sempre:
Society for Education, Music and Psychology Research

Article

Psychology of Music
2017, Vol. 45(3) 417–431

Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/0305735616666940
journals.sagepub.com/home/pom
SAGE

Musicians' perceptions and experiences of using simulation training to develop performance skills

Lisa Aufegger[1,2], Rosie Perkins[1,2], David Wasley[3] and Aaron Williamon[1,2]

Abstract

Simulation has been applied as a tool for learning and training in sports, psychology and medicine for some time, but its current use and potential for training musicians is less well understood. The aim of this study was to explore musicians' perceptions and experiences of using simulated performance environments. Nine conservatory students performed in two simulations, each with interactive virtual elements and vivid environmental cues: a recital with a virtual audience and an audition with virtual judges. Qualitative data were collected through a focus group interview and written reflective commentaries. Thematic analysis highlighted the musicians' experiences in terms of (1) their anticipation of using the simulations, (2) the process of performing in the simulations, (3) the usefulness of simulation as a tool for developing performance skills and (4) ways of improving simulation training. The results show that while simulation was new to the musicians and individual levels of immersion differed, the musicians saw benefits in the approach for developing, experimenting with and enhancing their performance skills. Specifically, the musicians emphasised the importance of framing the simulation experience with plausible procedures leading to and following on from the performance, and they recognised the potential for combining simulation with complementary training techniques.

Keywords

expertise, learning, perception, performance, practice, simulation, qualitative

Current performance training often strives to deliver a holistic framework that enhances musicians' performance confidence and creates a positive performance experience (Liertz, 2007). Some of the most innovative approaches directly address aspects such as musicians'

[1]Centre for Performance Science, Royal College of Music, London, UK
[2]Faculty of Medicine, Imperial College London, London, UK
[3]Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK

Corresponding author:
Aaron Williamon, Centre for Performance Science, Royal College of Music, Prince Consort Road, London, SW7 2BS, UK.
Email: aaron.williamon@rcm.ac.uk

self-efficacy (Bandura & Locke, 2003), stage presence (Davidson, 2012) and an increased sense of control over the performance situation, in particular the employment of performance-facilitating thoughts (Clark, Lisboa, & Williamon, 2014). In order to improve musicians' performance outcomes and help them manage the challenges of performing, a wide variety of strategies and techniques are now being applied within the musical domain and tested internationally (Kenny, 2011), including cognitive-behavioural interventions, mental skills training and biofeedback (Braden, Osborne, & Wilson, 2015; Clark & Williamon, 2011; Gruzelier & Egner, 2004; Rodebaugh & Chambless, 2004; Thurber, Bodenhammer-Davis, Johnson, Chesky, & Chandler, 2010). While there is evidence that these are effective (Kenny, 2005; Williamon, 2004), they are typically experienced and practised some distance away from the venues and situations in which performance actually occurs. Effective performance training should allow musicians access to and experience of performance in the real world (Kassab et al., 2011). Taking this into account, music educators are now beginning to experiment with *simulation* as a complementary training tool, where virtual reality (VR) components are interwoven alongside key features of real performance environments so that "a person can move around and interact as if he actually were in this imaginary place" (Satava, 1993, p. 203).

Simulation training has been applied successfully in a wide range of fields, including clinical psychology (Krijn, Emmelkamp, Olafsson, & Biemond, 2004; Safir, Wallach, & Bar-Zvi, 2012), medicine (Selvander & Asman, 2012) and sport (Zinchenko, Menshikova, Chernorizov, & Voiskounsky, 2011), addressing anxiety-related problems. Across these domains, the relationship between anxiety and perceptual-motor performance in response to demanding performance conditions (e.g. critical surgical procedures) has been put under scrutiny. Anxiety can have detrimental effects on performance execution, attention and decision-making and an increased likelihood of perceiving the environment as threatening, leading to a focus on task-irrelevant information (i.e. attentional bias) and to the display of threat-related behaviour that may interfere with the overall performance outcome (Nieuwenhuys & Oudejans, 2012). Simulation training offers an evaluation of these effects in a consistent performance setting that is less exposed to situational variability, therefore providing a promising tool for educational and interventional assessments (Scalese, Obeso, & Issenberg, 2008).

