Strauss, Op. 28), was chosen as the set work because it is a well-known excerpt from the orchestral flute repertoire. A scoring protocol designed specifically for the study was developed by a flute player from a premier national orchestra. Players were scored on a criterion-referenced scale from 1 to 10 (each mark required the standard to be met for all rankings below the ranking given).

Procedure

Ten days before the scheduled participation, participants were sent the FNE and STAI-T questionnaires, the orchestral extracts, an instruction letter, a map of how to get to the venue, and clothing instructions. These practices are employed in most orchestral auditions, thus giving participants exactly the same time-frame in which to prepare the music. Participants had an electromyographic trace of the left trapezius muscle taken and their HR recorded during their performance in the acoustic laboratory at the Australian Centre for Applied Research in Music Performance (ACARMP), Sydney Conservatorium of Music, University of Sydney. An expert flute player with extensive adjudicator experience blind rated all the (recorded) performances in terms of musical and technical proficiency from the industry standard recording.

Prior to commencement, participants completed the *State Anxiety Inventory* (STAI-S). Powerlab recording was commenced and the neutral maximal voluntary contraction (MVC) was recorded with the levels adjusted appropriately. Once measured successfully, the MVC was repeated for flute playing posture. Participants were then instructed to begin playing after the researcher tapped on their shoulder. At the end of the performance component, participants completed the player physical profile questionnaire and the K-MPAI.

RESULTS

The sample comprised 20 flute players (3 males, 17 females) who were all students of flute at the Sydney Conservatorium of Music studying in the Bachelor of Music (n=17) or Master of Music (Performance) (n=3) degrees. Participants were aged between 19 and 32 years of age. They had been studying flute for a minimum of 10 years and a maximum of 22 years (Table 1). Fifteen of the participants (75%) wanted to become professional musicians, three were undecided, and two did not wish to become professional musicians.

A number of univariate analyses were undertaken to assess the relationship of demographic and other factors with performance quality. None were significantly associated (see "Discussion"). Hierarchical regression analyses tested the hypothesis that the specified variables—level of accomplishment on the flute (ranking given for the highest level of achievement as a soloist), performance preparation (number of minutes the test pieces were practiced), psychological measures (K-MPAI, FNE, STAI), and physiological measures (HR, EMG)—would account for variation in expert ratings of the Strauss excerpt. Because the variables in the predictive model were on different scales, they were converted to z-scores with a mean of 0 and a standard deviation of 1 before being entered into the regression analysis. ANOVA indicated a significant F-statistic ($F_{7,12}=4.59$, $p=0.01$), showing that using the model increased the probability of correctly predicting expert ratings over chance. The overall R^2 for the model was 0.73 (i.e. the model accounted for 73% of the variance in expert ratings in the Strauss excerpt, see Table 2).

DISCUSSION

In the univariate tests, the amount of time participants had been playing their instrument was not associated with how much MPA, fear of negative evaluation, or state or trait anxiety they experienced. Length of time one has been playing one's instrument is a poor proxy for both the quality of practice that

Table 1. Means and standard deviations (SD) for player characteristics and expert ratings of musical performance.

Characteristics	*Mean*	*SD*
Age	23.05	3.76
Years playing flute	13.98	3.15
Practice episodes per week	6.90	3.09
Average daily practice in minutes	131.25	58.71
Highest level of achievement as a soloist	4.50	2.12
Highest level of achievement in ensemble	5.05	2.26
Minutes practiced test piece	41.25	30.30
Expert rating Strauss	5.60	1.96
Physiological measures		
EMG percent Strauss excerpt	24.42	9.22
Heart rate playing Strauss excerpt	99.15	13.31

Table 2. Beta coefficients, t-tests, and significance for the regression model predicting expert ratings for the Strauss excerpt.

Strauss	*Unstand. coeff.*		*Stand. coeff.*	*t*	*Sig.*
Z scores of predictors	B	SE	Beta		
(Constant)	1.78	2.75		0.65	0.53
Highest achievement as soloist	0.85	0.16	0.91	5.34	0.001
Minutes practised test piece	0.03	0.01	0.39	2.19	0.05
MPA total	0.04	0.02	0.38	1.83	0.09
FNE total	-0.03	0.03	-0.15	-0.80	0.44
EMG percent Strauss excerpt	0.04	0.04	0.20	1.07	0.31
Heart rate Strauss excerpt	-0.04	0.03	-0.26	-1.42	0.18

the performer undertakes and the amount of musical ability the performer has. A better measure to assess these elements is the highest level of achievement attained in solo and/or ensemble performance, which was associated with significantly lower reported MPA. Those with the most ensemble experience and achievement also had significantly less fear of negative evaluation. A very robust yet simple model was developed for the prediction of expert rating of skilled performance. Three factors—highest level of achievement on flute, minutes practiced the test piece, and MPA—accounted for 73% of the variance in expert ratings of performance quality, although the Beta coefficient for MPA did not reach statistical significance. It is no surprise that the first two factors predicted expert rating of performance quality. Any model of performance quality must take into account the level of expertise attained and the amount of practice undertaken. It is of concern that some models and some treatment programs for performance anxiety do not take into account these essential elements in both performance quality and genesis/maintenance of MPA. Replication of the model on larger samples is needed, as is further analysis of the role of MPA in performance quality.

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Influence of musculoskeletal dysfunction and pain on performance excellence

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Playing-related musculoskeletal disorders (PRMD) and pain are a common phenomenon in professional musicians, with a prevalence of up to 80%. A majority of musicians are not aware that pain influences their performance excellence. Recent research data demonstrate that pain has the impact to change motor control strategies. Musicians with pain experience coordination impairments, muscle inhibition, and changes of motor control, influencing their movement patterns while playing their instruments. Vice versa, motor control impairments in musicians with poor body awareness or body control can have an immense impact on the development of musculoskeletal dysfunctions and pain. There is evidence that musicians suffer double the amount of musculoskeletal dysfunctions than non-musicians. Additionally, evidence is growing that the failure of stabilization systems as the feedforward activation of transversus abdominus muscle for the lumbar spine contributes to the development of a chronic pain syndrome. A study at our clinic has provided clinical data demonstrating the dysfunctions in various stabilization systems. Preliminary results of ultrasound investigations of the activation of the transversus abdominus muscle in musicians with musculoskeletal dysfunctions support these findings. This research data suggest an association of the impairment of the lumbopelvic stabilization system with PRMD.

Keywords: playing-related musculoskeletal disorders; pain; motor control strategies; muscle function; stabilization systems

Although the last 20 years have provided an enormous amount of research data regarding playing-related musculoskeletal disorders (PRMD), prevalence rates persist with up to 80% of musicians affected. PRMD and pain compromise the capability of musicians to perform and limit their performance excellence. Affected musicians frequently report on coordination impairments associated with PRMD, notwithstanding measuring motor skills or performance excellence remaining challenging. The MIDI-based technique (Musical Instrument Digital Interface) for piano provides an opportunity for analyzing specific movement parameters in piano playing, such as irregularities in key pressing (timing, loudness). Therefore, MIDI-based *scale analysis* was developed for objective quantification of focal dystonia in pianists (Jabusch *et al.* 2003). Apart from focal dystonia, data on incoordination or aberrant movement patterns in musician is scarce. Fry *et al.* (1998) investigated incoordination in pianists with overuse syndrome, also by analyzing characters of key presses (duration, velocity, interval between key presses, time off the metronome beat). Interestingly, musicians with overuse showed distinct incoordination already in basic tasks such as playing C major scales at different velocities. Development of further analyzing methods for string and wind instruments are absolutely essential and should encompass a standardized questionnaire screening for incoordination signs. Moreover, clinicians managing musicians with PRMD should be aware of the influence of pain on motor control strategies in order to provide tailored therapy strategies.

MAIN CONTRIBUTION

Muscle activation patterns and recruitment are altered in the presence of pain. Several studies have demonstrated delayed activation of the deep abdominal muscles, especially the transversus abdominus muscle (Hodges and Richardson 1996, Hodges 2001), and increased activity of superficial muscles (Leinonen *et al.* 2001) in low back pain (LBP). In order to stabilize the spine during limb movements the tranversus abdominus muscle precedes in a feedforward activation the contraction of the muscles producing the limb movement (Hodges and Richardson 1996, Hodges and Richardson 1999). Moreover, Hodges and Richardson demonstrated that these changes persist even after the resolution of symptoms.

In LBP, these postural control deficits have been argued to contribute to the recurrence of episodes (Hodges and Moseley 2003, Cholewicki *et al.* 2005). Likewise, there is evidence that in chronic neck pain the feedforward activation of the deep cervical flexors is delayed in voluntary arm movements (Falla *et al.* 2004a, 2004b) and that neuromuscular efficiency in the superficial neck flexors as the scalene and the sternocleidomastoid muscle is impaired (Falla *et al.* 2004c). Additionally, signs of myoelectric muscle fatigue develop in scalene and sternocleidomastoid muscles (Falla *et al.* 2003). Experimental pain studies provide data demonstrating changes in activation patterns of trapezius muscle subdivisions during repetitive shoulder flexion and alterations in task-dependent changes in cervical agonist/antagonist activity (Falla *et al.* 2007a, 2007b). Furthermore, in the arm, injection of hypertonic saline into biceps and triceps brachii muscles resulted in modification of the elbow flexor and extensor muscle activation during a repetitive elbow movement task (Ervilha *et al.* 2005) and muscle pain in the biceps brachii muscle increased EMG activity in the trapezius muscle (Ervilha *et al.* 2004, Schulte *et al.* 2004, Ervilha *et al.* 2005). Also, accumulating evidence points to an impairment in the lower division of the trapezius muscle in people with painful shoulder conditions (Ludewig and Cook 2000, Cools *et al.* 2003, Lin *et al.* 2005).

Based on these data, in an attempt to transfer these findings on the behalf of musicians, one can presume that:

- Musicians with neck pain show a delay of deep cervical flexor activation during upper limb movement (e.g. playing their instrument).
- In musicians with neck pain, muscle function of scalene and sternocleidomastoid muscles are impaired.
- Pain in the arm and the shoulder alters muscle activation and recruitment patterns of trapezius muscle.
- Musicians with low back pain show signs of delayed deep abdominal muscle activation.

Accordingly, musicians have to be aware that pain has a profound potential to alter their muscle function, contributing to performance impairments.

Musculoskeletal dysfunction in musicians

Pain is frequently preceded by musculoskeletal dysfunction. Motor control changes contribute to inhibition or weakness in some muscle groups and increased activity and hypertonicity of others. In consequence, trigger points (local contraction bands or areas causing referred pain) occur and muscle activation patterns, so called stereotypes, change. There is evidence that musicians experience twice the rates of functional disturbances as compared with non-musicians (Steinmetz 2007). A study at our clinic, examining 84 musicians consulting our outpatient clinic for PRMD, has provided clinical data demonstrating impairments in various stabilization systems (Steinmetz and Seidel submitted). Dysfunctions of the postural stabilization systems were present in 77 (92%) of the patients. Most frequently, in 85% impairment of scapular stabilization system was found within the examination and in 71% the lumbopelvic stabilization system (deep abdominal and back muscles). Preliminary results of ultrasound investigations of the activation of the transversus abdominus muscle in musicians with musculoskeletal dysfunctions support these findings. This research data suggest an association of the impairment of the lumbopelvic stabilization system with PRMD. Muscle dysfunctions and postural stabilization impairments can influence performance excellence in various ways. An example demonstrating this phenomenon is the case of a cellist with impaired interossei muscles, contributing to a lack of stabilization abilities of the fourth finger of the left hand. A second example is a violinist with neck and shoulder pain experiencing an alteration of shoulder muscle activation patterns, resulting in a changed up-bow pattern showing increased trapezius activation.

IMPLICATIONS

There is a need of further research to evaluate the influence of the lumpopelvic as well as scapular and cervical stabilization systems on the development of PRMD. The identification of typical motor control changes associated with the impairment of stabilization systems is of highest importance for musicians because of their potential impact on performance excellence.

Treatment regimes in chronic back pain patients have shown that training of these stabilizing muscles can prevent relapses of back pain. Adaptations of these treatment strategies in the therapy of musicians may contribute to a higher success rate in treating musicians with PRMD. Additionally, the therapy of musicians has to implement an approach integrating the work on motor control and muscle function during playing a musical instrument.

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Do pianists play with their teeth?

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The aim of this study was to find out whether the masticatory and postural muscles are used by pianists during their music performances. The study also aimed to ascertain whether the complex neuromuscular activity involved in the act of playing the piano also encourages hyperactivity in terms of the masticatory muscles. The bio-electric potentials of the masticatory and postural muscles of 20 pianists were recorded by surface electromyography (EMG). The EMG recordings obtained regarding the temporal and masticatory muscles are much higher than those recorded when in the resting position. These recordings, which are not the same as those obtained, for example, when the individuals are chewing hard food such as a carrot, are nonetheless indicative of daily parafunctional activity in musicians who often study for as much as seven hours per day.

Keywords: pianists; electromyography; muscular hyperactivity; masticatory muscles; postural muscles

Music performance is based on the knowledge musicians acquire through a great deal of deliberate practice to obtain high levels of skills (Ericsson *et al.* 1993, Hallam 1997). Consequently, the incidence of focal dystonia, for example, may be as high as one in 200 professional musicians (Altenmüller 2000). Research has shown the musculoskeletal system to be the most frequently involved area of impairment (Morse *et al.* 2000). Orofacial problems may also be included as result of the musicians' professional activity. Orthodontic problems, focal dystonia, herpes labialis, dry mouth, and temporomandibular joint disorders (TMD) have been identified especially among wind and string players, as well as vocalists. These problems may result from the impact of the selected instrument on the orofacial structures of the musician (Raney

2006) or from an inadequate dental treatment and increase with stress. In all cases, it may be detrimental to the musicians' careers.

Pianists are among the highest in number of music college students in Portugal, both in classical and jazz degree courses. Research on piano related injuries is mainly focused on the upper limbs, namely the hand adaptation to the keyboard, hand pain, focal hand dystonia, finger joints or tendon, and arm overuse related problems (Shields and Dockrell 2000, Sakai 2008). Yet, little has been written about their orofacial activity. Given the duration and intensity of the daily practice these pianists might undertake (as much as seven hours per day), they may well develop a parafunctional activity, especially in the masticatory and postural muscles. It is extremely important to monitor such activity so that muscular hyperactivity does not interfere in maintaining a functional equilibrium of the cranio-cervico-mandibular complex. Hence, the aim of the present study was to determine whether the masticatory muscles, whose main functions are chewing, swallowing, and speaking, are used by pianists during their music performances and so to ascertain whether the complex neuromuscular activity involved in the act of playing the piano also encourages hyperactivity in terms of the masticatory and postural muscles. Since we had both classical and jazz pianists in our sample, an additional aim was to ascertain whether different styles have a different effect on the masticatory and postural muscles.

METHOD

Participants

The experiment was conducted with 20 participants, ranging from 18 to 27 years old with classical and jazz piano training. In this article, we present the most significant cases.

Materials

The electromyographic (EMG) activity was recorded using the Bio EMG 2 electromyograph with eight channels (Bioresearch Associates Inc., Milwaukee, Wisconsin, USA).

Procedure

An alcohol pad was wiped in the area where the sensors were to be placed and a conductive gel was placed on a 9 mm diameter disposable silver/silver-chloride bipolar surface electrodes (Duo-Trode, Myotronics Inc., Seattle, Washington, USA), before their attachment to the skin. These bipolar surface

Figure 1. Pianists performing a jazz (left) and a classical piece (right).

electrodes were located on the muscular bellies of the anterior temporalis, masseter, digastric, and trapezious muscles of both sides (right and left), and parallel to the muscle fibers.

The electromyographic activity was recorded during the following procedures: (1) at rest, (2) maximum voluntary clenching in the intercuspal position, (3) maximum voluntary opening, (4) playing piano, and (5) eating a cake. Subjects played a piece of their choice in a classical and jazz style (see Figure 1). A resting period of one minute between recordings was allowed to avoid muscular fatigue.

RESULTS

The head posture adopted by piano players during their performance gave different patterns of EMG activity in the masticatory and postural muscles. The visual system used in this study played an important role in the perception that there are variations in seated positions between classical piano and jazz players, with direct implications on the cranio-cervico-mandibular complex.

Likewise, it is possible to verify an adoption of an anterior head position on jazz players, with a tendency of most of these subjects to maintain a jaw position by using the anterior temporal more than the masseter muscles. In classical players, there were higher values on the EMG activity of the masseter muscles compared with the jazz players. A contributing factor can be that jazz players are used to improvising during their performance while classical players have a prolonged and strained stress placed on the masticatory muscles, specifically the masseter muscle. For the particular case of classical pianists, we were able to compare the activity of a mandible elevator muscle

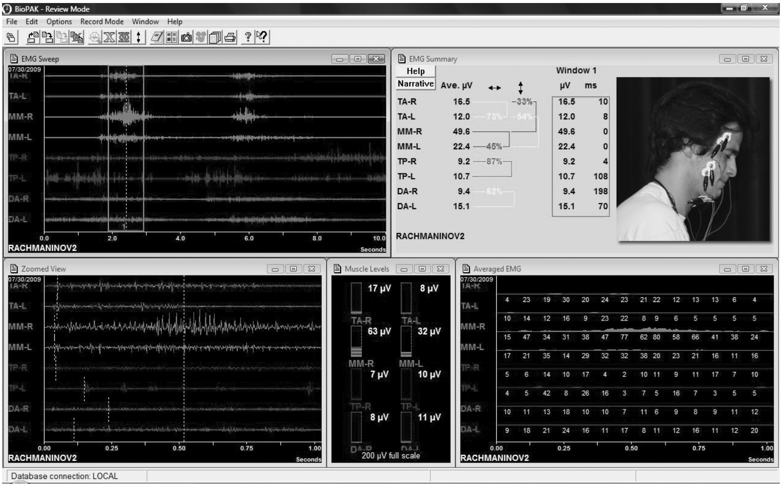

Figure 2. Pianist with high electromyographic activity of the masseter muscle.

(masseter) during one of its main functions: eating. When eating a cake, the bioelectrical potential of the masseter muscles reached 15-18 µV, while playing for example the C minor Rachmaninoff concerto, the masseter muscle can reach values of 49.6 µV.

The findings of this study illustrate that pianists may feel persistent neck and orofacial pain due to the large number of hours of piano exposure, highlighting the physical demands as well as the psychosocial factors involved in such a demanding profession. Understanding what kind of muscles are being used in the cranio-cervico-mandibular complex during the performance of a pianist is of vital importance as it can help in the correct diagnosis of a concrete problem originated by repetitive movements.

The aim of the study was to understand how the orofacial muscles behave during voluntary exercise such as piano playing, where the activity of some muscles—like masseter, digastrics, or the anterior temporal—should have minimum activity given that their key activity should occur mainly during mastication, speech, and swallowing. In this particular case it was not a question of being able to evaluate if the fatigue of these muscles could restrict the pianist to the point of no longer being able to performing the task: piano playing. An overuse of these muscles may have a direct impact on the pianists' quality of life when performing their maximal voluntary performance of these orofacial muscles during normal tasks like eating.