To put this into context, Emmelkamp, Krijn, Hulsbosch, and de Vries (2002) exposed patients suffering from acrophobia either to a simulation (generated by a dark room, a virtual display and surrounding audio to create the feeling of height) or to in-vivo-exposure to high places. Self-reports of anxiety and behavioural avoidance were measured before and after exposure, and compared with the in-vivo-exposure. The results showed a significant decrease in both measures after simulation training. Simulations have also been used to train elite performers of many types, from athletes and pilots to surgeons, where there are limited possibilities to train specific skills in real-life conditions (Kassab et al., 2011; Lendvay et al., 2013; Sutherland et al., 2006). Kassab et al. (2011) demonstrated a significant improvement in surgeons' abilities to perform a laparoscopic cholecystectomy using simulation compared with standard training tools and demonstrated that surgeons felt as confident of operating afterwards as if exposed to real scenarios.

In music, relatively few studies have tested the use of simulation in managing performance anxiety. Orman (2003, 2004) asked eight saxophonists to perform in public (for peers) and in front of virtual scenarios using a head-mounted display, inducing different degrees of anxiety such as an empty room versus an audience. Self-reports of anxiety were taken before, during and after the performance, while heart rate was monitored throughout. The results were inconclusive, with no consistent patterns of change in either self-reported anxiety levels or heart rate as a function of exposure to the simulated performance situations. In another study, Bissonette, Dube, Provencher, and Moreno Sala (2011) asked 17 pianists and guitarists to take part in simulation training that included exposure to a VR display recreating a concert audience on a large screen and immersive ambient sound and stage lighting. They found a significant decrease in self-reported state anxiety for high trait anxious female musicians from before to after the exposure, although no significant decline in state anxiety for men or women with moderate to low trait anxiety.

More recently, Williamon, Aufegger, and Eiholzer (2014) examined musicians' ratings of their experiences while performing in simulated recital and audition situations. The study also examined self-reported state anxiety and heart rate variability in the simulated auditions compared with corresponding real auditions. The simulations were created in a specially designed performance space that included abstractions of key features found in recital and audition environments, such as a waiting area (backstage) with a backstage manager and CCTV footage and a performance area (on stage) with a piano, spotlights and curtains. The virtual interactive audience and audition panel were programmed to respond positively, negatively or neutrally, controlled directly from the backstage area. Overwhelmingly, the musicians rated both the recital and audition simulations as useful tools for developing and refining their performance skills. Furthermore, there were no significant differences in state anxiety or heart rate variability between the simulated auditions and the real auditions, suggesting that the simulation was able to evoke similar stress responses (psychologically and physiologically) as a real performance situation.

Although these studies offer first insight into the uses and utility of simulation training in the musical domain, a thorough investigation of *how* musicians experience simulation training has yet to be conducted. Understanding musicians' experiences in this new field is essential in terms of informing the potential and effectiveness of simulation for facilitating musical learning and performance. The aim of this study, therefore, was to understand holistically how musicians' experience two simulated performances: a recital and an audition. Both have distinctive qualities and are typical to a musicians' performing career; while the recital provides a more performer-supported environment where musicians are likely to receive positive reinforcement at the end of their playing (i.e. audience applause), auditioning is highly competitive, often with little immediate feedback and characterised by expectations of the highest quality musical, technical and sight-reading abilities.

Our overarching research question sought to understand: *How do conservatory students experience simulation training?* Informed by the literature, this question comprised two main areas of enquiry. First, to what extent is simulation training immersive for musicians, as compared with real-life performances (Price & Anderson, 2007)? Studies have shown that the degree of emotional involvement during simulation training depends on personal expectations and the technology used (Mazuryk & Gervautz, 1996), and it directly impacts on the degree of "presence" (Schubert, Friedmann, & Regenbrecht, 2001), which is "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 225). In other words, the more immersed students feel during the simulation training, the more likely they are to "overlook" and "neglect" its artificial construct, thus allowing them to experience simulation training similar to real-life situations. Second, this study set out to understand the characteristics of the musical simulation reported to facilitate (or not) immersive experience; in other words, to what extent is simulation training experienced as a tool for improving specific performance skills and tackling performance-related anxiety problems? Thus far, simulation training has been applied in a wide range of domains to either enhance specific performance skills (Clayton et al., 2013; Kassab et al., 2011) or to reduce symptoms associated with (performance) anxiety (Bissonette et al., 2011; Morina, Brinkman, Hartanto, & Emmelkamp, 2014). Considering research executed in the musical domain, however, simulation training has only been validated alongside anxiety reducing protocols (Bissonette et al., 2011) rather than performance enhancement strategies. With this in mind, this study set out to examine musicians' experiences of simulation training as a tool to enhance performance, reduce performance-related anxiety, or both.