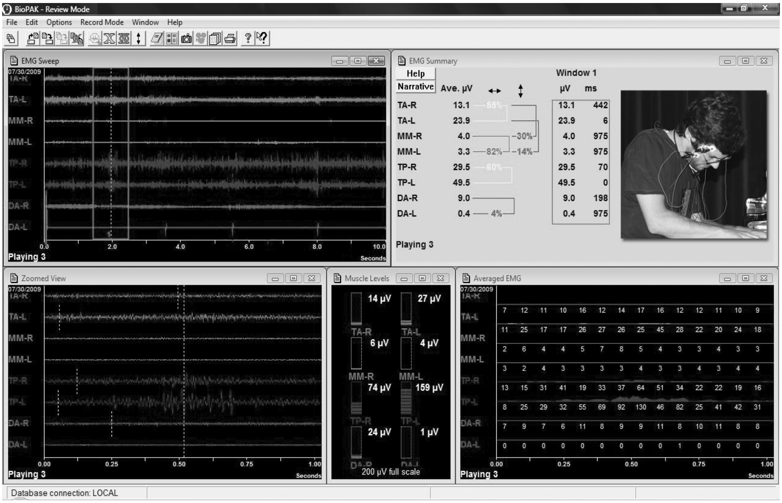

Figure 3. Pianist with high electromyographic activity of the trapezious muscle.

In time, these kinds of restrictions can induce pain that can be related to certain movements or occur at any time of the day. This special attention toward performers' health issues and specific needs will provide a working diagnosis, allowing health care professionals to focus their examination rather than conducting a series of tests that are usually time consuming.

Having piano players, teachers, and performing arts medicine professionals conscious of what is actually happening to the orofacial region while playing piano will encourage the daily supervision of any parafunctional habit like clenching their teeth during performance.

DISCUSSION

Do pianists really play with their teeth? The essential point is "yes," some pianists do in fact play with their teeth, since they have an activity of their masseter and anterior temporal muscles that acts as an elevator of the mandible, forcing the mandible teeth to contact the maxillary teeth. So here piano players, during their daily performance, have parafunctional habits inducing hyperactivity of some of the orofacial muscles that very often is associated when an individual is concentrated on a particular task or when anxiety levels rise.

Further studies would benefit from a multimodal approach in which this method would run in parallel with high resolution sound recording and motion capture.

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ISSTIP performing arts clinics at the London College of Music 1990-2005: The first ideas, the realization, and the lessons for the future

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We take this opportunity of presenting data from the International Society for the Study of Tension in Performance (ISSTIP) clinics in London between 1990-2005. The ISSTIP clinics were multi-disciplinary and were based at the London College of Music. They were founded by Carola Grindea (1914-2009), a piano pedagogue specializing in posture and relaxation techniques. ISSTIP clinics were among the very first performing arts clinics in the UK, and they aimed to address the pressing issues of performing artists—general psychological and physical tension and pain and posture problems in practice and performance. The aim of this retrospective study is to examine the structure and success of the ISSTIP clinics and to look at what kind of models these early clinics represented compared with contemporary theory and practice.

Keywords: performing arts health; performing arts psychology; performing arts clinics; posture; relaxation techniques

The International Society for the Study of Tension in Performance (ISSTIP) clinics offered free consultations to musicians and other performers, and in the first years, took place twice a month. Carola Grindea acted as the focal point and coordinated the clinics in collaboration with medical specialists. Additional practitioners included psychologists specializing in the arts, Alexander and Feldenkrais technique specialists, and therapists from the fields of complementary medicine. This multi-practitioner approach was typical of ISSTIP's holistic and inclusive outlook. During the period 1990-94, we also studied two other clinics run by leading performing arts practices in London: the British Performing Arts Medicine Trust (today known as BAPAM) and the Arts Psychology Consultants (APC). Together, such comparative data forms an interesting and valuable profile of how performing artists were treated in London during the early 1990s.

In terms of the development of organizations dealing with the health of performing artists, the 1980s was the pioneering decade where new ideas and new people came into the field. The 1990s was the decade of conferences and clinics. Practitioners interested in the performing arts flocked to conferences, and a large number of performers came to the clinics to benefit from the new initiatives. This new decade since 2000 has seen the emphasis shifting to the education of new practitioners, with courses in performance health such as the masters program in *performance health and personal development* at Thames Valley University and a number of short courses, meetings, and seminars organized by ISSTIP, the Centre for Performance Science at the Royal College of Music, the Institute of Musical Research, BAPAM, and individual music colleges in the UK. The UK clinics active in the 1990s and for a big part of the 2000s were largely staffed by competent professional musicians like pianist Carola Grindea and health professionals, most of whom were also amateur musicians. One reason for the effectiveness of the new raft of practitioners was their own intimate knowledge of performing and performers, enabling them to speak the language of musicians and to identify with many of their more technical, social, and psychological issues.

METHOD

Participants

We have looked at data from three clinics active in London in the period 1990-94: ISSTIP, BAPAM, and APC. For the period 1995-2005, we only examined the data from the ISSTIP clinics. The ISSTIP clinic had a break in operation in 2005 but is due to restart in 2009.

Procedure

We analyzed the collected data from those attending the clinics in two periods: 1990-94 and 1995-2005. During the first period of our study, we examined comparative data from ISSTIP, BAPAM, and APC clinics. In the second period of the study we looked exclusively at the ISSTIP clinic, and we compared these results with those of the earlier period of the same clinic.

RESULTS

ISSTIP and BAPAM offered three areas of help: medical, postural, and psychological. APC offered just psychological help and referred cases needing

Table 1. Overall profile of the three clinics studied for the period 1990-94.

	ISSTIP	*BAPAM*	*APC*
Number	363	478	199
Male/female (%)	37.0/63.0	35.5/64.5	50.0/50.0
Average age (years)	26	31	n/a
Years of data	5	5	5

Table 2. Professions established by the Arts Council of Great Britain (1990-94).

	ISSTIP	*BAPAM*	*APC*
Music (%)	96.4	80.0	79.0
Dance (%)	1.7	7.0	5.0
Drama (%)	0.3	9.0	7.5
Media, literature, art (%)	1.6	4.0	8.5

Table 3. Type of musicians and type of instrument (1990-94).

	ISSTIP	*BAPAM*	*APC*
Classical/pop, jazz (%)	98.0/2.0	n/a	79.0/21.0
Strings (%)	29.0	15.0	22.1
Wind (%)	7.9	7.0	11.0
Brass (%)	2.9	6.0	6.4
Percussion (%)	0.9	7.0	7.1
Keyboard (%)	36.0	16.0	12.5
Plucked instruments (%)	7.1	21.0	9.9
Voice (%)	15.0	11.1	26.1
Conductors (%)	0.9	n/a	3.5
Composers (%)	0.3	n/a	1.4

Table 4. Employment status (1990-94).

	ISSTIP	*BAPAM*	*APC*
Professional (%)	36.0	79.0	66.8
Semi-professional (%)	0.6	6.0	3.0
Amateur (%)	3.8	2.0	4.5
Students (%)	51.2	13.0	25.7
Teachers (%)	8.4	n/a	n/a

medical or postural treatment to the other two bodies. As such its number of cases is proportionately less. The preponderance of females in the first two clinics is interesting since numbers were equal in those seeking psychological help (see Table 1). The breakdown by profession (see Table 2) shows an ISSTIP sample composed almost entirely of musicians. The choice of a music college setting with its attendant students would bias the numbers toward musicians in the case of ISSTIP, though it is clear that the clientele most interested in using such clinics was musicians in general. Musicians seem more willing to seek direct help from performing arts organizations, although dancers and actors do also have their own health networks. Table 3 shows very considerable bias to classical musicians which is not mirrored in the general pool of active musicians. With a music college setting we might expect this bias in the ISSTIP clinics, but it also occurs in the APC clinics.

ISSTIP clinics saw a proportionately larger number of students and teachers than BAPAM or APC (see Table 4), and the assumption is that again this is because clinics took place in a music college where teachers also sat in and took an interest. Even so, the fact that 36% of ISSTIP clients are professional musicians shows that the clinic was known and used by a much wider clientele. Also interesting is that music students, who would typically have a generalist student counselor available to them, preferred to seek specialized help with their performance problems. One quarter of APC clients were from music schools that had their own student counselors, indicating that specialist knowledge of dealing with performance problems responds to a need in music students. When Andy Evans was student counselor at the Royal Academy of Music, three quarters of the cases he saw were related to performance issues, rather than general counseling matters (Evans 2003).

ISSTIP clinics had an unexpectedly high percentage of keyboard players; other instruments being broadly comparable (see Table 3). This may be a bias due to the fact that Carola Grindea was a well-known piano pedagogue. Clearly, the profile of the organization affects the profile of those using it. Given the already established weighting toward classical musicians we would also expect larger numbers of string players to reflect their distribution in orchestras. Among the wind players, flute and clarinet predominated. Guitarists tended to go more to BAPAM where they would get medical help, while singers tended to make more use of psychologists. The nature of each organization determined the primary service offered to those who used it, and the primary focus in the ISSTIP clinics was on posture control, breathing, and music ergonomics (player-instrument interaction), with a secondary emphasis on medical interventions and a tertiary emphasis on psychological methods (see Table 5). This was the other way around in APC consultants who offered specialized psychological help, while BAPAM as a medical organization offered medical assessment and intervention with posture and psychological methods available for further referral.

Later data has been collected for the ISSTIP clinics only between 1995 and 2005 (see Table 6). After 1995, the psychologists were working privately and medical participation in the clinics had also declined since the doctors were mostly working through BAPAM. The ISSTIP clinics had therefore reduced internal medical and psychological input, and any cases needing such attention were referred externally. Observations include (1) the total number attending ISSTIP clinics per annum declined considerably, (2) treatment methods reverted almost entirely to tension control through postural adjustment, (3) there was a small increase in popular/jazz musicians, (4) the division between male and female had reverted to almost 50:50, (5) the percentage of keyboard players had increased dramatically, and (6) the number of students stayed at around 50%, while teachers attended more.

DISCUSSION

Clinics all have a distinct profile depending on the founders and their influence, the name of the organization and its implications, and the location of the clinics. This profile acts as a triage system for not only those who attend but the focus of the treatment they are thought to need and the treatment they actually receive. Clinics have been largely built around musicians—not only as clients but also music as the secondary skill of the practitioner. The early 1990s were a particularly active time for clinics as performers aired their problems in many cases for the first time. Ideally a performer who attends a clinic will get an impartial assessment entirely congruent with his or her needs. This sample of data shows that this was not happening because of inherent bias within the organizations. This may be an insoluble problem, and it is left ultimately with the client to make their own choices. In an ideal world referrals would take place routinely to the appropriate specialist, and it is to be hoped that teamwork will always be important in the field of performance health. Another issue is that medical practitioners are trained to pass clients to specialists, but this is less the case with therapists and posture teachers who believe they deal with the "whole person," not the problem. The field of performance health however relies on specialists, and it is important that specialization is respected by all who practice in this field, passing clients on where appropriate for the client and the problem.

From these conclusions, we can ask wider questions as to whether such clinics will always represent a symbiosis between the individual nature of

Table 5. Practitioners used by each clinic (1990-94).

	ISSTIP	*BAPAM*	*APC*
Medical specialists (%)	42.7	79.0	n/a
Psychologists (%)	5.8	13.0	100.0
Posture, physio (%)	51.5	8.0	n/a

Table 6. ISSTIP clinics data comparisons 1990-94 and 1995-2005.

	1990-94	*1995-2005*
Overall number seen	363	376
Male/female (%)	37.0/63.0	48.0/52.0
Musicians/dancers, actors, etc. (%)	96.4/3.6	98.0/2.0
Classical/pop, jazz (%)	98.0/2.0	94.0/6.0
Piano, keyboard (%)	36.0	64.0
Professional (%)	36.0	25.0
Students (%)	51.2	57.0
Teachers (%)	8.4	11.0
Medical treatment (%)	42.7	6.5
Psychology (%)	5.8	0.0
Posture (%)	51.5	93.5

their setup and how they function, or whether we should seek to move toward a more all-embracing provision of care that could be replicated in a more generic way for future clinics. Some such questions include (1) whether there are a set of protocols that would be helpful, (2) how staff should be chosen and trained, and (3) what should be the relationship between clinics, support organizations, educational establishments, and the wider world of the arts with a goal of providing students, teachers, and professional performers with a better and more effective service. When ISSTIP clinics resume later in 2009, these questions will be in the forefront of discussions.

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Thematic session:
Performance and life factors

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Diversity of dancer experience in a dance program

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This research describes the relationship between dance program structure and the types of experiences had by participating dancers. The research followed 48 participants through a 6-month dance project that culminated in a weeklong performance season. Recognizing that reported positive developments occur within the structure of programs, the aspects of a dance program that were significant in forming participants' different experiences were examined using a technique known as Q-methodology. The process of factor extraction and the content of factors are summarized to identify the different dancers' perspectives on their experience of the program. A discriminant function procedure was then used to determine whether demographic variables significantly discriminated between the groups. Divergent Q-sorts were analyzed to highlight that some dancers' experiences were different to the main types of experience available in the program. As dance participation has long been assumed to increase self-esteem, self-concept was measured using the Self-Description Questionnaire (SDQ). The paper concludes by outlining a multi dimensional view of dancers' experience.

Keywords: dance; education; Q-sort; dancer experience; SDQ-III

There is little research into how young students experience the educational dance activities designed by adults (Bamford 2006). Phenomenological research suggests that dancers share common experiences across age, culture, and gender (Alter 1997, Bond and Stinson 2000, Bracey 2004, Lindqvist 2001, Stinson 1997, Stinson *et al.* 1990). It has also been suggested that environmental factors may influence this experience (Fensham and Gardner 2005, Green 1999, Hefferon and Ollis 2006, Oliver 2000, Thomas 1993). In addition, within such experiences enhanced self-esteem appears to be one of the strongest measures of arts participation (Burton *et al.* 2000, Heath and Roach 1999, National Advisory Committee on Creative and Cultural Education 1999, Winner and Hetland 2000). In light of this, the present study examines the aspects of a dance program that are significant in forming dancers' different perspectives on dance experience while testing whether self-concept changes over the course of a dance program. A technique known as Q-methodology was utilized to investigate the structure of dancers' perceptions and evaluations of their experience as it provides an empirical method for the study of subjectivity (Brown 1996, McKeown 1988). Self-concept was measured using the Self-Description Questionnaire (SDQ) (Marsh 1992). The SDQ instruments have provided particularly strong tests of the Shavelson *et al.* (1976) theory of self-concept that posits a multifaceted, hierarchical model of self-concept.

METHOD

Participants

The participants comprised 48 dancers that had accepted a place in the program. This group contained equal numbers of female and male dancers (mean age=16.25 years, SD=2.41). The second group of participants contained 9 former dancers, aged between 17 and 23 years, who participated in focus groups designed to generate material for the Q-sort.

Materials

Basic demographics were taken for each participant including sex, age, and how many years they had been involved in (1) dance and (2) the program. The content of the focus group discussions served to generate Q-sort materials: 19 experience statements, which represented overarching descriptions of grouped quotes, and 8 categories, which grouped similar experience statements. The *future in dance* category contained only a future in dance experience statement. The *program elements* category contained performing, production week, rehearsals, and dancing experience statements. The *choreographic process* category contained the idea/concept, teamwork/groupwork, and making up movement experience statements. The *peers* category held only one experience statement: other dancers. The *role models* category included choreographers and the artistic director. *External people* contained outside friends and parents. The *personal attributes* category included growth/maturity, self-disciple, and confidence. Finally, the *program values* category contained equality, supportive, and competitive experience statements. The 136-item self-report inventory SDQ-III was used to assess three areas of *academic self-concept* (mathematics, verbal, academic), nine areas of *non-academic self-concept* (problem solving, physical abilities, physical appearance, same sex relations, opposite sex relations, parental relations, spiritual values/religion, honesty/trustworthiness, emotional stability) and a *global* (general) self.

Procedure

The focus groups were conducted leading up to and beginning the program. The Q-sort was conducted between 2-3 weeks after the conclusion of the performances. The instrumental basis of the Q-methodology is the Q-sort technique (McKeown 1988). This required the participants to rank-order systematically the 19 experience statements in a forced choice procedure according to their own personal perspective of the program. The Self Description Questionnaire (SDQ-III) was administered as a pre and post measure.

RESULTS

The 48 Q-sorts were subjected to a factor analysis using principal components extraction. The four factor solution had three dancers with either negative factor loadings or low factor loadings. It was decided to treat these three participants as separate cases and use deviant case analysis to highlight that their experiences were different to the other dancers. With these three cases removed, the remaining 45 Q-sorts were subjected to the same principal component analysis as previously described. Evidence suggested that four factors accounting for 67.66% of the variance would be the most interpretable solution. The members of the four groups were labeled *performers*, *investigators*, *personal growthers*, and *apprentices*. The *performers'* three most important experience statements were performing, production week, and dancing. The three most important experience statements for the *investigators* were the idea/concept, teamwork, and equality. The three experience statements with the highest factor scores for the *personal growthers* were growth/maturity, self-discipline, and confidence. The *apprentices'* three experience statements with the highest factor scores were future in dance, the artistic director, and choreographers. The three dancers who were not members of any factor group are labeled *peers*, *competitive performer*, and *future growth*. *Peers* rated outside friends, self-discipline, and other dancers as important. Performing, dancing, and competition were important to *competitive* *performers*. *Future growth* thought other dancers, future in dance, and growth/maturity were important.

In the second part of the Q-sort analysis a discriminant function procedure was used to determine whether demographic variables significantly discriminated between the four groups. The *performers* were more likely to be female with above average years dance experience. The *investigators* included an equal ratio of female and males but had lower than average years dance experience. The *personal growthers* were male with lower than average dance experience, and the *apprentices* were male with above average years dance experience. All three case studies were males aged 17-20 years, had been with the program for between 1-2 years, and had between 1-3 years dance experience. Clearly these were participants who were least experienced with dance.

Paired t-tests were run to analyze the differences in SDQ-III scale scores across time. Results revealed the largest differences across time on the emotional stability subscale (mean=-0.36, SD=0.70, d=0.37; t_{45}=-3.47, p=0.001) and general self-concept subscale (mean=-0.24, SD=0.68, d=1.49; t_{45}=-2.41, $p<0.05$). To determine if there were any significant differences between the four groups of dancers on emotional stability and general self-concept subscales, a repeated measures ANOVA was run. For emotional stability, the within subject test indicated that there was a significant change in emotional stability over time for all four groups. The between subjects test indicated that there was no significant difference between the groups ($F_{3,39}$=1196.91, $p>0.05$). However, there was a significant interaction effect by time ($F_{3,39}$=1196.92, $p<0.001$, partial η^2=0.97). There was an increase in emotional stability across time with the *investigators* and *personal growthers* increasing more than the *performers* and *apprentices*. The within subject test for general self-concept indicated that there was a significant change in general self-concept across time ($F_{3,39}$=8.55, $p<0.05$, partial η^2=0.18). The between groups test indicated that there was no significant difference between groups ($F_{3,39}$=0.29, $p<0.05$). Again, there was a significant interaction effect ($F_{3,39}$=1255.93, $p<0.001$, partial η^2=0.97). The *apprentices* had the largest increase in general self-concept across time.

DISCUSSION

The program provided different types of dancers with different ways of connecting into dance and demonstrated how dance programs can promote effective differentiated learning and opportunities for both male and female dancers. The dance as performance experience produced educational outcomes in relation to the intelligent and considered presentation of dance to audiences. Dance as investigation taught dancers about the creation of dance as a contemporary art. The educational outcomes inherent in the dance as personal growth experience taught the value of application and self-reflection to achievement. The dance as apprenticeship experience created educational outcomes in relation to learning from role models and accessing information in others. Analysis of the divergent cases provided valuable information on the recognition of important friendships both inside and outside of the studio. Whether they offered support through mentorships or friendships, an opportunity to improve through competition, or a pathway to a future in dance, the other dancers were integral to these young men's perspective on dance experience.

Conclusions can be drawn on where and why self esteem may be increased through dance participation. With their emotional stability increasing over the program, the *investigators* appear to have been experiencing positive psychological benefits from the psychologically challenging experience of composition and creation in dance. The *personal growthers* also demonstrated increased emotional stability across the program indicating that their ability to grow personally may have been a result of a supportive environment and positive peer relationships. The *apprentices* had the largest increase in general self-concept. They reported feelings of support from those around them, and it may be through strong role modeling that they were developing as young people. One of the features that differentiated them from those with different perspectives was their ranking of other dancers as neither important nor unimportant. Each of the other perspectives identified recognized their peers as important to their perspective on dance.

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A circle of life: The Caroline Plummer Fellowship in Community Dance project

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As the recipient of the Caroline Plummer Fellowship in Community Dance at the University of Otago in 2008, I coordinated a series of projects over a six-month tenure. The fellowship—which is in honor of Caroline Plummer, an extraordinary young dance student at Otago who died of cancer at the age of 24—offers the opportunity to research, examine, and explore the relationship between community and dance. My project was broken into five distinct sections. The first was a dance created by adult members of the cancer community; the second was art work created by visual artists responding to the adult dance sessions; the third was work facilitated with Canteen, an organization that supports young people living with cancer. I then wrote a children's book, *Come Dance with Me*, that deals with death and the healing power of dance. The fifth section involved working with senior high school dance students, who prepared solo choreographies around the theme of cancer.

Keywords: cancer; dance; community; therapy; performance

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Choosing the unstable: Dancing through the mid-career

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While professional instability is a lifelong challenge for dance artists, it is in mid-career that instability becomes particularly problematic and the issue of sustainability comes to the fore. Mid-career artists build increasingly diverse protean careers in a bid to generate stability while dealing with unpredictable work patterns, aging bodies, and increased financial, family, and future responsibilities. In addition to this is the sense of physical and emotional loss experienced when the fundamental need to dance is not being fully met. In this study, we underscore these big picture issues with a more personal dialogue with three Australian mid-career dance artists. Through these case studies, we examine the constant negotiation, reassessment, and instability inherent in dance careers. Our research reveals that "putting the body down" often entails putting down work, status, and identity.

Keywords: dance; unstable; protean; mid-career; sustainability

Since the early 1990s, work within contemporary dance in Australia has been undertaken almost entirely by independent dance artists. Existing company-based employment usually takes the form of contract-based employment interspersed with other work. As we have argued previously (Pollitt 2001, Bennett 2009), what was once a political choice in response to previous traditions or loyalties is now the mainstream in contemporary dance. As a result, the term "independent artist" today encapsulates the majority of contemporary dance artists, who typically complete tertiary dance training before entering a competitive market where they either secure one of few contract positions or, most commonly, join the industry as an independent artist. As such, independent status often occurs immediately upon graduation and is a default position: less a choice than a necessity.

The trend toward independent practice is reflected in an increasing number of Western settings and has resulted in career development centers such as the Australian *SCOPE for Artists* program and the Canadian *Dancer Transition Resource Centre*, both of which recognize that transitions between physical and other dance practice occur throughout dancers' careers. Being an independent dance artist in Australia encapsulates a portfolio of roles, including the responsibility for career development, which is managed solely by the artist.

Such relentless career navigation and management is physically and emotionally exhausting. In perpetual transition, the dance artist is further challenged in mid-career by increased social and familial responsibilities and shifting priorities. It appears to be at this point that artists begin to question the long-term sustainability of this career model. Indeed, the very existence of a career model, with its inference of some kind of logical progression, is brought into question. The constancy of instability is an ongoing concern for dance artists at all levels and ages, as expressed by Joysanne Sidimus of the *Dancer Transition Resource Centre* in Canada: "it is perfectly possible to be at the top of your profession and not be earning a living wage" (Levine 2005, p. 33). With dance now a formal university entrance course within several Australian states (most recently in Western Australia), and a corresponding increase in the numbers of dance majors, it is timely to examine the realities of sustaining a dance career through the mid-career period.

This paper acknowledges and locates some of the ongoing pressures, potential pitfalls, and personal costs of professional instability in a protean dance career. The paper aims to provide an intimate snapshot of independent dance artists' mid-career lives. It seeks to bring attention to the particular shift felt by independent dance artists in their thirties and to make a case for continued support throughout this period of heightened instability.

METHOD

Participants

The study reported here focused on mid-career dance artists, all with between 10 and 16 years experience in the sector, and asked the questions: what are the impact and direct affects of ongoing instability on the professional and personal identity status of mid-career dance artists? What are the available support mechanisms and personal strategies of artists in navigating this crucial career phase? What does a real-life mid-career in dance look like? All of the survey and interview participants were Australian-based dance artists with an active dance practice. The first phase of research involved a survey of

71 dance artists from which the responses of nine mid-career dance artists (7 F, 2 M) were extracted. This was followed by in-depth case studies of three dance artists in their mid-thirties: Maya and Steven, who are both identified with pseudonyms, and Jo, the third participant and principal investigator. It is the results of these case studies that form the basis of this paper. Jo's inclusion positioned her as both investigator and participant, giving her the opportunity to contribute in terms of both her "lived experience" as a dance artist and from an academic standpoint. This methodology proved to be highly effective in eliciting deep responses.

Procedure

Respondents were identified from within professional networks, and purposeful sampling was employed to locate successive informants likely to give a wealth of information (Patton 1990). The survey collected information relating to demographics, work, and career aspirations and was presented in print and electronic format. Each of the three case study interviews began by building a short profile of the participant including qualifications, professional background, and experience. The interview encompassed instability, professional and personal identity, status, support mechanisms, working life, economic circumstances, and career lifespan. The interviews were recorded and transcribed, then independently coded using Glaser's constant comparative method of analysis (Flick 2002, p. 231). Seeking new responses to the topic, aspects of grounded theory were adopted to develop exploratory interpretations of data that would focus future data collection.

RESULTS

Results of the study can be summarized in three key areas. First, the study highlighted the need for professional and economic support to be continued through mid-career. This is contrary to the traditional model of supporting emerging artists on the basis that initial support will lead to a level of stability. Second, the three case studies brought to the fore the complexities of family responsibilities and between male and female parenting and artist roles. Finally, the study shed some light on the quest for long-stability and the impact of this on creative dance practice.

DISCUSSION

Dance is inherently unstable, and the instability comes with the dance career rather than being chosen: "it's not necessarily that I would like to be in a high risk business, it just happens to be [that] what I have chosen is most high risk—I'm an artist" (Maya). All three case studies are dance artists who juggle a multitude of roles, often back-to-back or simultaneously. All accepted that the protean nature of working as a dance artist is a reality from the outset.

The impacts of instability were seen as both positive and negative. Negative impacts relate to the difficult economic and ecological landscape of working in dance. Card (2006, p. 13) offers that dance artists in the small to medium sector are akin to "a bunch of responsive scavengers who function in a state of perpetual crisis though a life of irregular support and erratic employment histories." However, positive impacts of instability include the development of a strong sense of self preservation and adaptability, alongside the freedom to be creative, unorthodox, or innovative.

The instability of dance is a given, but in many ways it is manageable. The difficulty seems to lie more in the disconnect between the instability of dance and the stability of everyday life; most participants reported to being personally and emotionally stable, in contrast to the unknown components underpinning the instability of their professional lives: "working in arts in Australia you're often able to work if other people allow you to work, rather than just continuing with your work. So that's unstable, because it's not up to you" (Maya). Multiple participants identified a need to justify their dance practice to friends and family who have difficulty understanding, accepting, and valuing irregular, often erratic work patterns. Such irregular project-based work was noted to be problematic in terms of accessing community resources such as childcare, which demands commitment to a regular schedule well in advance.

Acceptance of and rebellion against instability appears to be a gradual shift in attitude and priorities rather than a sudden decision point or age. For two of the case studies, parenthood was also a factor in the reprioritizing. Yet dance is not something that can be put down and picked up, either physically or emotionally. Jo reported that project-based practice results in a deep sense of loss during "down times" when she is financially unable to justify continuing work without funds. The reality that "physicality needs to be available on demand," regardless of other priorities and activities, was for Jo becoming both difficult and impractical. For both Jo and Steven the pursuit of stability was coupled with an overt grief at the potential loss of the physical dance practice. For Steven, this occurred when he made the decision to focus on business interests "to work smarter, not harder." Steven's failed attempt to create a stable income in support of an integrated work/art/life philosophy, when "theory and practice didn't add up," resulted in a loss of physicality that denied him opportunities to pursue his physical dance practice. His desire to teach also diminished as it was his artistic practice that gave him the "juice" to teach: a duel loss of both practice and other work potential related to practice. For Jo, the grief was a recurring state of "pre-heartbreak during every project, knowing an end is imminent."

Reflecting on his life in dance, Steven considered himself to have "careered rather than had a career," implying a lack of control in his "careering" through both dance and jobs outside of the arts. In identifying his motivation for working, he was clear that "I work for my family now, not for myself." Because of time constraints and family responsibilities, Jo stressed the need to generate income directly from artistic projects. For Maya, too, it was financially necessary to maintain a reliable income source. She separated her "paid work" from her "artistic practice," though she still expected to generate her future income from her arts practice. This is in line with our previous research, which found that the income source of artists may not align with their professional identity.

In summary, this paper has provided insights in three key areas. First, the real life snapshot of a dance artist in mid-career is complicated and unique to each individual: Maya remained hopeful and reconciled, "the same as always;" Jo was building stable frames around her to house the continuation of an ongoing practice in increasingly unstable circumstances, yet she did not envisage a departure from dance; and Steven continued to research job options and was prepared to "let go" of dance in order "to be the provider," though he was still deeply engaged in an ongoing inquiry of his artistic practice. All but one of the participants expressed a deeply felt need to stay connected to their own physical/emotional constitution, and grief when this need was not met. Secondly, the case studies, with their different stages and relationships with dance, all acted as reflexive balancers of the unstable. Possibly in direct response to the inherent instability in the dance environment, they actively sought to cultivate sustainability in their work, family, and lives, and all desired a home base in which to "locate and situate the chaos" (Jo). The role of parenthood here arose as a major factor in slowing the "artistic nomadism." Finally, the results reiterate the vital need for support once dance artists have moved beyond the "emerging" phase. Ironically, though mid-career is contemporaneous with the period at which many dance artists begin to enjoy an established practice and "senior" artist status, the factors of mid-career deeply challenge the equilibrium. The need for support is evidenced by the 107% increase in applications for the *Scope for Artists* program, with over half of participants currently in their thirties. Further funding schemes, such as the new mid-career dance fellowship in Western Australia will allow artists to benefit from the available career development assistance and continue to develop their practice. However, much more needs to be done in order to cultivate an environment in which dance careers can be sustained in the longer term, and where experienced Australian dance artists can be empowered to challenge and grow the art form.

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Thematic session:
Physicality of performance

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Physical movement and imagery in professional and undergraduate student solo marimba practice

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Cognitive strategies and imagery are important features of expert musical practice. Movement imagery is important for developing note-accurate marimba performance. We report findings of a study where four professional marimba players and four undergraduate student marimba players completed questionnaires regarding their practice strategies and use of imagery in performance preparation. Since pedagogical marimba practice involves developing movement imagery, each participant also completed the Movement Imagery Questionnaire (MIQ-R) to measure subjective kinesthetic and visual imagery ability. As expected, professional musicians' qualitative reports of practice were driven by cognitive strategies. The student musicians reported more regular practice habits focusing primarily on physical practice. Professional musicians reported use of imagery in practice more often than student musicians. As predicted professional musicians' kinesthetic imagery was significantly greater than student musicians'. Contrary to prediction no significant difference was observed between professional and student musicians' visual imagery. Results offer some support for a pedagogical approach to marimba playing specifically aimed at developing note-accurate performance through kinesthetic awareness and imagery.

Keywords: practice; music imagery; movement imagery; marimba performance; musical expertise

Cognitive strategies in musical practice involve mental rehearsal of skills, music analysis, and metacognition to direct efficient practice (Barry and Hallam 2002). Whereas novices tend to focus on technical physicality, such as playing the correct pitches in the right rhythm (Hallam 2001), expert musicians demonstrate well-integrated cognitive and motoric strategies in preparing for performance (Chaffin and Logan 2006). An important early facet of an expert's approach to preparing a musical work for performance is to form an *artistic image* of the piece (Chaffin *et al.* 2003). This includes imagined musical character and emotions to be realized as sound through movement. Recent empirical evidence suggests *notional audiation*—imagining or "hearing" sounds purely from reading musical notation alone—to be a process involving kinesthetic vocal and motor processes in expert musicians (Brodsky *et al.* 2008). Hence, musical imagery and movement appear to be inextricably linked in expert music practice. While cognitive strategies and musical imagery would be expected features in professional marimba players' practice, movement imagery is also vital in the Western classical art form.

Movement imagery is "the mental rehearsal of visual and kinesthetic properties of movements to enhance learning and performance of motor skills" (Gregg *et al.* 2007, p. 1). According to Guillot *et al.* (2004), visual imagery is "self-visualization of movement whereas kinesthetic imagery requires one to "feel" the movement, i.e. to perceive muscle contractions mentally" (p. 190). Arvinen-Barrow *et al.* (2007) found elite athletes' cognitive-specific (sports skills) imagery ability was significantly higher than novices'. Solo marimba performance involves overt and spatial movement where the performer is not in tactile, or often direct visual, contact with their instrument; movement imagery is anecdotally reported to be important in developing expertise. An entire pedagogical approach to marimba playing, *Ideo Kinetics* (Stout 2001), aims to develop accurate movement patterns through kinesthetic awareness and imagery. Therefore, professional marimba players might be expected to possess greater movement imagery than student marimba players.

The aims of this study are twofold. Firstly, we offer preliminary documentation of professional and student solo marimba players' practice strategies, both physical and imagined. Qualitative data are expected to demonstrate that where professional marimba players focus on cognitive strategies and imagery, undergraduate student marimba players' practice focuses on physical or technical aspects. Secondly, since marimba playing is a complex motor skill that develops over time, we investigate kinesthetic and visual imagery ability of participants. It is predicted that professional marimba players self-report greater kinesthetic and visual imagery than undergraduate student marimba players.

METHOD

Participants

Participants included staff and students of the Zeltsman Marimba Festival 2004: two female and two male internationally-renowned solo marimbists (mean age=47 years, SD=6.18; mean years playing marimba=38.0, SD=7.66); two female and two male undergraduate-student marimba players (mean age=20 years, SD=1.71; mean years playing marimba=8.5, SD=1.73).

Materials and procedure

A questionnaire (Q1) gathered demographic and musical background information; open-ended questions requested explanation of practice strategies and use of kinesthetic, visual, auditory, and emotional/musical character imagery. The Movement Imagery Questionnaire-Revised (MIQ-R) (Hall and Martin 1997) assessed participants' subjective movement imagery ability on two scales: (1) kinesthetic, and (2) visual. An eight-item questionnaire, the MIQ-R requires participants to perform one of four movement tasks and then rate the ease with which they can kinesthetically or visually imagine performing the task. The scales range from 1 (very hard to see/feel) to 7 (very easy to see/feel). Scores for items on each scale are summed separately, giving participants a kinesthetic and a visual imagery score. A score below 16 (out of a possible 28) on either scale indicates low imagery ability on that scale, 16-20 moderate imagery ability, and above 20 high imagery ability. Hall and Martin (1997) reported satisfactory internal consistency for the kinesthetic (α=0.88) and visual (α=0.89) subscales of the MIQ-R. Participants were provided with an information sheet and, following written consent being gained, were given Q1 to complete and return. At a convenient time, participants completed the MIQ-R individually in a quiet room.

RESULTS

As expected, professional musicians' practice focused on cognitive strategies: "studying the music away from the instrument" (G), "practice see(ing) the notes" (JG). An initial goal for a new work was to develop musical interpretation: "I try to figure out what I could say through a piece from the first moment of studying it" (N), "Try to engage your imagination from the beginning" (M). Time constraint and demands of the repertoire affected practice: "Practicing schedule is often dependent upon my…work schedule…; often when I must do it (because of an upcoming performance, etc.)…I try to learn a piece in as little time as possible" (G), "To save time of playing the whole piece through, I keep a log of the most challenging sections and focus on those as separate exercises" (N).

The student musicians reported regular practice habits (mean hours per day=3.25, SD=0.96; mean days per week=6.00, SD=0.96). As expected, their practice focused on physical and technical elements: "Warm-ups, technique, repertoire, mess around" (D), "Learn the notes, work with a metronome, practice fast changes" (J). Strategies for learning a new piece involved breaking it into manageable chunks: "Separate the piece into chunks, and learn each chunk until I finish the piece" (S), "Divide the number of measures by the number of days (e.g. until performance)...; work the sections each day until the piece is done" (D). Attention was also directed toward locating and working on the most difficult sections: "I read through the entire piece at first to get a feel for it...find the difficult spots and try to work on them first" (S), "Practice 'black' sections slowly" (JS). Musical interpretation was briefly mentioned: "After I have learned all the notes and listened to a recording(s) of the piece, I put character to it" (S).

Professional musicians self-reported imagery as part of their usual practice: Kinesthetic (100%), e.g. "You have to remember the movements...to play smoothly and accurately" (JG), "Slow, accurate practice...helps to develop kinesthetic memory of the notes" (G); Visual (100%), e.g. "You can't hit what you don't see" (JG), "Develop a visual image of the printed page" (G); Auditory (100%), e.g. "You can't shape musically what you can't hear" (JG); Emotional/character (100%), e.g. "Project...my relationship with the piece" (JG).

The student musicians self-reported imagery less often: Kinesthetic (50%), e.g. "To train muscles for different phrasing or difficult passages...different intervals using kinesthetic imagery" (J); Visual (75%), e.g. "The instrument, the audience, the performance setting...visual imagery of the keyboard" (J); Auditory (50%), e.g. "sometimes I try to sound like a singer or violin...; recently, I started to just sit somewhere and play my tune in my head" (J), "Decide on the auditory response I want the instrument to have" (JS); Emotional/character (75%), e.g. "It helps to make a story or a scene out of the music...; depending on what emotions I have while I practice, I use them and turn them into emotions that will hopefully bring out the musicality of the piece" (S), "Imagery of particular experiences I've had which inform my approach" (J).

Mann-Whitney U tests were conducted on the kinesthetic and visual imagery scales separately, with musical expertise as the grouping variable. As predicted, the professional marimba players' kinesthetic imagery (Md=26.6, n=4) was significantly greater than the undergraduate student (Md=20.5,

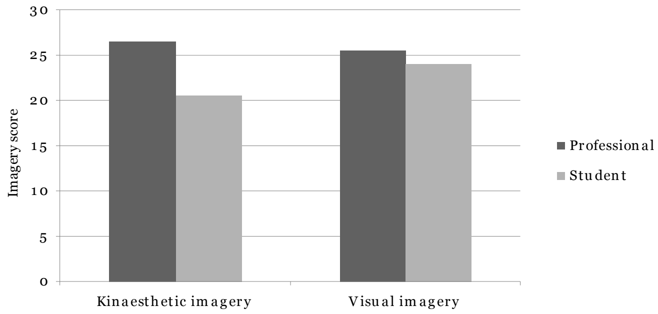

Figure 1. Median imagery scores for the professional and student marimba players on the kinesthetic and visual imagery subscales of the MIQ-R.

n=4) marimba players' (U=0.00, z=-2.34, p<0.05). Contrary to prediction, there was no significant difference between professional (Md=25.5, n=4) and student (Md=24.0, n=4) musicians' visual imagery (U =5.0, z=-0.89, p=0.37). Figure 1 shows the median scores for the professional and student musicians on both the kinesthetic and visual imagery subscales of the MIQ-R.