Method

Participants

Nine of 11 undergraduate music students enrolled in an optional performance psychology module at the Royal College of Music (RCM) agreed to take part in the study. The students were all women, on average 21.33 (SD = 0.81) years old, and studied the following instruments: clarinet, oboe, piano, recorder and voice. On average, they first performed at the age of 6.66 years (SD = 1.50), practised 4.5 hours per day (SD = 1.18) and performed in public 3.08 (SD = 2.01) times over the month preceding the study. The research was conducted according to ethical guidelines of the British Psychological Society, and informed consent was obtained from all participants.

Procedure and data collection

Participants were allotted a specific performance time and asked to attend at least 10 minutes beforehand for warm-up in a designated space. They were then called to the backstage area of the simulated performance space by a backstage manager where they waited quietly for approximately two minutes before receiving the signal to enter the stage area. At that point, they performed a 2-minute unaccompanied piece of their choice in front of either the virtual audience or the virtual audition panel (see Figures 1, 2a and 2b; extended descriptions of each simulation are provided by Williamon et al., 2014). For the audience, a neutral applause was

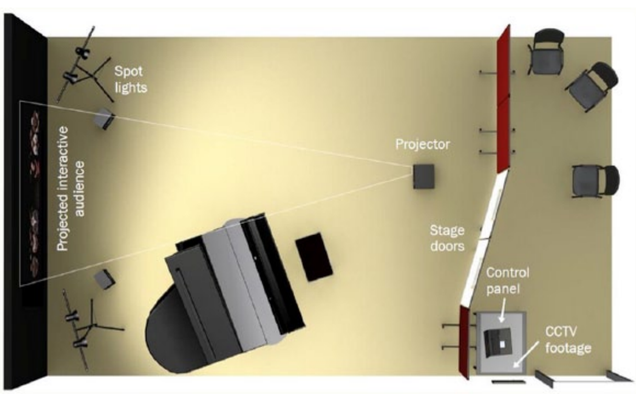

Figure 1. The performance space housing the recital and audition simulations, showing backstage (right) and stage (left) areas. Backstage, CCTV footage of the virtual audience or audition panel is shown on a wall-mounted flat-screen monitor and controls for operating the audience and audition panel are located on a nearby computer. On stage, a ceiling-mounted beamer projects the life-sized audience or audition panel onto a wall, with spotlights and loudspeakers on both sides. Stage curtains (not shown) frame the projected image.

Figure 2a. Still of the virtual audience.

Figure 2b. Still of the virtual audition panel.

provided, followed by listening behaviours similar to those of a typical Western classical performance (e.g. naturalistic body swaying and discrete fidgeting and movement). For the audition panel, a neutral introduction was given (i.e. "Hello, please start whenever you are ready"), followed by typical evaluative behaviours such as making notes and leaning back while simultaneously portraying a neutral facial expression. After the performance, the audience applauded politely, while the audition panel gave a polite but noncommittal "Thank you very much". The order of the two performances was counterbalanced, and all performances were audio and video recorded for the participants' own use.

After the two performances, qualitative data were collected through (a) a focus group interview and (b) individual written reflective commentaries, both with all nine participants. The focus group was carried out directly after the simulation training in order to capture students' spontaneous reflections on their experiences, while the commentaries were written weeks after the simulations to allow for retrospective reflection. The aim of the focus group interview was to gain an in-depth understanding of the musicians' perceptions and experiences. Ideally, such interviews should be as loosely structured as possible (Krüger & Casey, 2000), and in this study, the moderator, along with two assistants operating as quiet observers, asked open-ended questions about the musicians' expectations of using the simulations, their experiences of using them, suggestions for improvements to the facility and to the procedure, what they learned from performing in the simulations, and the potential uses of simulation training in music education (see the Appendix in Supplementary Material Online for the focus group interview schedule). Participants were encouraged to answer in as much detail as possible, and the discussion was audio recorded and fully transcribed by a member of the research team.