DISCUSSION

As expected, professional marimba players' practice strategies focused on cognitive issues and imagery (Brodsky *et al.* 2008, Barry and Hallam 2002, Chaffin *et al.* 2003, Chaffin and Logan 2006). While these habits were somewhat evident in these advanced student musicians' practice, their focus was primarily on the physical aspect (Barry and Hallam 2002, Hallam 2001). As predicted, professional marimba players reported significantly greater kinesthetic imagery than the undergraduate student marimba players (Arvinen-Barrow *et al.* 2007). These results conservatively support the *Ideo Kinetic*, kinesthetic-imagery-based, pedagogical approach to marimba playing (Stout 2001). No significant difference was observed between professional and student marimba players' visual imagery, contradicting the prediction. This may be because the spatial nature of movement required to play the marimba and hit specific targets explicitly incorporates the visual sense early in training. A more expansive study is necessary to validate these results. Future work will gather additional data to verify and broaden the scope of these findings, and identify links between performance practice and audience perceptual responses to recorded performances.

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Monitoring work and rest during performance and life-style: A study case with a principal ballet dancer

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Traditionally, dance training is based on day-to-day technical routines: the class. Studies in dance physiology started in the 1980s have shown that there are significant differences between the effort made during performance and that made in classes. The challenge for researchers and for those in the field (dancers, teachers, choreographers) is to find out training methodologies that allow improved performance, reducing the high number of injuries and prolonging careers. In this paper, we present a research methodology that can help to improve dance training by changing the starting point: past or future. Planning based on the past is to continue to repeat the same routines as always has been. Planning based on the future requires an analysis of the future task (dancing a particular role)—technical, energy, informational, psychological, and artistic—so that the preparation takes into account these different demands; what is known today as nonlinear periodization. This training must be specific and individualized.

Keywords: energy expenditure; work-to-rest ratio; dance training; elite ballet dancer; performance science

The prevalence of injuries in dance, mainly for professional dancers, is extremely high. Literature suggests that 80% of dancers get injured during their carrier (Hamilton 1989). The most frequent type of injury is normally named as overuse, a minor injury that gets worst by overload; micro traumatisms caused by the exhaustive repetition of the same technical exercises in order to achieve artistic perfection. This kind of injury, according to Garrick's (2008) studies, varies between 60-90% of total injuries, and the remaining are considered acute injuries that result from macro traumatisms (sprain, collision/impact, overstretch, etc.).

There are many factors that contribute to the occurrence of injuries: fatigue, excessive exercise/overtraining, inappropriate warm-up and cool-down, continuing to work when injured, deficient physical condition, hypo- or hypermobility, postural problems, alignment deficits, inadequate en-dehors, poor nutrition, disordered eating, menstrual irregularity, osteoporosis, psychological factors (sleeping problems, anxiety, depression), and factors related to equipment use (point shoes, floor type, wardrobe).

It seems to be consensual that injury happens when some of these factors occur together, with it being impossible to consider the injury occurrence the result of just one factor. However the *training* factors have a great contribution: 90% of the injuries happen when the dancer is fatigued (Liederbach 1997). Used to training over and over, it is common for dancers to hide the injuries and to keep working. Hamilton (1998) was responsible for an inquiry that collected the following results: 66% of dancers had continued to work with a chronic injury, 52% with tendinitis, and 27% with stress fracture and with arthritis.

One of the central problems of training consists of the specific choice of the balance between work and rest. To find the adequate amount of load and the adequate duration of recovery is important to improve performance and to prevent injuries. An insufficient load does not improve performance. On the other hand, loads too high or with a lack of time to recover are negative for health and performance maintains or decreases.

The aim of the study is to quantify the energy expenditure of high level performance in dance in order to characterize the dance task requirements and energetic costs in different time periods, and also to understand the balance between load and recovery.

METHOD

Participants

A 31 year old principal ballet male dancer was studied for eight days. For this study, the subject wore a multiple physiological sensor (*SenseWear Pro Armband*) during a week of performing *Coppélia*.

Materials

The arm band provided the following measures: total energy expenditure and active energy expenditure (at 3.0 METS or higher), physical activity duration, intensity (sedentary, moderate, vigorous, and very vigorous), and sleep duration. All the stage performances, individual and company rehearsals, and classes were filmed and submitted to a specific observation system. The movement analysis is centered on the kind of motor actions, and other variables, to calculate the movement density and the work-to-rest ratio.

Procedure

The subject wore the *SenseWear Pro Armband* on the right arm, and energy expenditure was estimated using proprietary equations developed by the manufacturer. The measurement periods were continuous for several days (until 14 days). Time ranges were selected according to the desired analyses work periods: week and day, including class, rehearsal, and performance. The collected data were analyzed in research software. The classes, rehearsals, and performances were filmed and recorded in digital base for posterior analysis with the observational system.

Estimated energy expenditure from the *SenseWear Pro Armband* is broadly validated in the literature, namely with standard indirect calorimetry. The sensewear data should be accompanied with information obtained through the completion of a simple diary. The different data were integrated over time. The equipment proved to be reliable and easy to use for all levels of dancers, and even during performance. A brief instruction period to the subjects is enough to achieve reliable results.

For the observation of the motor actions, the "system of observation of motor behavior in dance" created and developed by Rodrigues (1992, 1999) was utilized in this study. Through the systematic observation of motor behavior in dance we have identified nine motor actions: *steps*, *jumps*, *turns*, *gestures*, *falls*, *displacements*, *postures*, *balances,* and *contacts*. The list of motor actions proposed is limited and their definition based on two criteria: the support (link to the ground) and the group of specific features of each action. The observational system was validated in 1999.

RESULTS

Energy expenditure

On average the total energy expenditure was of 2933 Kcal, oscillating between 2300 on days-off and 3500 on performance days. During the eight days observed, the dancer had three performances of 2 hours and 20 mins (including intervals) and lost on average 600 Kcal in each one. For 50 mins he was in sedentary activity and about 90 mins in physical activity. The physical activity was distributed in 74 mins of *moderate* (3.0-6.0 METS), 14 mins of *vigorous*

(6.0-9.0 METS), and 3 mins in *very vigorous* (9.0 METS and higher). The sleep period was on average 8 hours.

The analysis of movement allows us to identify the relation between energy expenditure and density of movement: there is an increase of energy expenditure when the number of actions per min. also increases and mainly when those actions are moveable (jumps, displacements, and steps). However, some differences in the content are found between the classes (individual or collective) and the specificities of performance because classes are more like a routine without a direct relationship with the different requirements of choreographies.

Another characteristic that is important is the difference between what the subject does in his individual trainings before the performance and what he does during the company class. The expenditure (about 400 Kcal) is higher during his individual trainings of 1 hour and 15 mins (on average 4.0 METS) than during group classes (270 Kcal, 3.0 METS) with the same time. This last activity presents a sedentary and moderate activity, while the first situation has periods of vigorous activity like in the performance.

Work-to-rest ratio

One of the most interesting observations in this study concerns the comparison of the collective training with individual training. Typically, on performance day the company (with about 70 dancers) usually does a class similar to the other days. But on performance days our subject (principal dancer) holds his individual preparation/training just immediately before performance, instead of the collective class that occurs two hours before performance. What are the differences between these two classes?

In terms of content the differences are not much (at the end of the individual training there is some specific work/preparation with passages of the choreography, but only in the last 5 mins), but differences arise at the level of work-to-rest ratio: for a similar duration of 73 and 71 mins, in the collective class there was a total of 28-45 mins from work to rest, while in the individual training 32-39 mins of work to rest. The average time of the barre exercises is, respectively, 90 and 70 s, with similar values (33 s, 32 s) of rest.

In the centre the differences increase, with values of work of 28 s and 30 s, but with periods of rest significantly different from 180 s and 45 s, respectively. The organization of the exercises in small groups can explain this difference; in a class where there are on average 40 dancers, the rest time of each dancer will at least triple. The problem is that the physiological effects are quite different—e.g. if one waits 3 mins to work about 30 s, or if one just waits 45 s to do the same 30 s. The more experienced dancers are aware of this, and when they work individually they work more (39 versus 28 mins) and better.

DISCUSSION

The results shows that physical activity is mainly moderate (91%): on average, the eight days observed presented 3 daily hours of moderate physical activity, about 15 mins of vigorous, and 2 mins of very vigorous activity. The complexity of the tasks, which demands high coordination, may justify these results.

Another aspect that we must enhance is the importance of individual training for success. In the individual training periods, we found a work-to-rest-ratio more similar to performance than in the group class company.

The underlying question that arises in this study (in our line of research) is how to assist the performers to reach the peak level of performance at the right moment? Planning and monitoring are key words to achieve these objectives. If we continue to train only based on tradition, with a routine daily lesson for all the elements of the company, probably the same high rate of injuries will continue and the individual's potential is not developed: at the highest professional level, a lesson for all is a lesson for anyone. We need to individualize the training, planning well to find a balance between work periods and rest periods and to avoid overuse injuries.

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Will supplemental fitness training have an affect on the aesthetic components of contemporary and classical ballet dance performance?

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Exercise scientific research in dance to date has mainly been observational in nature; there is a paucity of literature investigating the effect of supplemental fitness training on dance performance. Many dancers have cited fatigue as one of the most prominent causes of injury and a decrease in performance components. The aim of the current study was to examine the effects of specifically tailored fitness training program on the incidence of injury and the quality of performance of both classical ballet and contemporary dancers, compared with relevant control groups. Participants underwent a series of fitness tests and a proficiency in performance test at the outset and end of the study. The intervention groups partook weekly training session that included aerobic interval training and circuit training. Data regarding injury incidence were collected with the assistance of the dancers' physiotherapist. Results indicated no significant difference in injury occurrence between the respective groups. Both classical ballet and contemporary intervention groups significantly increased their performance scores ($p<0.05$) compared with their equivalent control group. It was concluded that supplementary fitness training has a positive effect on the aesthetic components of dance performance as studied herein; further research is recommended on a larger and more varied sample.

Keywords: ballet; contemporary; performance; aesthetics; fitness

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Thematic session:
Defining performance

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Is composition a mode of performing? Questioning musical meaning

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The formalist approaches, focusing mainly on scores—which are just sets of instructions—have missed a significant part of music's processes of meaning production and its communicational dimension. This research is an attempt both to acknowledge the role that personal meanings play in the creation of a composition and of its performance and to verify if composers and performers work from the same mode of knowledge when making their respective meaning constructions. Based on gesture *intermodality*, a composer and performer created, separately, two video-clips that express the personal meanings that have guided their respective compositional or interpretative choices concerning two sections of a piece for solo flute. The two pairs of video clips were analyzed, compared, and conclusions were drawn. The results showed that, in spite of the different imagery used by composer and performer, the relations of tension and relaxation, movement, and rest were analogous: it appears that the personal meanings of the composer guided his work procedures to create those relations and that the performer has created a personal emotional narrative to give meaning back to those same relations. This study could support future research on the application of gesture intermodality in teaching strategies for musical performance.

Keywords: music; meaning; intermodality; composition; performance

The fact that performers cultivate a *narrative attitude* toward performance and performance preparation is a crucial notion for the present research, as it illuminates a range of questions on the difficult issues of musical meaning production. Although referring to listeners, Swanwick (1999) argued that it is our deep *personal* involvement with music that accounts for the high sense of value that we accord to it:

> Patterns or schemata of "old" experiences are activated but not as separate entities. They are fused into new relationships. We can thus make an imaginative leap from many old and disparate experiences into a single, coherent new experience. It is this potentially revelatory nature of music that accounts for the high sense of value frequently accorded to it (p. 21).

But these processes take place by the performers as well, who, consciously or not, more or less trained and more or less (historically) informed, end up projecting a *personal* interpretative style; and, we suspect, they take place also by composers, who, again, consciously or not, more or less trained and with more or less erudition, end up producing a score that is inevitably a pale reflection of their creation—that is, of the performance that, intimately, they were imagining when composing. We believe that personal meanings play a central role in the creative process, unifying all the dimensions of the musical work and determining decisively the actions and events of a musical performance, be it imagined or actually performed. These meanings guide the performers' intentionality in the unifying process of the musical creation and embodiment.

However, it is the embodied nature of music that is perhaps most relevant to musical understanding as it will be explored in this article. Based on the theory of enactive cognition (cf. Gibbs 2006, Thompson 2001), Martinez (2008) argued that structural metaphors might, to a certain extent, model music experiences and demonstrated how listeners use the metaphorical component of music cognition to experience the underlying structure of tonal music. For professional performers, music is inseparable from a communicative dramatic attitude, their account of the music they are about to play is always (or, at least, hopefully) an "aesthetically oriented narration of dramatic action" (Maus 1997, p. 129). After having collected the available information—be it anecdotal, historical, or analytic—performers create a kind of synthesis, a personal amalgam that they apply to the music material. This synthesis is, thus, much more an open, personal, subjective, symbolic amalgam, emotionally motivated to a large extent, than a reductive, closed, rigorous, conceptual definition, deductively constructed. This synthesis has indeed to be concentrated, like an embryo that develops adapting itself to the environment, in order to pragmatically fulfill its function of (e)motionally exploring the musical material. Putting aside the issues concerning the specific instrumental techniques of each musical genre or style, which are in fact just means of expression, performers' hermeneutic approach to scores, in other words, their *subjective, symbolically charged, embryonic amalgam* has a clear purpose: to create a communicative, convincing narrative of musical gestures: "performers tell a story and the concert begins with 'Once upon a time…'" (interview with Patrick Gallois, in Correia 2003). When applying their subjective, symbolically charged, embryonic amalgams to explore (e)motionally the musical pieces, performers are exploring *figures*, which are "constellations" of embodied symbolic meanings, and invoking inevitably analogies, metaphors, or, simply, memories. This implies that it is the realm of *tacit knowledge* that is aimed in this (e)motional exploration, as if the figures would invoke the actual "presence" of the (e)motional memories and the performers would re-enact them, recuperating their unconscious dimensions to a large extent and making in this way their interpretations more authentic and convincing. But, if composition is as a mode of performing, composers, when composing, should be applying a *subjective, symbolically charged, embryonic amalgam* as well, actively imagining a performance which would guide their compositional decisions.

To find out more about this, and having in mind that one may express through different sense modalities (aurally or visually) the same gestural dynamics and shaping, we designed the experiment we report here. It is based, thus, on the application of the concept of intermodality (cf. Johnson 1987, Hatten 1999), which will enable us to compare the performer's and the composer's personal (embodied) meanings for the same piece. The simple verbal explanation of these meanings would utterly miss the point: their *embodiment*. Thus, we had to create the conditions under which these personal meanings could be manifested while keeping their embodiment. In order to do that, we asked both performer and composer to express in visual terms (directing videos for two excerpts of the piece) the same subjective, symbolically charged, embryonic amalgam they had created for the musical work. They were asked to "translate" their personal (embodied) meanings—whatever they intimately and introspectively have imagined for each musical excerpt—into visible scenes, actions, and physical gestures; our main objective being to understand if the role that embodied meanings play in composition is similar to the role they play in performance. If they play a similar role, then composition should be considered a mode of performing.

METHOD

Participants

Composer was Sara Carvalho, who teaches composition at the University of Aveiro. The performer was Jorge Salgado Correia, who teaches flute at the University of Aveiro. The actors were Joana Carvalho, Graciana Romeo, Juan Capriotti, Miguel Correia, and the author.

Materials

Two excerpts with about 50 seconds duration taken from the work *Solos III* for flute by Sara Carvalho (CD *Nova Música para Flauta* 1999, ed. Numérica, No. 1095) were chosen as the musical material upon which the video clips were created. The first excerpt (M1) corresponds to the score measures from 1 to 16; the second excerpt (M2) from measure 123 to 137. For the video recordings, an amateur digital camera was used (Samsung S760-7.2 mega pixels).

Procedure

Sara Carvalho wrote the script and directed and edited two of the video clips expressing the view of the composer (Cv1, Cv2). She was asked to express in this way the meanings that each of the excerpts had for her when composing the piece *Solos III*. The performer was asked to do the same for the same two excerpts, reporting himself on the time when he was preparing to perform this piece (Pv1, Pv2). In all videos, the actors were asked to do exactly what the directors required, neutralizing as much as possible any kind of interference. The four videos are available on the internet: www.youtube.com, search term "jorgesalgadocorreia".

RESULTS

The videos of the composer (Cv1, Cv2) tell the story of a man who sees and meets two women in two different scenarios; in Cv1, the woman is lying in the sun on a beach, and in Cv2, the meeting happens in a coffee shop. In her script the composer explained that, in her narrative for this piece, each section corresponds to a meeting of the same man with different women. The video of the performer for the first (Pv1) excerpt portrays the anxiety of a woman looking for something but trying not to be seen by the boy who happened to be in the same room. In the second video of the performer (Pv2), the camera catches a domestic discussion between a man and a woman.

DISCUSSION

Beginning with what the two pairs of videos have in common, the main thing to highlight seems to be the profound sense of narrative that all of the videos clearly display. Both composer and performer thought and worked in terms of constructing a narrative, of telling a story. The main structural points of the music—beginning with the presentation of a conflict or an opposition (in M1 the opposition between the *pizzicatos* and the *normal* notes, in M2 the opposition or dialog between low and high registers); growing tension through repetition (in M1 repetition and some degree of *stretto*, in M2 repetition and ascendant melodic movement); and conclusion (in M1 resolution of the opposition, confluence, in M2 definitive separation of the opposites, divergence)—are clearly reproduced in the videos of both composer and performer. Of course, they tell different stories, but it is remarkable how the important structural features are present in both versions. For example, Cv1 and Pv1 both express in the end a sense of success, while Cv2 and Pv2 both express the same feeling of irreparable separation; also the points of highest tension in the videos are the same, corresponding to measure 8 in M1 and measure 135 in M2. It seems, thus, that embodied imagination assisted composer and performer in mapping the same expressive process between different experiential domains, and more importantly, this intermodal or *transmodal* operation was only possible because the structural features emerged from a system of spatial-temporal organization elaborated upon patterns of image schemata (cf. Johnson 1987).

It is this fundamental connection to a bodily ground that makes personal meanings so decisive in musical meaning production and communication. But there was a remarkable difference as well. The two videos of the composer have both the characteristic of suggesting much more psychological action than physical: the viewer is invited to imagine what the characters are feeling and the musical gestures seem to portray much more these emotional experiences than the physical actions of the actors. There are a few exceptions where there is obvious coordination between the musical events and the visible actions in the videos of the composer: at the beginning and the end of Cv1, measure 8 in Cv1 where some agitation in the music is expressed through the movements of the actress, in Cv2 measure 134, and at the end where again and respectively the actor and the actress seem to physically express, say, more literally, the correspondent musical gesture. The physical actions in the two videos of the performer are much more connected with the musical events: the characters move with the music, so to speak, starting and stopping in synchrony with the musical phrases, expressing with movement and physical gestures the relations of tension and relaxation of the music. Only in Pv2 there are two occasions (curiously, both have sustained multiphonics) where the viewer has no physical action to interpret and is, thus, implicitly, invited to imagine what emotions the characters are experiencing; the first is in measure 128, where the man sits impotent and leans with his elbow on the arm of the sofa, and the second is at the end, measure 137, where the man walks devastated away from the woman and toward the window. To our understanding, these two different approaches result directly from the specific conditioning of their respective professional activities: the composer is normally giving instructions and *suggesting*, while the performer is actually *doing* or performing and, as we have argued, for performers, music is inseparable from a communicative dramatic attitude. So, the videos of the performer reflect this additional preoccupation of communicating as intensively and as clearly as possible, exteriorizing *in motion* all the emotions. The exploration of this attitude is very useful for performance students as it is the application of gesture intermodality to develop intentionality and, consequently, expressiveness and musicality.

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Seeking excellence in danced postgraduate degrees

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Excellence as an evaluative category is implicit in the attainment of "doctorateness," so how can excellence be evaluated? The practices of dance, now recognized as legitimate components of doctoral studies, complicate evaluation processes while suggesting possible revisions as to how these processes may be refined. The combination of tacit knowledge and engagement, though contrary in logical senses, may provide a dynamic solution for evaluating studies that exceed a concept of excellence constrained measurement.

Keywords: postgraduate dance studies; assessment; engagement; criterion of excellence; conceptualization

Excellence as an evaluative category is implicit in the attainment of doctorateness: "as the highest level of degree conferred by most universities, the PhD is commonly understood as indicating the height of formal educational attainment, and has, until relatively recently, been above reproach and alteration" (Brien 2009, p. 3). At the same time, excellence is neither a simple attribute to define nor a concept of measurement without contestation. Indeed, a crucial reason for embarking on the project at the core of this discussion was a desire expressed by candidates, supervisors, and examiners of doctoral degrees to gain guidance in what achievement in danced research at the top of the academic scale might be.

Sparshott views the sole function of excellence is to signal the "sum of those qualities for which anything is praised and prized," concluding summarily that excellence "represents standardization and 'quality control'" and, ultimately, "compliance" (Sparshott 1986, p. 137). Through clever semantic arguments, Sparshott demolishes the validity of the term except when it might apply to rival manifestations and persons who "can be said to be doing the same thing more or less well" (Sparshott 1986, p. 138). Excellence measurements may be able to be applied to virtuosity but not, he argues, to imaginativeness or expressiveness, originality or beauty. His final comment, however, is telling, introducing an ambivalence that is less characteristic of his overall scepticism: excellence is "what gives art a public identity and a public place, without which art could not achieve whatever deeper significance it might have" (Sparshott 1986, p. 140). The idea of excellence, though ultimately incalculable across the complexities of human behavior, thus has its function.

Similar tensions pervade the evaluation of degrees involving artistic practices. However, whereas Sparshott and later aesthetics' advocates like Stastny (2002) cling to traditional contours of thought, the new generation of practitioner-scholars abide in uncertainties that lie between excellence determined by academic perspectives and that advocated within the professional arts community, often emphasizing a confusion between what Melrose (2003, 2006) distinguishes as expert *spectatorship* and expert *practitioner* mastery. Melrose highlights the divergent motivations of those who look back to retrieve knowledge and those who use their practical mastery (albeit skills in movement, sound, and image developed in the past) to project forward into the concept of discovery itself. Curiously, the two distinctive forms of mastery resonate with similar past determinates on which excellence in the field must be gauged.

Thus, evaluation of research acts springs from what has been learned through time by individuals/examiners devoted to pursuits articulated in words as much as in movement. In both, the sedimentation of "thought" acquired through exposure to the form, an individual's tacit knowledge, plays a vital role in measuring whether that "same thing" is delivered "more or less well." Judgment is, by nature, thereby enmeshed in the past even if, and this point is significant, judgment is not confined solely to its dictates but should also be pervious to novelty, surprise, and confrontation. Acts of doctoral examination might begin with Sparshott's observation about relative merits of technical factors reasonably based on tacit knowledge, but they also have to move into the less definable territory of imagination and originality, where concepts other than excellence invariably pervade.

METHOD

Procedure and materials

This perspective on "performing excellence" is prompted by a recent collaborative research project, *Dancing between diversity and consistency: Refining assessment in postgraduate studies in dance*, conducted with funding by the

Australian Learning and Teaching Council in 2006-08. Researchers, Cheryl Stock (Queensland University of Technology), Kim Vincs (Deakin University), and myself, questioned why dance artists and/or scholars pursue academic degrees alongside explorations into assessment, particularly in those programs involving artistic practices.

Extensive literature reviews into higher degree dance studies, postgraduate examination/assessment issues, and peculiarities pertinent to artistic practice components helped to structure the interview and focus group questions within the two principal disciplinary clusters of participants; the broad professional dance community represented by *Ausdance* (the Australian Dance Council) and the group of Australian universities who offered dance or related postgraduate degrees.

Participants

Perceptions were drawn from 74 open-ended interviews with supervisors/examiners, research deans and administrators, and candidates/graduates as well as from forums organized through *Ausdance* networks tapping into the profession's views on postgraduate research. Eighteen months into the project, responses to a draft code of practice document, disseminated at the 2008 *World Dance Alliance Global Summit* in Brisbane, also played a vital role in constructing the culminating guidelines and discussion papers, as did interaction with Susan Melrose, the project's international evaluator.

RESULTS

Legitimacy and/or engagement?

Responses indicated that the primary motivation for doctoral degrees is the validation of dance knowledge, whether performative or choreographic, pedagogical or therapeutic. Given the context, this emphasis on intellectualization was unsurprising and, yet, arguably slightly at odds with an aesthetic form often propelled by the rebellious forces of its contemporary manifestations. Ironically, when faced with delineating attributes that characterize doctorateness, the range of participants expressed a slightly divergent, though not incompatible, view emphasizing the role of engagement or the "wow" factor which ostensibly appears more consistent with traditional perceptions of dancing than a reliance on its intellectualism.

Indeed, engagement emerges as a key attribute of evaluation when dealing with ideas of excellence where the mode—whether dance, writing, or symbolic notation—matters less than a discernible brilliance or clarity of articulation in the medium concerned. One candidate's observation makes this issue of articulation and its enmeshment in skill and form clear:

> William Forsythe's CD-ROM—his solo in that—it's about eight minutes long. I would call [the solo] a doctorate level of performance. It's amazingly sophisticated—tight, clear, it compresses years of dance into eight minutes.

Encapsulated in this observation is an ability to recognize excellence almost without dispute. Similar resonances are perceptible in the following selection of responses from supervisors/examiners on the characteristics of doctorateness across the modalities of practice and word: reading involves "not a step [but] a run—a dash—a dance," candidates "embrace the unknown and use the unknown," they are "agents and leaders of change within the discipline," their work exhibits a "transformative imagination," is "courageous, thoughtful," embraces a "depth of practical investigation/embodied substance," displays a "mastery of craft plus inventiveness," and evokes "more than a personal capsule view; a sustained processual perspective."

Responses thus suggest that engagement is a strong indicator of excellence within doctoral evaluations related, perhaps, to Csikszentmihalyi's (2001) proposition of flow: "the condition that is necessary for an individual entering the state of flow is concentration, an intense focus on what he or she is doing" (p. 8). Csikszentmihalyi's analysis, honed to creative individuals and their learning aptitudes and processes, may be equally applicable to examiners and their willingness to learn within the evaluation process. Or rather, I believe that the rigorous examiner actually embodies this notion of flow and actively participates in the thesis journey through alignment of his/her tacit knowledge and involvement in a "deep, intrinsically motivated experience...[wherein] they forget themselves" (p. 7). Incorporating the two seemingly oppositional intentions thus invites a dynamic concentration on, or ideational dialogue with, the candidate's research. The examiner's tacit knowledge constrains an "anything goes" or egocentric artistic foray but, at the same time, should not impede concerted visions into "what if" questions.

Generating dynamism

Thus, there is a metaphorical give-and-take in the evaluation exercise which involves an examiner's tacit knowledge, the candidate's capacity to acknowledge that grounding, and the courage, on the part of both parties, to venture into new or possibly refined territory. That said, in actuality, an examiner's immersion is more likely to be impeded by disjunctures in some aspects of presentation and/or conceptualization within the doctoral study, since excellence as noted by Sparshott is both ideal and relative. Nevertheless, aspirations of excellence on the part of candidates and examiners do sustain the disciplinary community, and it would appear that this is an important message to convey, even if a state of "flow" or dynamic embodiment is not always achieved.

How then to encourage examiners to "engage" in the excellence seeking process of evaluation? Ultimately, guidelines have to be porous so as not to delimit incursions into new knowledge at any point along the process to product continuum. At the same time, examiners and candidates do need guidance into expectations.

Two factors appeared crucial in the provisional recommendations that we put forward; each candidate's ability to articulate their research questions and pivotal variables involved and each examiner's willingness to "engage" dynamically with the articulated situation given his/her tacit knowledge and the unfixed environment of the unknown. The former indicates the importance of clarity, while the latter offers credibility of change. As such, our report (Phillips *et al.* 2009) offers dynamical systems for examinations that attempt to suggest interactions, rather than checklists, for variations that may occur in theses. These diagrams intend to dialogically mesh academic and professional perspectives on excellence that, though not easily achieved with their distinct value sets, is desirable. Dynamical systems, moving and forever challenging, should be able to embrace difference and singularity. Wherever experimentation occurs, intellectualization and creative play should be evident. The combination may not always work, but that too is an issue of engagement and adventure.

DISCUSSION

Excellence then is not a necessary measure of doctorateness, but the idea of excellence operates like an aspiration, challenging candidate mettle and inviting examiner engagement. Our project points to the notion of dynamic interactions between the examined and the examiner that have to be travelled without certainty and without actual face-to-face communication. But the dash and dance into knowledge does involve engagement of both parties, for when engagement withers on either side, excellence is an idea without meaning, even in aspiration. The project is ongoing.

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Intention revisited: From composition to performance

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Within the context of Western art music performance, intention is a fundamental key concept, generally viewed as a representation of the composer's creative and interpretative intents. Even though intention is considered a decisive factor in performance, the focus is placed on the composer, and the performer's own range of interpretative choices has been neglected. This issue is especially pertinent in collaborative work between composer and performer(s) in the interpretation of contemporary repertoire, often informed by the intentional contribution of both parties. This research focused on a case study, documenting the collaboration between a composer and a performer, which involved the première of a new composition for pianoforte, and intended to demonstrate that: (1) the concept of authorial intention, which is traditionally viewed by performers as a mandatory interpretative framework, can also be addressed from the performer's perspective and (2) a multi-level appraisal of intention can be applied to collaborative procedures in order to promote a successful performance. The concepts of authorship and intention provided a theoretical framework for the analysis of the collaboration process, establishing a parallel between the dichotomies author/reader and composer/performer, and the concept of intentional level was applied in the description of the collaboration stages.

Keywords: author; intention; composition; collaboration; performance

Within the context of Western art music performance, intention is a fundamental key concept, generally viewed as a representation of the composer's creative and interpretative intents. This concept has been the subject of debate especially in the context of historically-informed performance, namely by authors such as Dipert (1980), Kivy (1995), and Butt (2002), and has been influenced and marked by similar issues raised in the field of literary studies.

Wimsatt and Beardsley's essay "The Intentional Fallacy" (1946), which criticized the relevance of authorial intention as a criterion for critical evaluation, defended the text, and not the author, as the focal point for interpretation. This approach led to the announcement of the "death of the author" by Barthes (1994), a position that was subsequently reformulated by Foucault (1992).

In music, the debate has mostly been focused on the relevance of composer's intentions for interpretation. Intention, as discussed by Dipert or Butt, is presented as a multi-level/multi-sided concept, following a similar approach by some literary-studies theorists (namely Hancher 1972). The focus is mostly placed on the composer or the musical text/score, and its significance for the performer's own range of interpretative choices has been neglected.

This neglect derives from post-romantic views of the work concept, views that emphasize the primacy of author and text over the contingencies and variability normally assigned to performance. Burke points out that "the crucial historical change in conceptions of authorship did not occur in the theoretical upheaval of the last thirty years but with the romantic revolution and the eighteenth-century philosophical and aesthetic discourses upon which it grew" (Burke 1995, p. xix). This statement could also be applied to changes in the notion of musical work during the same period, which led to differentiated views of the relative relevance of composing/performing/listening as creative actions. The intentional fallacy criticized by Wimsatt and Beardsley located the merits of a literary work in the correct interpretation of the author's intentions. The tension generated by the pressure of playing under the ideal of *Werktreue* (implying fidelity to the work's essence), mentioned by Goehr (1992), is a parallel situation, placing constraints and restrictions upon performers on the basis of authorial intention.

This article intends to demonstrate: (1) that the concept of author's intention, which is traditionally viewed by performers as a mandatory interpretative framework, can also be addressed from the performer's perspective and (2) that a multi-level appraisal of intention can be applied to collaborative procedures in order to promote a successful performance.

MAIN CONTRIBUTION

This research was developed in the context of a case study documenting the collaboration between a composer and a performer, which involved the première of a new composition for the pianoforte. The concepts of authorship and intention provided a theoretical framework for the analysis of the collaboration process, which was grounded on two main challenges: applying a contemporary style of composition involving a less-known historical instrument, and building on the sense of historical ambiguity without compromising the effectiveness of the performance.

Composer/performer/work

The rise of the concept of the autonomous musical work and the associated concept of *Werktreue* led to the redefinition of the relation composer/performer and the gradual dissociation of these roles, most noticeably from the beginning of the nineteenth century. Goehr mentions that Liszt "spent a considerable part of his musical life developing two distinct forms of performance, first, performances committed to faithful renditions of his works, second, virtuoso performance devoted to the art of extemporization and the show of impressive performance technique" (Goehr 2002, pp. 232-233). Liszt's option for two different types of performance is representative of the establishment of a viewpoint that distinguished composers' and performers' activity. The text became paramount in this new outlook.

Intention revisited: From literature to music

The relevance of intention has led to an ongoing debate in the realm of literary studies, linked to the notion of authorship and the establishment of critical parameters. This research extends this theoretical stance to music, drawing a parallel between the dichotomies author/reader and composer/performer. This parallel is not fortuitous: as pointed out by Kivy, there is an "almost universal tendency since at least the eighteenth century to try to understand absolute music on a linguistic model of one kind or another" (Kivy 1995, p. 284).

The debate surrounding the notion of authorship in the late 1960s challenged an author-centered appraisal of literary texts. Barthes announced "the death of the author" in his much-debated essay, highlighting the multiplicity of voices implied in a text: "there is one place where this multiplicity reassembles, and this place is not the author, as hitherto said, it's the reader" (Barthes 1994, p. 595). Foucault, on the other hand, does not dismiss the intellectual implications of the author figure: "a discourse associated to an author's name…is not a fleeting and momentary discourse, immediately consumed, but rather a discourse that is perceived in a certain manner and given, within a given culture, a certain status" (Foucault 1992, p. 45). Foucault, however, dissociates author and writer, characterizing the author as a function that can acknowledge the existence of a multiple "I".

The fact that intention as a conceptual idea remains a recurring issue in literary—and art—studies theory reflects the enduring dichotomy between "the programmatic intention (what the author set out to say) and the operative intention (what his text ends up saying)" (Burke 1992, p. 142). Some critics approach this dichotomy through a hierarchy—or category—based outlook, namely Hancher (1972, p. 835), who writes that the author's intention:

> Can be analyzed into three kinds: his intention to make a literary work of a certain sort ("programmatic intention"); his intention to be (understood as) acting in a certain way ("active intention"); and his intention to cause something or other to happen beyond the mere understanding of his meaning ("final intention").

The hierarchical/categorical approach has also been the preferred model regarding theories on musical intention.

The concept of intention in musical interpretation has been criticized for its prescriptive stance, often based on textual and analytical constraints that limit the performer's freedom of expression. As Taruskin ironically contends, "composers do not usually have intentions such as we would like to ascertain, and…the need obliquely to gain the composer's approval for what we do bespeaks a failure of nerve" (Taruskin 1995, p. 98). Historically-informed performance, nevertheless, is undeniably connected to the maintenance of intention as a working concept, and represents an innovative trend in musical performance that cannot be dismissed solely on the grounds of poor hermeneutical grounding.

Part of the problem regarding the adaptation of intentional theory to music may lie on the exclusive focus on the composer's perspective, which contrasts with the above-mentioned trends in literary theory that question the conventional notion of authorship and emphasize the importance of multiple perspectives. Dipert's description of intentional levels, and its re-evaluation by Butt (2002), are, as acknowledged by Butt, unsatisfactory as theoretical tools, as the distinction between levels of intention, despite the fact that they are established with the composer in mind, is in fact partly or mainly dependent on performer's choices. Dipert, while mentioning the limited relevance of composer's intentions for performance, proposes a 3-levelled hierarchy. Butt rejects the hierarchical outlook, and proposes a division between "'active intention'—a composer's specific decisions concerning such matters as instrumentation, tempo, dynamic, …and 'passive intention'—those factors over which he had little control, but which he consciously or unconsciously assumed" (pp.89-90).

Intention revisited: *Prelude in Fugue*

From the early stages of collaboration (*Prelude in Fugue* was composed by Sara Carvalho for Helena Marinho), it was decided that composer and performer would not assume the conventional separation of roles and that the effectiveness of the work would require a close interaction. It also became clear that intention was the focal concept within the collaboration process and that former intentional models should be subject to reformulation.

The initial challenge involved mechanisms of adaptation derived from the composer's unfamiliarity with the pianoforte, the performer's dilemma of mediating between historically-informed performing practices, which are particularly suited to the instrument, and the need to convey an original and effective interpretative approach. The issue of intention was addressed initially as being especially pertinent in collaborative work between composer and performer(s) in the interpretation of contemporary solo repertoire, where this type of cooperation often leads to performances that are informed by the intentional contribution of both parties. Thus, theoretical frameworks focusing solely on the composer's perspective are unsuitable to describe this type of collaboration.

Even though the intentional model proposed by Hancher (1972) addressed the author's perspective alone, its acknowledged reliance on Austin's division of speech acts into locutionary, illocutionary, and perlocutionary kinds, allows us to establish a parallel with musical interpretation as a communicative action.

- Programmatic intention, in this case study, was developed through collaboration prior to the composition process: the performer introduced the instrument to the composer, suggested effective techniques, and described instrumental characteristics, namely: the type of dynamic contrasts, the effects obtained through specific pedaling effects, arpeggiation, and flexible tempo choices; the composer departed from a situation of near absence of contemporary repertoire for the instrument and had to find a suitable way to express her intention.
- Active intention was developed in alternating joint and individual work sessions. In joint sessions matters of articulation, tempo, pedaling were discussed, and some changes were gradually introduced; in individual

work sessions, both composer and performer worked on their own vision of the piece for further discussion.

- Final intention was shared by composer and performer, who centered their attention in details that differed in some instances: the composer mostly focused on structural coherence and impact, whereas the performer was more focused on aspects such as effective dynamic contrasts, expressivity, and even articulation.

IMPLICATIONS

The concepts of authorship and intentionality can be successfully applied to procedures of collaboration between composers and performers that promote exchange and mediation. Intention emerges thus not in its now outdated perspective of mandatory fidelity to the composer's directions, but as the core of a collaborative and creative process in which intention is envisaged from the standpoint of the performer as well. Furthermore, the description of the phases and level of exchange between performer and composer demonstrate that intention can be addressed and described as a multi-level concept shared by composer and performer alike.