In addition, based on their experiences of performing, the musicians were asked to write a 1,500-word reflective commentary as part of their assessment for the undergraduate module. The structure of the commentary was open for the student to determine, but they were required, as per the module syllabus, to focus on what they expected of the simulation training, their experiences of the two simulations (including how effective they felt it to be as a performance platform relative to live performance and any differences between playing to a virtual audience and audition panel) and what they learned from the experience. The musicians gave informed consent for their written course work to be included in the research, and the research team were not involved in assessing the submissions.

Data analysis

The focus group transcripts and reflective commentaries were analysed thematically using NVivo 10. The full dataset was closely examined several times before meaningful phrases, ideas and concepts were identified as codes and compared between and within participants. Codes were subsequently clustered into a series of sub-themes that characterised the musicians' experiences of the simulations, and sub-themes were clustered once more into overarching themes (Bernard & Ryan, 2010; Krüger & Casey, 2000). Codes, sub-themes and themes were discussed and agreed between the first and second author throughout the data analysis process (Clark et al., 2014). In what follows, the main features of each overarching theme are introduced, supported by indicative evidence from the data and related where appropriate to existing literature. To assure anonymity, participants are numbered 1–9, and the source of information (focus group or reflective commentary) is indicated by FG and RC, respectively.

Results and discussion

Four main themes emerged from analysis (see Figure 3): (a) the anticipation of using the simulations, including expressions of nervousness and scepticism but also intrigue and hope; (b) the process of performing in the simulations, such as the transition between the backstage and onstage areas, the available auditory and visual cues, the experiences of performing for the audience and audition panel, and the degree of interaction between the performer and the virtual displays; (c) the usefulness of simulation as a tool for developing music performance skills, discussing the advantage of having a "safe space" to present and evaluate skills; and (d) ways of improving simulation training, emphasising the potential for enhancing the current performance procedure and facilities, such as the waiting time in the backstage area and the performance space on stage, and using simulation alongside other interventions such as biofeedback and mental skills training.

The anticipation of using the simulations

The musicians taking part in the study had not previously performed in simulated environments, and anticipation of doing so resulted in four main feelings of anticipation of the first performance: anxiety, scepticism, curiosity and hope.

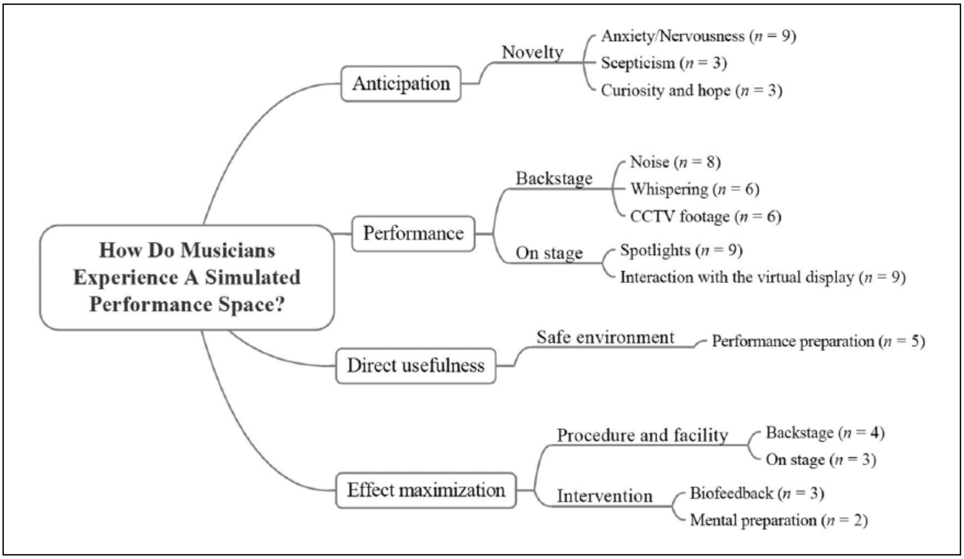

Figure 3. Themes, subthemes and frequencies emerging from the thematic analysis of the focus group interview and reflective commentaries.