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Thematic session:
Psychology of performance

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When repetition isn't the best practice strategy: Examining differing levels of contextual interference during practice

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Two experiments examined the effects of blocked and random practice schedules on the performance accuracy, speed, and temporal evenness of performance by wind players. Blocked schedules used repetitive practice orders, while random schedules constantly changed the order of tasks practiced. Beginning clarinet students completed three days of practice on three short technical tasks, in either a blocked or random order. Twenty-four hours after practice, beginning students who had practiced in the random order were able to play significantly faster than students who had practiced in the blocked order ($F_{1,38}$=24.95, $p<0.001$, η^2=0.92). Students in the blocked group performed significantly slower at 24-hour delayed retention than immediately after practice ($p<0.001$). Contrary to non-musical motor learning investigations, there was no speed-accuracy trade-off: students maintained high accuracy scores while speed gradually improved. In Experiment II, university wind students practiced three short technical tasks in either a blocked or random order for two days. Retention testing occurred 24-hours and one week following practice. Preliminary results were presented in the conference session.

Keywords: practice; contextual interference; blocked; speed-accuracy trade-off; speed

Musicians and music educators are always seeking to better understand factors contributing to efficient and effective practice. Motor learning research, which studies how people acquire and refine movements over time, offers a potentially valuable framework for exploring the challenges of instrumental performance. To the extent that playing a musical instrument is a motor task, motor learning theories and methods may be relevant to the study of music practice.

A series of two studies applied the motor learning principle of contextual interference, the amount of cognitive disruption present when practicing multiple tasks within a practice session, to instrumental practice. The purpose of these studies was to examine the effects of differing levels of contextual interference on performance speed, accuracy, and temporal evenness by beginning and university-level instrumentalists. Low levels of contextual interference were defined as blocked practice orders (AAA BBB CCC), while high levels of contextual interference were defined as random practice orders (ABC BAC ACB). The contextual interference hypothesis (Shea and Morgan 1979, Battig 1966) predicted the blocked condition would exhibit superior performance immediately following practice (acquisition) but the random condition would perform better at delayed retention testing. This hypothesis is generally consistent in laboratory motor learning studies (e.g. Lee and Magill 1983, Brady 2004), but less consistent in applied studies of sports skills (e.g. Landin and Hebert 1997, Hall *et al.* 1994) and fine-motor skills (Ollis *et al.* 2005, Ste-Marie *et al.* 2004).

In a music context, university non-percussion majors practiced right hand lead snare drum sticking for one practice session in either a blocked or varied (random) order or an unstructured free condition (Rose 2006). After retention delays of 30 minutes to 24 hours, no significant differences were found between blocked and random groups for accuracy. Likewise, Stambaugh and Demorest (under review) found second and third year clarinet and saxophone students learned 8-measure method book songs equally well in either 6-minute blocked, 1-minute serial (ABC ABC), or hybrid (2-minute serial) orders.

The current investigations expanded on previous research by using designs more similar to traditional motor learning experiments and musicians with different levels of expertise.

METHOD: EXPERIMENT I

Participants

Participants (n=41) were beginning clarinet players recruited from 16 elementary schools in the northwest USA. Students were enrolled in the first year of their school band program, which started in either fifth or sixth grade (age 11 or 12 years).

Materials

The stimuli (e.g. see Figure 1) were composed by the researcher to meet the following constraints: limited performance range, task brevity, transposable

Figure 1. Practice task for Experiment I.

to two other keys to control for any aural confounds, inclusion of a novel pitch to prevent ceiling effects, and majority tonality. There were two screening tasks, three practice/retention tasks, and two transfer tasks.

Procedure

Students began by playing the screening tasks, and this accuracy score was used as a covariate. The practice sessions occurred in group settings led by the researcher. Microphones were attached to students' clarinets during all playing. Cubase multi-track software enabled individual recordings to be made of each student's playing while in the group setting.

Students within schools were randomly assigned to either the blocked or random practice condition, attending three practice days and one delayed testing day. Students were instructed to play as "accurately and quickly as possible." In the blocked group, students played 18 trials of one task on each day. Random group students played 6 trials of each of the 3 tasks in a random order. At retention testing, students within groups were further divided for testing in either a blocked or random order (blocked practice-blocked retention, blocked practice-random retention…). After performing 3 retention trials of each task and 3 trials of the transfer tasks, students completed a brief questionnaire about their attitude toward their practice condition.

Accuracy and speed scores were determined for each of the 3,554 performance trials. Accuracy was scored through repeated listening by the researcher using a point-deduction system, and speed was measured in Cubase as the time lapsed from the onset of the first pitch to the onset of the last pitch in each trial. Temporal evenness was scored for the final three practice trials (acquisition), retention, and transfer trials (1,286) using an equation determining the average interonset interval in relation to trial duration: $|IOI_x - IOI_m| = IOI\Delta$, $\sum IOI_\Delta / \sum IOI$.

RESULTS: EXPERIMENT I

Figure 2 presents means and standard deviations of speed and accuracy averaged for every 3 practice trials. After 18 practice trials, there were no significant differences between groups for accuracy, speed, or temporal evenness ($p>0.02$). A repeated measures ANCOVA for speed found a main effect for trial ($F_{5,34}=5.05$, $p=0.001$, $\eta^2=0.11$), indicating both groups did improve speed

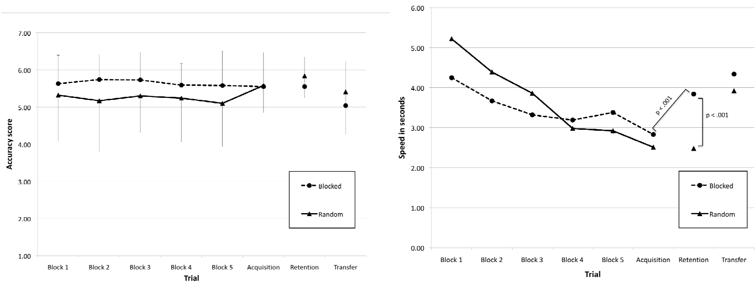

Figure 2. Accuracy and speed mean scores averaged across every three trials.

during the practice trials. At 24-hour delayed retention, the random group performed significantly faster than the blocked group ($F_{1,38}$=24.95, p<0.001, η^2=0.92), and pairwise comparisons indicated the blocked group played significantly slower at retention than at acquisition (p<0.001). There were no significant differences for accuracy or evenness at retention, and no significant differences between groups on transfer tasks. When students within practice groups were tested in blocked or random orders at retention, there were no significant within-practice group differences for accuracy, speed, or evenness. Regarding attitude toward practice, both groups exhibited a similar (t_{40}=-1.10, p>0.28) positive response.

METHOD: EXPERIMENT II

Participants

Participants (n=40) were members of university bands, playing woodwind or valved brass instruments.

Materials

The researcher composed the stimuli (e.g. see Figure 3) to be a major tonality, short task, and difficult enough to prevent a ceiling effect.

Procedure

Procedures were similar to Experiment I, with three notable differences. First, participants completed practice sessions individually, without the re searcher present. Second, the 18 practice trials occurred over two, rather than three, days and a one-week delayed retention test was added. Third, the

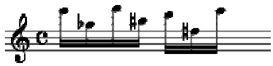

Figure 3. Example task for Experiment II.

blocked practice order was 9 trials of each task on both days in a blocked order, to control for consolidation effects.

RESULTS: EXPERIMENT II

Preliminary results were presented in the conference session.

DISCUSSION

Like many applied studies, results of Experiment I were partially consistent with the contextual interference hypothesis: although group scores were similar at acquisition, the random group performed faster at retention. A possible explanation for the similarity between group performances at acquisition is differences between the single-day practice design and the three day practice design used here. In single-day designs and in the blocked group in Experiment I, block 6/acquisition occurred on the same day as all practice trials: there was no sleep-based consolidation interval (Duke and Davis 2006, Duke *et al.* 2006). However, the random group in Experiment I distributed their practice across three days, allowing some consolidation to occur before playing block 6/acquisition. This potential confound was addressed in Experiment II.

Notably, these results are also inconsistent with the snare drum task practiced in Rose (2006), perhaps due to the nature of the musical task. The clarinet stimuli were specifically designed to begin and end on tonic pitch. During the 18 trials, students cultivated an aural imprint of the task, and as automaticity progressed, it is possible this melodic component facilitated a pitch-to-finger mapping that was not possible in the non-melodic task.

The learning advantage exhibited by the random group suggests this practice strategy is beneficial for beginning clarinet students practicing short technical tasks, contrary to the drill-type strategies promoted in many beginning method books, practice software, and lessons.

Acknowledgments

Experiment I is based on the author's doctoral thesis, *Effects of Blocked and Random Practice Schedules on Performance by Beginning Wind Players*, University of Washington, adviser Steven M. Demorest.

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Imaging the music: A context-specific method for assessing imagery ability

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This study compared timing profiles of live and mental performances to determine if such an approach could provide a context-specific and objective indication of musicians' imagery abilities. Of further interest was how performance on this type of task may relate to scores obtained on standard imagery use and vividness measures. Thirty-two music students were recruited from the Royal College of Music (RCM). They first completed two imagery use and vividness measures, followed by two live and two mental performances of a two-minute extract of their choice. Following the generation of timing profiles for each performance, correlations were calculated within and between the two performance conditions. These were normalized by conversion to Z-scores and then compared with results obtained from the imagery use and vividness measures. While all participants achieved a significant correlation between the timing profiles from the live performance condition, only 17 did so within the mental performance condition. When comparing the timing profiles between the two conditions, 22 obtained significant correlations. Significant correlations emerged between the imagery vividness measures and Z-scores from the live performance condition, while amount of time spent employing imagery significantly correlated with Z-scores from the mental performance condition.

Keywords: imagery; mental skills; mental chronometry; performance science; music education

Prior to the development and implementation of mental skills training programs for musicians, it is necessary to generate an accurate assessment of their skills and abilities. However, assessment of musicians' mental skills, imagery included, is not straightforward. A number of self-report questionnaires for assessing imagery vividness currently exist, yet they have been criticized for lacking objectivity. In addition, research would suggest that imagery ability is comprised of three distinct features: vividness, controllability, and accuracy of reference (Denis 1991).

One potential alternative to self-report questionnaires employs temporal comparisons between live and mental performances, also termed mental chronometry, as employed by Repp (1999a, 1999b) and Wöllner and Williamon (2007). These researchers proposed that by removing sensory feedback during performance, insight could be gained into the strength and content of musicians' mental images. The use of chronometric comparisons between live and mental performances is also based upon work from human movement sciences which suggests that imagery processes are mediated by neuronal mechanisms similar to those used in perception (Mellet *et al.* 1998).

While previous research would indicate that musicians are capable of performing works with similar timing profiles across repeated performances, results derived from studies employing mental chronometry caution that there is variability among musicians' ability to perform such a task, particularly in the absence of kinaesthetic feedback (c.f. Repp 1999a, 1999b, Wöllner and Williamon 2007). Due to these varying results, musicians' ability to perform this type of chronometric task successfully is still somewhat unclear, as is the range of factors that may help or hinder their ability to do so.

Given the current state of understanding surrounding musicians' imagery use and abilities, this study sought to investigate the efficacy of a context-specific and objective method for assessing musicians' imagery abilities. In particular, timing profiles of live and mental performances were compared to determine if such an approach could be a valid indicator of imagery ability and vividness. Of interest was how performance on this type of task may relate to scores obtained on standard imagery use and vividness measures.

METHOD

Participants

Thirty-two undergraduate and postgraduate music students were recruited from the RCM. The sample comprised 11 men and 21 women, ranging in age from 20-28 years (mean=22.29, median=22.0, SD=2.20). In terms of the participants' year of study, 4 were year 1 undergraduates, 6 were in year 2, 14 were in year 3, 4 were in year 4, and 7 were postgraduates. For their instrument groupings, 7 were pianists, 9 were vocalists, 12 were string players, and 4 were woodwind and brass players.

Materials

In order to gain an understanding of the participants' previous experience with imagery and mental rehearsal, as well as their mental approaches to practicing and performing in general, a survey was developed to ascertain the types of mental activities in which the participants engage in relation to their musical activities. Participants were also asked to provide an approximate indication of the amount of time they engaged in each type of mental strategy or activity per week, how long they had been using the particular activities, and how skilled or effective they were in using each of them by rating themselves on a scale from 1-7, with 7="very skilled."

The randomized short version of Betts Questionnaire upon Mental Imagery was employed to assess imagery vividness (Betts QMI, Sheehan 1967). This is a 35-item self-report questionnaire in which participants are asked to rate on a 7-point Likert-type scale the strength or vividness of suggested sensory experiences, with 1="perfectly clear and vivid" and 7="no image present at all." Each of the senses is addressed, including sight, sound, taste, smell, movement, and interoceptive and exteroceptive sensations. As per the standardized instructions, participants were asked to imagine a particular sensory experience and then to rate the vividness of the image created. Responses are summed for a total questionnaire score as well as scores for each of the subcomponents. A lower score indicates a greater level of imagery vividness.

Finally, a mental chronometry task was developed with the aim of providing a contextually relevant, empirical measure of imagery ability that extends beyond self-report measures. The full procedure for this task is described below.

Procedure

Following completion of the survey and questionnaire, the participants were requested to perform a 2-minute extract of their choice that was at a public performance standard. The participants first gave two live performances of their chosen extract followed by two mental performances of the same extract, tapping a light metal object upon a desk to indicate the beats of the piece as they imagined themselves performing it. All performances, live and mental, were recorded using a Tascam portable stereo audio recorder.

Initial data preparation involved the generation of mean scores and standard deviations for the survey and questionnaire, as well as relevant individual items or subscales within them. For the mental chronometry task, the inter-onset-intervals (IOIs) for each of the four performances were extracted to produce timing profiles. Following the creation of timing profiles, similarity between the IOIs of the two performances within each of the two conditions was assessed using one-tailed Pearson correlations. One-tailed Pearson correlations were next used to assess the similarity of the IOIs between the two conditions. All correlations were normalized by conversion to Z-scores for use in further analyses with the imagery use and vividness measures.

RESULTS

When asked to identify the types of mental strategies or activities that the participants employed as part of their regular practice activities, imagery was identified most often (n=20 of 32). Of those who cited regularly employing imagery, they reported using it for an average of 25.95 minutes per day (SD=28.54), that they had been using it for 6.48 years (SD=5.87), and rated their effectiveness with imagery at 4.80 out of 7 (SD=1.28). Within this, the participants reported singing or hearing their music in their minds, memorizing music away from their instruments, and playing on a surface other than their instrument (or "finger practice").

For the Betts QMI, the participants obtained a total mean score of 89.66 (SD=26.09). The potential range for this questionnaire is 35-245, with a lower score indicating greater imagery vividness. The participants' ability to imagine sounds (auditory sub-component) and movements (kinaesthetic sub-component) were the senses achieving the greatest vividness on this measure, while the participants' ability to imagine smells (olfactory sub-component) achieved the least amount of vividness.

When considering the participants' performance on the mental chronometry task, all 32 participants achieved a significant correlation between the IOIs of the two live performances. When examining the mental performance condition, however, only 17 participants achieved a significant correlation. Comparing the IOIs between the two conditions, 22 of the 32 participants yielded a significant correlation between the two conditions.

Comparing the results from the different assessment measures (see Table 1), a significant positive correlation emerged between the amount of time per day that the participants reported employing imagery and their ability to perform consistently within the mental performance condition. A significant positive correlation also emerged between the participants' self-rated ability to engage in imagery and their ability to give multiple temporally similar performances within the live performance condition. A link between imagery vividness and ability within the live performance condition was also found with the Betts QMI. The normalised Z-scores from the live performance condition achieved significant negative correlations with total scores from the

Table 1. Significant Pearson correlations between the Z-scores derived from the mental chronometry task with the imagery use and vividness measures.

	Live performance condition	*Mental performance condition*	*Between conditions*
Imagery: Mins. per day used	0.31	0.46*	0.07
Imagery: Self-rated ability	0.42*	0.36*	0.25
Betts QMI Total score	-0.35*	-0.01	-0.13
Betts QMI Auditory	-0.54**	-0.06	-0.14
Betts QMI Visual	-0.40*	-0.10	-0.02
Betts QMI Gustatory	-0.36*	-0.13	-0.23

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Betts QMI as well as the subcomponents of visual, auditory, and gustatory imagery. As lower scores on the Betts QMI indicate greater levels of imagery vividness, negative correlations indicate a promising connection.

DISCUSSION

For 63% of the participants, imagery formed a significant part of the practice activities. Within this, auditory and kinesthetic imagery were the senses for which the participants reported the greatest amount of vividness. Within the mental chronometry task, while all participants were able to give two performances of comparable timing profiles within the live performance condition, some musicians were less able to do so with the removal of sensory feedback in the mental performance condition, supporting results from previous investigations of this type. Based upon examination of the results from the three assessment measures, the three scores derived from the mental chronometry task appear to provide an indication of either imagery vividness, controllability, or accuracy of representation, supporting the proposal that imagery ability is comprised of three distinct features (Denis 1991).

Possessing high levels of vividness and control over their imagery should be of great importance for musicians, and while previous research would suggest that greater imagery ability facilitates enhanced performance quality (McIntyre *et al.* 2002), this link within music needs to be explored more fully. Having reliable methods for accurate assessment of imagery ability is central within this. Lastly, these findings support recommendations for the use of a mixed-methods design when assessing musicians' imagery use and abilities, with a mental chronometry task such as that employed here adding an element of objectivity to these investigations.

Acknowledgments

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Learning to play double bass by stimulating mental imagery

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It is well establish that mental simulation of movements has beneficial effects on learning and rehabilitation of a large range of gestures. Dot pattern videos were found to be of great efficiency to stimulate mirrors neurons because they stimulate dorsal pathways more than standard video recordings. Until now, these effects were mostly reported in the domain of sports or medicine. Only a few studies attempted to generalize them to music. The purpose of this study was to optimize the learning of double bass in beginner children (mean age=8 years) with a new method that encourages mental simulation of basic movements of the right (bow) and left hands of double bass players. The improvement in performances in children was also documented with a light motion capture device that tracked several parameters of the bow speed and right arm movement. Eight children who had recently begun studying double bass at the conservatory in Dijon used a traditional method consisting of 24 lessons (one per week) accompanied with a DVD. The DVD contained a set of 24 imagery training sessions, each being associated with one lesson. Each week, the children completed approximately ten mental imagery exercises displayed on the DVD. These exercises were designed to boost associations between movement-audition, movement-sight reading, and movement-musical expression. All videos were made with dot patterns methods. The improvements of the child were followed by registering the number of errors made for the mental imagery exercise and by capturing the evolution of their motor performance on the double bass with a light motion capture device, easily transportable to the conservatory. The device allows the measurement of velocity, acceleration-deceleration of movements, as well as the online changes of the angles formed by different parts of the arm.

Keywords: mental imagery; mirror neurons; music learning ergonomics; developmental psychology

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Thematic session: Perceiving performance

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Computer assisted analysis and display of musical and performance data

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The coordinated storage of performance data in such a way that it can be used across multiple projects is problematic: general purpose systems that can store gestural, score, and other performance data are not generally available. Using data from current projects, we aim to provide a unified database that can store and present a musical score alongside associated performance data and musical analysis. Using a general purpose representation language, Performance Markup Language (PML), aspects of performance are recorded and analyzed. Data thus acquired from one project is made available to others. Presentation involves high-quality scores suitably annotated with the requested information. Such output is easily and directly accessible to musicians, performance scientists, and analysts. We define a set of data structures and operators that can operate on musical pitch and musical time, and use them to form the basis of a query language for a musical database. The database can store musical information (score, gestural data, etc.) and audio/video artifacts. Querying the database results in annotations of the musical score, potentially augmented with audio/video selected from stored performances. Two demonstrations are provided: an analytically-based query and a performance-gesture-based one. In the former, dissonant notes/intervals are identified in a performance of a Bach two-part invention. The score is then graphically annotated to indicate the performers' mean inter-onset intervals in the neighborhood of these features. In the latter, a score of a 19-ET microtonal song is displayed, annotated with the deviation in the soprano's pitch from that notated. The database is capable of storing musical score information and multimedia recordings and cross-referencing them. It is equipped with the necessary primitives to execute music-analytical queries, and highlight notes identified from the score.

Keywords: music information retrieval; visualization; performance analysis; score analysis; database

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Gestural communication: Linking multimodal analysis of performance to perception of musical structure

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A two-tiered experiment was conducted to assess the communication of phrasing structure from performance nuance to audience perception. Nine solo piano performances of two selected Chopin preludes, comparable in musical structure and complexity, were recorded multi-modally through audio, MIDI, and the Vicon motion capture system. Analyses of performance parameters such as tempo, dynamics, and movement were then conducted with reference to the notated score. Videos of each performance were presented to observers with musical knowledge who used a slider to determine the shape of each musical phrase. Having previously been presented performances in visual only mode, participants were now presented the performances in three modalities: visual, audio, and audiovisual. Further to findings that occurrence of performance gestures correlated with notated and perceived phrase boundaries, multimodal analysis of performance parameters confirmed that performers conveyed musical structure as intended in auditory as well as visual elements of performance.

Keywords: performance analysis; music perception; multimodal interaction; musical structure

In a western classical music performance, the performer uses certain expressive functions to communicate features of the notated score and highlight interesting points throughout the course of the music. Research in music performance has acknowledged that this musical experience is multi-modal and that musical information is contained not only in the aural but also the visual stream (Davidson 1993, Wanderley 2001). Cross-modal interaction in the perception of structural features within a piece of music have shown, for clarinetists' performance, that the visual stream can help to better decode the information presented in audio-visual instances (Vines *et al.* 2006). Previous research by the authors has focused solely on this visual information in piano performance, particularly as performers do not require the physical act of breathing between phrases. A relationship between overall performer gestures and phrasing structure of the written score was demonstrated (MacRitchie *et al.* 2009). This research aims to investigate the multi-modal information contained within piano performances of two Chopin preludes and to discover the relative contributions in terms of musical perception.

METHOD

Participants

Nine highly trained pianists from the Royal Scottish Academy of Music and Drama and the Universities of Glasgow and Edinburgh were recorded playing the selected preludes. They were paid a one off sum of £25. Fifteen musically knowledgeable audience judges were recruited by email from the University of Glasgow and local orchestras. They were paid £6 per hour for participation.

Materials

The two test pieces performed were Chopin Preludes Op.28 No.7 in A major and No.6 in B minor. *Prelude 7* was chosen as a control piece across performers as it comprises rhythmically repeating 2-bar phrases. *Prelude 6* is slightly more complicated, as it contains expanded phrases and changes in rhythm; the opening 2-bar phrase of each prelude is shown in Figure 1. Eighteen "audience-perspective" recordings were used to generate 56 perceptual stimuli comprising two practice performances by a tenth performer and presentations of each prelude by the nine performers in three modalities: visual only (VO), audio only (AO), and audiovisual (AV). Presentation stimuli were ~40 s each in duration for *Prelude 7* and ~90 s for *Prelude 6*.

Procedure

Nine highly trained pianists performed the two preludes on a Roland RD-150 88-key weighted keyboard and were recorded through audio, MIDI, and motion capture. Passive markers were attached to the upper body and head via a cap and jacket worn by all performers. Performers were required to perform the preludes as they would in a normal concert setting. Performances were also filmed from an audience perspective. The 56 "audience perspective" performance stimuli were presented to 15 audience participants in AO, VO, and AV modes across two sessions. Participants were initially presented with

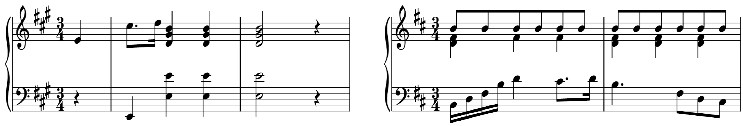

Figure 1. Opening 2-bar phrase of Chopin's Prelude in A major Op.28 No.7. (left) and Chopin's Prelude in B minor Op.28 No.6 (right).

the VO stimuli and asked to shape the phrasing structure of each performance using a slider bar moving from left-right-left as the phrase was shaped. They were then presented with the stimuli in all three modalities, and the task was repeated. Stimuli were presented in randomized order to avoid order effects.

RESULTS

Performance Analysis

Estimations of tempo, dynamics, and motion were taken from the MIDI, audio and motion streams, respectively. Performed notes were matched to the score notes using "performance markup language" and matcher (described in McGilvray 2009). Queries on note information were returned by the Pullinger database (Pullinger 2009). The inter-onset intervals (IOIs), normalized to a quarter note beat, were divided by 1/60 to give an estimation of beats per minute. Dynamics were estimated by the RMS amplitude of the signal. 2D motion curves were extracted by performing principal component analysis (PCA) of all markers and adding the weighted components. Figure 2 shows audio, MIDI, and video data plotted against phrase boundaries as they occur in the audio. To allow direct comparison across performers, all data was time-warped with respect to the occurrence of phrase boundaries in the audio. Distances to the nearest troughs in dynamics and tempo curves were extracted for each phrase boundary. Distances from either troughs or peaks were extracted for the motion curves depending on each performer's movement patterns. Two-way Analyses of Variance (ANOVAs) showed significant effects of both performer and phrase number on motion norm ($F=3.56$, $p<0.001$ and $F=6.63$, $p<0.01$) and a significant effect of performer on dynamics ($F=5.78$, $p<0.001$) and of phrase on tempo ($F=37.24$, $p<0.001$). Other effects were not significant. This suggests performers have a distinct motion style varying between phrase boundaries and that they differ in their use of diminuendo. While performers may not vary how they use ritardandi, this is varied between phrases. Two-way ANOVAs for the first three phrases of *Prelude 6* also demonstrate a significant effect of performer on motion ($F=12.85$,

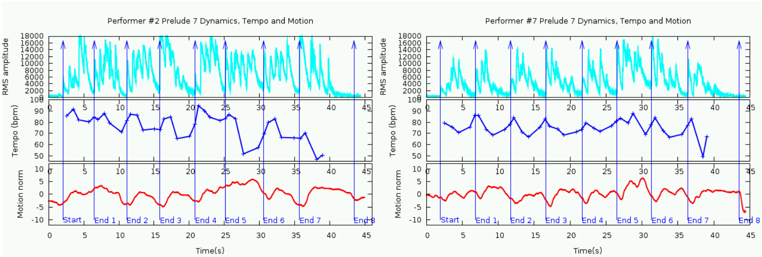

Figure 2. RMS amplitude (top), tempo (middle), and motion norm (bottom). Variance weighted average of principal component scores of motion markers against phrase boundaries (blue vertical arrows) for performances of *Prelude 7* by performers 2 and 7.

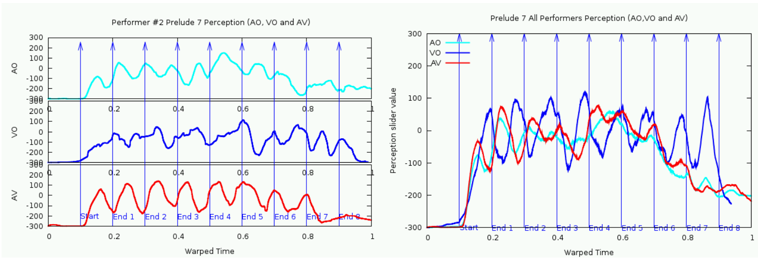

Figure 3. Comparison of responses by all participants for all three presentation modes. Troughs indicate perceived phrase boundaries, vertical lines indicate phrase transitions. (See full color versions at www.performancescience.org.)

p<0.001). The significant effect of phrasing on dynamics (F=17.98, p<0.001) may be due to changes in phrasing structure in phrase 3. Parameter extraction at phrase boundaries gives an indication that the data streams are varying similarly to *Prelude 7*. However, further investigation into the continuous data streams and their correlations is required.

Perceptual analysis

Participants' slider responses were time-warped with respect to the occurrence of phrase boundaries in the audio stream. Time locations of perceived phrase endings were averaged across participants. Participants were surprisingly skilled when judging phrasing structure of *Prelude 7* in the VO condition, with eight clear phrases appearing for all performers. Perceived phrases occurred after the auditory phrasing boundaries and closely follow the per-

Table 1. Three-way ANOVA for factors presentation mode, phrase, and performer.

Source	*SS*	*df*	*MS*	*F*	*p>F*
Presentation mode	0.3374	2	0.1687	239.48	p<0.01
Phrase no.	10.6658	7	1.52369	2162.94	p<0.01
Performer	0.0426	8	0.00533	7.56	p<0.01
Mode x phrase	0.0464	14	0.00332	4.71	p<0.05
Mode x performer	0.0760	16	0.00475	6.74	p<0.01
Phrase x performer	0.0279	56	0.0005	0.71	0.9238
Error	0.0789	112	0.0007		
Total	11.2751	215			

formed motion trajectories (Buck *et al.* 2009). Comparison of presentation modes reveals large differences in the second section of *Prelude 7* between AO and VO modes (Figure 3). Phrasing judgments in the AO and AV conditions precede phrase boundaries, most likely with judgments being made as a cadence is recognized and the final phrase note is played, rather than when the sound diminishes and the true phrase ending occurs (Figure 1.). Spearman's rank correlations of perceived phrasing reveal extremely high correlations between each presentation mode, the largest being between AV and VO conditions (0.985, $p<0.01$). A 3-way ANOVA of performer, phrase number, and presentation condition revealed significant effects of all three factors and interactions between presentation mode and phrase number, and presentation mode and performer (Table 1). Individual analyses of presentation modes indicate these differences to lie between the VO condition and the AV and AO conditions. The significant effect of presentation mode ($F=239.5$, $p<0.01$) and interaction between mode by phrase ($F=4.71$, $p<0.05$), and mode by performer ($F=6.74$, $p<0.01$) corresponds to the difference in playing style, particularly where performers vary differently in tempo and dynamics in phrases 6 and 7. Initial analyses of *Prelude 6* responses support findings for *Prelude 7*, with participants demonstrating clear phrasing structure for the initial three phrases in all modalities. The timing differences across modalities are consistent with those found in *Prelude 7*.

DISCUSSION

Performance analysis of movement, tempo, and dynamics reveals differences between performance styles that are relative to a performer's individual interpretation of the music. These performance differences are still conveyed to and understood by an audience, assisting with clear recognition of phrasing structure. Audio information within a performance appears to communicate a deeper level of structural information. This is seen in the similarity between tempo and dynamics analysis with the AO audience phrasing judgments, where phrase boundaries are perceived to occur slightly before the actual phrase ends. The visual aspect of performance provides clear phrasing structure through movements that extend beyond the actual sound, exaggerating the shape of a phrase and so assisting the audience in their interpretation and understanding of the musical structure of the piece in hand. When combined, these visual and auditory elements produce a global effect whereby the audience is able to understand better the musical structure as well as interpreting the weighted importance of the various parts.

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Music performance venues: Keeping them in tune with modern requirements

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Throughout the history of music composition and performance we can perceive a strong link between compositional style, the qualities of places where composers imagined their music would be played, and the instrument technology of the age. We must examine whether modern listening preferences are now being shaped by the capabilities of modern recording technology to the point where it is no longer possible to satisfy these in a live performance venue using a passive design (i.e. non-electroacoustical). The results of a survey of music listening habits and preferences imply that live-performance venues should respect an "originality" criterion and not impose features on a performance which are inconsistent with the architecture and technology of the era (or intention) of the composer.

Keywords: acoustics; electro-acoustics; concert hall; listener preference

Over the last 15 years or so we have seen a maturing—and hence an increasing acceptance—of electro-acoustical techniques for varying the acoustics of music auditoria (e.g. Poletti 1994). However, it must not be assumed that providing a sound field via an active (i.e. electro-acoustical) technique will be as acceptable to listeners as the same sound field provided by a passive (i.e. purely mechanical) technique.

The first major use of an active system was in London's Royal Festival Hall (RFH). Peter Parkin's "assisted resonance" (Parkin *et al.* 1964) was conceived as a solution to a specific shortcoming in the hall which is a dedicated *concert* hall, and there was considerable disquiet among musicians and concertgoers at the thought of loudspeakers being used in auditoria. However, it was obvious that the active hall concept offered—in principle—the perfect answer to the needs of a *multi-purpose* hall. Such multiple-use halls could be built to have—passively—the low reverberation time (RT) suitable for speech (and small-group music performance) and be equipped with an electro-acoustic system to be switched in to provide the longer RT's required for choral and symphonic works. This approach avoids acoustical conditions that are a compromise and, compared with attempting to provide a comparable change in acoustics by passive mechanisms, offers the advantages of economy, ease, and speed of operation. However, in these situations the active contribution to the sound field becomes very audible and significant (compared with the subtle change produced by the relatively small corrective action of the original Assisted Resonance system in the RFH). Hence listener acceptance of the subjective sound becomes critical.

One would hope that active technology, which epitomizes the technology of our era, will be seen by musicians and composers as a proper element to be incorporated in their creative works as a new artistic dimension, just as in the past new musical instruments, made possible by technological development, have been adopted and become the basis for new composition.

Modern recording and "mixing" practices are introducing features into music production that confound the idea of a traditional live performance. By adding differing amounts of acoustical qualities like distance, echo, and reverberation to separate performers in a recording, the recording engineers are putting the performers in what our instincts (shaped by passive acoustic experience) would interpret as different auditory scenes. Yet the modern listener accepts the result as a unified performance. Thus, there must be changes to our perception of the nature of performance. We must relinquish our concept of music *ensemble* as something necessarily mediated and unified by the singular acoustics of a performance venue.

All this puts the acoustical designer in a difficult situation. What should modern venues provide? Can active systems (those that are available) offer the variability and flexibility that might be needed in a modern performance venue and do so with a sound quality that will satisfy? Since modern trends in recorded music and reproduction systems are providing sound fields in the home that cannot be matched in passive halls, is it still valid for us to assume that today's listeners still wish to go to public performances in traditional concert hall acoustics rather than listening at home to the "engineered" sound from a mixing desk? Further, if we were to consider carrying out experiments with listeners to try to establish criteria for active sound fields this would assume that there are preferences regarding active sound fields *already inherent in our listeners*. However, if listeners are truly being presented with extensions of their listening experience, then a learning and acclimatization period will surely be required, or we risk these being rejected as merely distortions or perversions of familiar passive sound fields. This period will need to be long enough for our perceptions and appreciation (and consequently *acceptance*) of these new sound fields to evolve.

So, in thinking about the design of new spaces for public performance which are likely to include active features in their realization, we should question how new technology is influencing the habits and preferences of listeners and, even, whether public performances are what the music consumer really wants.

METHOD

Procedure

To attempt to find answers to some of these questions, a survey of people and their listening behavior was initiated (Dodd 2001). Since one of the questions being investigated was whether listener habits and preferences are evolving with time, it was clear that the survey needed to be longitudinal. As it was not possible to predict the timescale required to track significant changes, a decade was chosen as the minimum period over which to monitor listeners.

Participants

Respondents were selected to: include a representative cross section of the populations surveyed (young, old, concertgoers, non-concertgoers etc), have some matched groups that were nominally similar each year, and include cohorts from France and New Zealand.

Materials

The survey used a questionnaire about respondents' recall of their patterns and preferences when listening to music and included "thought experiments" where they were asked to make certain choices and then give reasons to explain their decisions.

The questionnaire was constructed to answer the following questions: (1) is listening to music important in people's lives, (2) are listening habits evolving/changing, (3) is there evidence of changing attitudes toward electroacoustical systems or instruments, (4) do people prefer listening to live performances rather than recordings and, if so, why, and (5) how many discernibly different sub-groups/types of listener can we identify.

Three final questions (questions 9, 10, and 11) aimed to collect information that could be used in the development of variable acoustics systems for auditoria. This included finding out about attitudes to live performance and the possible reactions to the introduction of electro-acoustical elements in performance venues for live classical music.

RESULTS

The importance of listening to music

Approximately 30% of respondents described music as being essential for their lives. A notable difference emerged between New Zealand and France in the percentage that described music as a major factor of life (60% in New Zealand and 75% in France)

The choice between a live performance, recorded performance, and simultaneous broadcast

Respondents were asked to indicate a choice between identical performances in either a live, recorded, or simultaneous broadcast performance where the experience of both the live and the recorded performance would happen in exactly the same venue. The intention was to focus respondents' thoughts on those features that differentiate the live performance from the recorded performance. The responses showed unequivocally that, other things being equal, a large majority—around 90%—of people would choose a live performance over a recording. The most frequent reason given for preferring a live performance is "atmosphere" or "ambience." This was cited by 45% of respondents who chose live over recorded music. In second place is "communication with the performers," a reason given by 15% of the group.

The use of loudspeakers in live performance

Question 10 was formulated to focus on the issue of the acceptability of loudspeakers in live performances of music where the original instruments for that music are ones that radiate purely mechanically produced sound. Respondents were asked to choose between an organ recital on a pipe organ compared with the same recital on an electronic organ (assuming it to be of the highest in sound quality). The responses showed a large majority (75%) choosing a traditional organ over an "electronic" organ, a strong indication that we might expect a continuing dislike for the introduction of loudspeaker-based systems for fashioning the acoustics of auditoria.

The most frequent reason given (accounting for 25% of respondents) for preferring a traditional organ was "truer sound." The other main reasons (accounting for 44% of respondents)—"aesthetics," "tradition," and "authenticity"—make the case clearer. These cannot be linked to measurable features of the objective sound and, hence, cannot reflect on the *performance* of the electro-acoustical components. We thus conclude that *consciousness of the substitution* of electro-acoustical elements, in what originally would have been a totally mechanical chain of sound production, transmission, and reception, is a determining factor for audiences. This could explain the opposition that is encountered toward the concept of active auditoria.

The demand for live performance

A comparison of the result from question 9 (which showed a large 90% preference for live performance) with the data that respondents gave on their listening patterns indicates that there is a large discrepancy between how people would prefer to listen to their choice of music and how they actually do. However, the answers to question 11—where the option of listening at home was deliberately included in the experiment—confirm that there *is* an unsatisfied demand for live performance.

DISCUSSION

The reasons given in the responses to the experiments of questions 9 and 11 provide some clues for designers of live performance venues. We should be conscious of optimizing for listeners those features that will attract them to live performances. Obviously, non-acoustical features will contribute also (e.g. sight lines, seat comfort, visual aesthetics, and ease of access to the bar during the interval), but our focus here is on acoustical issues.

Foremost in importance is the promotion of “atmosphere.” However, the second most common reason given for the superiority of a live performance—“communication with the performers”—can immediately be linked to acoustical performance. What is implicated here is whatever characterizes the difference between the communication happening when listeners hear instruments directly and the communication happening when they hear them via a recording. Clearly there is communication from performers to listeners taking place in both cases, but respondents seem to sense that at a live performance they also communicate *back to the performers*—i.e. a two-way communication is inherent in the live performance.

This two-way communication is at its most obvious during periods of applause but one suspects there are other, less overt (as well as non-acoustical) ways in which the audience transmit their “vibes” back to performers. Thus an optimized venue is one that maximizes this sense/feeling of two-way communication for the audience. For passive venues this is—acoustically at least—automatic. Transmission is identical in both directions because of the principle of acoustical reciprocity. However, in an active auditorium, the use of amplification channels will—in principle—remove reciprocity.