Anxiety. Similar to a live performance, the musicians experienced feelings of apprehension prior to entering both simulations:

> I started experiencing some anxiety a few hours before the first session began. (RC 3)
>
> I was slightly nervous in anticipation. (RC 1)
>
> It was scarier than I thought it would be. (FG 1)
>
> To my surprise, I felt nervous waiting outside of the room. (RC 9)
>
> I thought this simulation was going to be fun. Then I got there, and I got nervous. (FG 2)

Feelings of anxiety or nervousness are common pre-performance experiences and have been related to musicians' personalities and past performance experiences (Kenny, 2011). Here, these feelings appeared to emerge mostly in reference to the novelty of the situation, the fact that the students did not know what to expect from the simulations and the impact of arriving and waiting outside the performance space. Studies have shown that the pre-performance period can have a pronounced impact on musicians' physiological reactivity to stress (Abel & Larkin, 1990), and Williamon et al. (2014) demonstrated that it was the *anticipation* of performing that caused the highest reactivity among musicians, a finding lent support by the current study.

Scepticism. The musicians also declared feelings of scepticism and doubt about whether the simulations would be truly immersive and realistic:

> Because I knew it was just a simulation, I thought it was not going to feel that real. So I was a bit unsure. (FG 2)
>
> I was sceptical of the simulator initially and how effective it would be. (RC 4)
>
> I expected it to have less effect on me than it [actually] did. (FG 2)

Similar to the feeling of anxiety, scepticism arises alongside a general reluctance to facing something unknown (Millar, 2012). The musicians expressed scepticism in terms of the effectiveness of the simulations, in particular how realistic the performance experience would be compared with a real performance and how it might, mentally and physically, affect them as performers.

Curiosity and hope. Curiosity and hope are viewed as positive qualities, characterised by an eagerness to explore, investigate and learn something new. Furthermore, both qualities facilitate psychological growth, self-discovery and creativity (Ofer & Durban, 1999). The musicians were certainly curious and expressed hope about the new experience of performing in the simulations:

> I was curious about what it would entail and how it would work. (RC 5)

> I was intrigued as to whether or not I would feel as if I was walking onto a real stage, and wondered whether I would get nervous at all despite being aware that it was not a "real" performance. (RC 2)

The musicians expressed curiosity either in terms of the performance environment itself or the effect that the simulations may elicit. Comparisons were drawn to the musicians' real performance experiences, as well as whether they were able to engage fully with the simulations. More specifically, they expressed hope for a tool that could recreate performance experiences similar to real performance settings:

> I was not convinced that the experience would impact me in the same way that live performances do. Nonetheless, I hoped it would! (RC 5)

> I had high hopes for the performance simulator. (RC 3)

The musicians' comments highlight the desire of having access to training that has been shown to be effective in other domains. They demonstrated a general open-mindedness towards new approaches to learning, an attitude shown to be crucial to allow an immersive and successful experience in simulation (Murray, Fox, & Pettifer, 2007).

Overall, the anticipation towards using the simulations was expressed by feelings of anxiety and scepticism, but also curiosity and hope. The way musicians approach a performance and its subsequent success typically depend on whether their thoughts are facilitative or debilitating (Clark et al., 2014). In this study, the musicians' expressions of emotions varied – reflecting the novelty of the simulation experience – but included anxiety similar to that felt in real performances. However, these diverse feelings during the anticipatory period positively changed once the musicians entered the simulated performance space, with their first hands-on experience of what it actually means to perform in a simulation and in front of virtual displays.

The process of performing in the simulations

The musicians' experiences of performing in the simulations were categorised according to different stages in the performance process, focusing first on the backstage area and then on the stage area.

Backstage. The experience of waiting in the backstage area evoked performance anxiety symptoms including fidgety behaviour and elevated heart rate:

> I was surprised that just seeing the [CCTV] screen with the audition panel in the backstage area was enough to trigger the usual anxiety I get before a performance. Typically I feel slightly nauseous … and start fidgeting or feel shaky. (RC 3)

> Before going on stage, [the backstage manager] was whispering to me, and I thought “is this actually a performance?” [laughter]. (FG 4)

> I had *that* backstage feeling. (FG 5)

> The backstage feeling was surprisingly real. It was dark, [the backstage manager] was whispering, and I could hear the audience murmuring and moving. My heart started pounding. I didn’t know what lay on the other side of the door. (RC 6)

The symptoms described here were primed specifically by the backstage environment, including the inclusion of pre-filmed (fake) CCTV footage of the performance space and background noise such as whispering and murmuring from the audience and audition panel. It also gave rise to a feeling of uncertainty of what was going on through the stage door. An increased feeling of realism was added by the presence of the backstage manager, who acted out a scripted role of liaising with the front-of-house and who coordinated the transition from backstage to the stage area.