Thus, when including active acoustics in venues and wishing to respect the preferences of our audience we must choose those systems that try to retain reciprocity for the communication path between performers and listeners. The types of system that use microphones to pick up the direct sound from performers, and loudspeakers arranged to radiate their processed signals primarily as direct sound to the listeners (hence described as in-line systems), have nothing to recommend them in this respect. Other systems (so-called non-in-line) place their transducers remotely from performers and are effective in reverberating the sound from both performers and listeners. This suggests that non-in-line systems should—wherever possible—be selected in preference to in-line systems.

However, if new music, electro-acoustical musical instruments, and recording practices change listener expectations and preferences we may be unable to meet these expectations with traditional design approaches using "non-in-line" active assistance. Ultimately, it may require that venues for live performance be constructed as anechoic spaces so that passive acoustics do not compromise the engineered sound from the performers. Transmission to the listeners will then be achieved by the ultimate in-line system, with the "sound engineer" becoming as much a player in live performances as the musicians.

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Keynote paper

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The dominant artistic discourse as a health determinant

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This paper examines how elements of different discourses are appropriated or resisted by artists and the effects on health and wellbeing. More specifically, the results of a series of ethnographic studies—conducted with professional dancers, choreographers, rehearsal directors, and students in different contemporary dance settings in Montreal—are presented. Although aesthetic and ethical issues based on grounded empirical material in dance are discussed, many ideas can be transferred to other performing art forms. Vocation or passion for the arts is often presented as an explanation for why artists jeopardize their health and accept difficult working conditions. However, these studies demonstrate that the dominant discourse in the performing arts, which values the supremacy of artistic work and the surpassing of one's limits, is at the top of a long chain of decisions that negatively impact artists' health. Unless all participants in the dance milieu, individually and collectively, critically address the different discourses and their embodied "truth," positive changes in dancer's health and wellbeing will remain limited.

Keywords: health; dance; passion; discourse; aesthetic

This article presents some conclusions of my latest research on the socio-cultural dimensions of health as it relates to the artistic practice of dance. During the last six years, my research assistants and I have conducted a series of studies with more than 100 professional dancers, choreographers, rehearsal directors, and students in different contemporary dance settings in Montreal (Fortin 2008). We conducted individual interviews and engaged in participant observations of dance training and rehearsals, which provided us with rich, grounded material that we analyzed qualitatively. We also obtained data from self-report questionnaires, which we analyzed quantitatively. Moreover, we initiated an action research to deepen our understanding of how dancers conceptualize their health and the impact on their performing practices and vice versa. Although my research pertains to dance, I believe that many ideas can be transferred to other performing art forms.

Adopting the epistemological claim that individuals construct "reality," my research is part of a growing body of literature on how diverse cultural groups conceptualize their health differently. More specifically, I look at how artists construct themselves and are constructed in many ways by various, and sometimes competing, discourses. According to Foucault (1963), discourses are composed of ideas, attitudes, beliefs, courses of action, and practices that enable, as much as they constrain, what can be said or done in particular times and places. Discourses construct current truths and what power relations they carry with them.

For example, the dominant Western health discourse posits individuals as being primarily responsible for their own health. This discourse implies constant surveillance and auto-surveillance, encouraging individuals to avoid risk and to adopt safe behaviors such as not smoking or eating junk food. Critics of this discourse say that personal body maintenance is promoted to reduce the economic burden on public services, and ultimately, it undermines social responsibility to improve health and wellbeing. Assuming that individuals will act in their own self-interest is also problematic since individual health is often subject to external forces (Crawford 2006).

MAIN CONTRIBUTION

A delicate balance between dominant discourses

This idea is corroborated by dance research that shows how dancers privilege the integrity of the art form over their own safety. Whereas ballet and contemporary dance can differ in their underlying assumption about the body, the contemporary dancers in our sampling tended to align themselves with the dominant discourse of Western theatrical dance that promotes an ideal body where aesthetic criteria of beauty, slimness, virtuosity, devotion, and asceticism prevail, and where fatigue, pain, and injury are accepted silently (Laws 2005, Sorignet 2004, Wainwright *et al.* 2005).

When questioned about the relationship between health and dance, performing artists in our research relegated the former to a backstage role, valuing pushing the limits of the art form and expanding individual skills sometimes beyond reasonable limits. The artists we interviewed regarded dance as a "risky endeavor," since dance-making involves "seeking innovation," and this invariably "damages the body." Thus, we concluded that dancers appropriated certain elements of both the contemporary dance discourse, which assumes a certain risk associated with innovation, and the dominant health discourse, which preaches physical self-discipline and the avoidance of risks.

Individual responsibility and spread-out guilt

Without exception, all the artists considered themselves as "healthy but damaged." They did not feel that their current and past injuries conflicted with their sense of being healthy, since being healthy means "being functional"—that is, being able to respond to the choreographic demands. To this end, dancers employed various strategies to "prepare, protect, and repair" their body. They attributed failure to themselves and consequently felt guilty, telling themselves they could have had "better concentration," "warmed-up or trained more," "stopped dancing earlier," "eaten better, slept more," etc. Confusion and uncertainty regarding the effectiveness of different options sometimes engendered what seems to be an endless search for ways to heal injuries and to relieve pain and psychological distress.

Individual guilt has been related to the dominant health discourse, which is driven by a focus on the individual's responsibility and which minimizes socio-economic and political factors (Lupton 1995). Although some dancers spoke out against low income, unsecure employment, and difficult work conditions (e.g. additional rehearsals before shows, freelancers' fatigue from holding down two jobs, inadequate studios, tight schedules aimed at minimizing touring costs, etc.), they rarely acted to counter these issues, which is not surprising in a competitive and small work environment. In this context, the likely result of complying with the dominant health discourse is that collective mobilization of dancers around health issues is restricted.

Divided about unionization

In Québec, most dancers are freelancers. Bringing them into a worker union was initiated ten years ago. Some individuals regarded union contracts as a way to improve working conditions and better health for dancers. For others, the legislative framework constituted a threat because, for them, it had a stifling effect on the creative processes which need to come out of "disorder, disequilibrium, and instability." These artists revealed a profound attachment to this dominant artistic discourse that they considered to be incompatible with their perception of regular disciplined and ordered workplace environments. As such, they were reluctant to take on the employer-employee etiquette, and they did not like the term "cultural industry" because their motivation to dance is aesthetic rather than economic. Choreographers did not like to think of themselves as employers, although all of them are leading their own dance companies. Many mentioned preferring to be called creators rather than choreographers.

The process of unionizing dancers indirectly summons the dance community to take a critical attitude to the concept of individual responsibility for health, and calls into question such firmly-grounded dance milieu values as the normalizing of pain and the acceptance of precarious working conditions as being commonplace. Dance artists' narratives reflected a low propensity to push collectively for change, which might encourage governments and agencies to keep investing so little in the arts, and this eventually has consequences on artists' health. In our opinion, to improve the state of health of dance artists there must be a critical analysis of the cultural, social, and economic contexts in which dance is situated.

Money and health: Myth and reality

In our interviews, many addressed the issue of the financial health of the dance milieu, which in Canada (as in many other countries probably) suffers from chronic under-financing. But can it really be said that increasing funding to dance companies would directly improve dancers' health? On one hand, yes, since the equation money=health is verifiably true. For example, all the artists raised the negative impact on their health of substandard rehearsal studios and theatres. On the other hand, however, no, because injuries and suffering are not solely due to financial conditions. Aesthetic choices often take precedence over health considerations. From our analysis, we concluded that having more funds does not necessarily mean that more is spent on health.

Worthy of note is the case of a choreographer whose assumption of responsibility for his dancers' health was shown in the partial financial support he provided for their training and therapeutic treatments. The same person, however, disavowed responsibility by pushing his dancers to extreme limits, leaving the "protection" of dancers' health up to the rehearsal director and the dancers themselves. He confided to us: "the choreographer's intention is to present something striking on stage. I require dancers who can impel this idea, and there are no limits to this. As the choreographer I have all the rights." This is an attitude that even this choreographer considers extreme and problematic. To us, dance development cannot rest on the acceptance of excess, unless specific occupational health and safety conditions are implemented. Improved financing is one of the means for preserving both the dancers' health and the choreographer's vision; but what is also needed is a critical examination of the dominant artistic discourse which overvalues the individual artist exceeding his/her personal limits. Clearly, changes require that sufficient financial resources be made available; nonetheless, many transformational strategies depend more on relationship skills or involve aesthetic compromises that all concerned are unwilling to accept.

Methods of creation as central to aesthetic and health issues

In their creative work, many choreographers asked the collaboration of the dancers who actively participated in the development of the dance. We asked if this supports the dancers' health and wellbeing. One choreographer's point of view was: "I work based on the actual state of the dancers' bodies; the movements are not imposed on them from without. I always tell them that it is they who must choose their tortures [laughing]." In certain cases, it seems likely that creative collaborative method means a sharing of health responsibilities between choreographer and dancers. However, often there is a gap between the egalitarian intentions of the choreographer and the actions that should, in principle, follow. It must be noted in defense of the choreographers that sometimes dancers themselves willingly submit to situations that negatively impact their health. As a result of a long and complex process of integrating the dominant discourse in dance, artists have internalized the ways of thinking, seeing, and acting that lead to an overarching devotion to the art form. As Rannou and Roharik (2006) note, collaborative methods of creation may often be even considered as the "ultimate form of self sacrifice" (p. 181), which is something artists value in conformity with the dominant dance discourse.

Another example of a problematic approach to choreography was revealed in those instances when the creative process involved intentionally fatiguing the dancers in order to have them reach a state of vulnerability and exhaustion. Some choreographers and dancers believed that this helped to bring the dancer's subconsciousness to the fore, thus providing richer material for the piece. However, this strategy was not always explicitly stated, and agreed upon by everyone. For health concerns to become an integral part of collaborative type work, artists need to develop better communication skills.

Silence as a risk factor

In dance, women outnumber men, which results in a competitiveness affecting all aspects of their professional life. Often women have had a longer socialization process than men and they have deeply embodied "a culture of silence." Playing down the experience of pain becomes an implicit norm in a professional dance career, since expressing pain may have negative consequences. The following comments of an experienced dancer speak directly to this issue:

> At the outset, the choreographer accepted or seemed to accept the situation [injury during the creative process]. After two weeks, he became pretty angry and made a big fuss about it. I started to say "I'll be able to do it later, the injury will have healed, but right now I can't do it." I wanted to explain, but he wouldn't listen to anything from me. The choreographer's attitude is really important. It's a constant struggle to have the freedom to speak your mind. It's not easy because I get sidelined. Even with all my experience. Emotionally it's very difficult.

Our interviews with both choreographers and dancers suggested a "virtual blacklist" of choreographers to avoid if a dancer values his/her health. But no one revealed their names; the milieu is small, and secrets remain kept. As mentioned, some choreographers profess to be very open-minded, and deplore the fact that sometimes it is the dancers who do not want to disclose their health conditions, but other choreographers maintain an absolute aesthetic bias and want to know as little as possible about their dancers' injuries. This is not inherently a problem when the responsibility is passed on to the rehearsal director, who has been described unanimously by both choreographers and dancers as being the "critical outside eye essential to the work and the health of the dancers."

All in the name of art

Choreographers, driven by the vision of their gestating choreography, are the first to admit being more attuned to their artistic vision than to the physical needs of the dancers. The idea that a choreography takes on a life of its own and that it is the choreography itself that indicates the necessary creative decisions, could often be discerned from choreographers' comments. "I am God when I am creating," said one choreographer. "My role is to create a world in my own image. There are no limits to this. I tell my dancers that I, as the choreographer, have all the rights. I may ask them to jump from the fourth floor window, and if they're crazy enough to do it, that's their problem; but that won't stop me from telling them to do it." Such a view of art as an egotistical sacred endeavor provides justifications for the aesthetic decisions. Giving predominance to the dance being created and according a messianic status to its creator has repercussions on the health of dance artists. In an ideal situation, both dancers and choreographers share the satisfaction of surpassing physical and psychological limits. It is not our intention to create a tension between choreographers and dancers, but the fact remains that it is the dancer who, to a greater extent, suffers the physical consequences of the risks, while it is the choreographer who receives the recognition for the work's originality.

It is worth mentioning that for choreographers and dancers, dedication to their art form can involve both alienation and exhilaration. In our research we did not focus on the latter, although there was touching commentary about how the making of dances enriches one's life. In one of our studies, we assessed the degree to which dance is part of the person's identity, and as Wainwright *et al.* (2005) posit, we can say, too, that dance "is not just something that you do, in a very deep sense it is who you are" (p. 49).

Health and ethical dimensions

That dancers give life to the choreography is an idea often expressed in the dance literature; less so is the notion that choreographers participate in molding dancers' bodies (Dantas 2008). During our interviews one choreographer remarked: "I constantly put my dancers in an uncomfortable situation; so where is the boundary between making an effort and going too far? Between injuring one's body and being violent to oneself?" The question of "exceeding the limits" perhaps takes on lesser significance in other art forms because in dance it is the dancer's body that is at stake. As a dancer put it, "a painter will look at his canvas and wonder if the good colors are correct, but the canvas will not ache the way we dancers do."

Interestingly, a denunciation of human injustice forms the subtext of many choreographies, but in our observations of different creative processes, we sometimes noted a lack of consideration for the health and wellbeing of the performing artists who give tangible form to the work. Jackson (2008) explains that there is a tendency in the dance world to correlate good products (choreography) with good processes and good people (choreographers, dancers, rehearsal directors), as if no dichotomy could exist between the moral dimensions of a choreography and the people that engendered it. If someone appears to have been mistreated, or if an artist is shown to have acted immorally, this is viewed as an exception or as necessary for the sake of art. Health poses a huge challenge for choreographers who have the pressure to create original work that meets the assessment criteria of grant agencies. Can health advocates expect that one day grant agencies will require dance companies to deal comprehensively with aspects of occupational health and safety, or that soon dance schools and dance organizations will seriously engage in health-promotion? I hope so because, if the dance profession does not rise to the challenge, it may come to be regarded as irrelevant by educationists, decision makers, and the public alike.

Harmonious or obsessive passion

In the dance literature, passion and a sense of calling is frequently used to explain why dancers accept the physical suffering or psychological distress they often experience (Turner and Wainwright 2003). "Being on stage requires many sacrifices, such as dancing with an injury," as an experienced dancer explained. "Doing this makes no sense at all, but you don't think about it. Great passion is involved." But from our results, it seems that, more so than passion, it is the dominant artistic discourse that drives a long sequence of health-related decisions.

In our analysis, we differentiated the dominant artistic discourse from the passion with which artists endorse this dominant discourse. In a quantitative study with pre-professional dancers, we looked at whether dancers exhibit distinct injury profiles as a function of their passion for dance. We distinguished harmonious passion—which occupies a significant place in one's identity but is not overwhelming and leaves room for other life pursuits—from obsessive passion, which consumes one's thought and overwhelms one's identity. We found that obsessive passion for dance was associated with dance-related injuries and prolonged suffering from chronic injuries, whereas harmonious passion is associated with sustained and healthful involvement in dance (Rip *et al.* 2006). Differentiating harmonious and obsessive passion could contribute to envisage health in dance as no longer being a threat to the integrity of the art form. My intention is not to reject the dominant dance discourse, which would be foolish and unrealistic, but to invite artists to think critically about the benefits or the cost of participating in different discourses that inevitably have consequences on their health. Because dancers are devoted to and passionate about their art form, and because the dance milieu features a culture of pain in which dancers are expected to suffer in silence, helping artists to understand that their passion can be experienced in a manner not detrimental to their health should be a goal of educational programs informed by research.

Somatic education for better or for worse

Questioned about the younger generation of artists, certain older choreographers somewhat caustically raised the issue of "self-absorbed children lacking discipline, passion and the will to achieve." They spoke of learning/training environments that left dancers ill-prepared for the milieu's harsh realities, while others brought up the improved preparation acquired through the increasing number of somatic and anatomic classes.

> At one point, I was skeptical. I felt like saying to the dance schools "give more technique classes to your dancers." I was worried that I would have work with dancers who are too preoccupied by their anatomy, who know that it is a particular muscle which is sore, who know they shouldn't force another one [laughing]. But now I see that the young dancers work so well. I would have loved to have had such knowledge of my body.

Originating from outside the field of dance, a variety of somatic education practices such as Alexander Technique, Body Mind Centering, or Feldenkrais Method, have made their way into dance. They are all concerned with "listening to the body and responding to these sensations by consciously altering movement habits and movement choices" (Eddy 2009, p. 7). According to Shusterman (1992), increasing subjective sensorial experience can help to reduce the prominence of external agencies on the individual. Somatic education thus provides dancers with an alternative discourse to counteract the fantasy of an ideal body, which is so often removed from the concreteness of the sensing body.

In our study, we found that dancers integrate the somatic discourse in three distinctive ways. For one group of dancers, the heightened perceptiveness developed through somatic education did not serve to improve their wellbeing; it was subverted and used to work toward what was important to them—namely, pushing the limits of their performance. They had fully appropriated the dominant dance discourse and considered it as inescapable and even essential to building a dance career. A second group of dancers, on one hand, manifested critical thinking in how they verbalized their reticence about certain aspects of the dominant discourse; on the other hand, they did not seem to experience physically the changes that they professed verbally. In a third group, the experience of somatic education allowed dancers to develop an internal authority. They made choices based on their intimate self-awareness, respecting the limits of their own bodies. For these dancers, the normality of pain or the excessiveness of certain artistic practices were no longer so blindly tolerated or, if so, only under certain conditions and for a limited period of time.

Markula (2004) appropriately points out that any discourse can be either emancipatory or oppressive. A somatic-based discourse is no exception, and this needs to be looked at critically. What really is important when negotiating between different discourses is knowing how they operate, each having its own "game of truth" linked to an accepted consensus about what is sound knowledge and to the accompanying hegemonic procedures that legitimatize power relations. It is worth mentioning that power, according to Foucault (1963), is not exercised through the imposition of external constraints on the person, but rather is achieved by an internalization of norms by the person.

IMPLICATIONS

Differentiated ways of integrating various discourses—dance or health, dominant or marginal—emerged over the course of our studies with dance artists. Overall our data revealed how:

- Artists have integrated the dominant Western health discourse of individual responsibility and have minimized the importance of external factors shaping their health.
- Health is mostly defined in functional terms with a reluctance to question the hegemonic norm of pain and suffering of the dominant discourse of Western theatrical dance.
- The process of unionization confronts the dominant dance discourse by prompting collective mobilization for better occupational health and safety conditions.
- An increase in the arts budget does not necessarily improve artists' health.
- Methods of creation based on collaboration do not necessarily contribute to securing health.
- A culture of silence prevails in dance, which we consider a risk factor.
- Women deal with specific gender challenges impacting their health.
- Health accountability is weakened when the artwork prevails over the artists who give life to the artwork.
- Health issues can play a central role in the promotion of shared notions of ethical behaviors.
- Artists participate in the dominant discourse in dance with different types of passion that have different effects on dance injuries.
- Somatic education questions the dominant discourse in dance by lessening its negative impacts on dancers' health.

The above conclusions indicate how important it is for dancers to raise their consciousness about the competing discourses surrounding them and the effects on their health and wellbeing. Whereas vocation or passion for the art form is often presented as an explanation for why artists jeopardize their health and accept difficult working conditions, we conclude that it is the dominant performing arts discourse, which values the supremacy of the artistic work and the surpassing of one's limits, that heads a long sequence of decisions negatively impacting artists' health. Unless all participants in the dance milieu, individually and collectively, critically address the different discourses and their embodied "truths," changes in dancer's health and well-being will remain limited. "Games of truth" are unavoidable, but they can be played out with an ethically-based concern for oneself and for others.

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