On stage. Authentic simulations depend on realistic auditory and visual cues to achieve a feeling of immersion (Morina et al., 2014; Murray et al., 2007). The main points mentioned by the musicians in this study centred on the spotlights that were directed at them immediately upon their entrance on to stage:

> The spotlights were one of the first things I noticed, and they surprised me. They gave me a full feeling of actually being on stage. (RC 1)

> To play with this unusual kind of lighting added more pressure to the musical performance in situ, as the whole experience felt a lot more real. (RC 5)

> I felt nervous when I saw the spotlights. (FG 2)

The use of spotlights generated a feeling of sudden surprise, an immediate increase of pressure, as well as nervousness. Thus, the musicians appeared to experience feelings similar to those of a real performance, leading to an increased perception of authenticity.

Interaction with the virtual display. In research into virtual reality, the feeling of “presence” (i.e. an increased ability to “overlook” or “neglect” the knowledge of the virtual components) depends on the graphical reality and interactivity of the technology used, as well as one’s willingness to engage fully with it (Sas & O’Hare, 2002). Interactivity and related feedback should be “prompt, fluent and synchronized” and, ideally, highly synchronised within and between different modalities (Mazuryk & Gervautz, 1996, p. 18). The musicians focused particularly on their interaction with the virtual displays and the human-like appearance and behaviour of the audience and audition panel:

> I wasn’t really expecting that kind of real situation. … You know, with [the audience] actually moving … it made me feel more like they were human even though they were not. (RC 9)

> With the audition panel, I felt connected. They spoke to me, and I felt like I should speak back. (FG 3)

> The fact that the audition panel was interactive made the first session very genuine. (RC 5)

It seems that the musicians were not expecting the virtual display to interact with them before, during or after their performance and that even basic interactions between performer and the virtual displays enhanced the reality of the simulations.

According to the wider literature on simulation, adequate sensory feedback should consider the relevance of the sensations of vision, audition, touch, smell and taste (Downtown & Leedham, 1991); in addition, the virtual reality components should be synchronised and exhibit marginal latency effects with the user's behaviour (Sherman & Craig, 2003). As in this study, simulation designs in other fields have also been able to provide these cues effectively, without the need for elaborate motion tracking systems (Mazuryk & Gervautz, 1996).

Usefulness of simulation as a tool for developing music performance skills

The musicians identified one prevailing way in which the simulations were directly useful to their own practice: the generation of a safe environment to train and to practise performing:

Safe environment. Simulated performance spaces have been classified as "safe" environments – that is, they are potentially less harmful than in-vivo desensitisation exposure, while offering a more tangible and real approach than cognitive therapies using imaginal desensitisation (North, North, & Coble, 1997). The musicians in this study confirmed that the simulator was a safe space in which to practise performance:

> The simulator could potentially serve as a platform that provides the necessary safe space to acquire performance skills through trial and error. (RC 9)

> [It is a] safe environment knowing that no one real is there. (FG 4)

> Waiting for an exam where one will be judged and criticized is much less often experienced than the hours spent in the practice room and is, therefore, more likely to throw one off balance before a performance. This is where simulation can help overcome this fear, by repeated exposure in a safe and controlled environment. (RC 8)

Students emphasised this benefit in terms of having a space in which the fear of failure is reduced through the elimination of negative appraisal that may come from real audiences and evaluators. Additionally, the simulations allowed for experimentation and skill development through a process of trial and error iteration. The musicians also acknowledged the possibility of using repeated exposure to overcome problems such as performance anxiety and to prepare them physically and mentally for real performance experiences, be they positive or negative.

Reflection on performance is an indispensable part of performance enhancement (MacNamara, Button, & Collins, 2010). Rather than a standard practice room and a distressing real stage, simulation training provides a halfway approach that comes closer to real performance than the former and is more accessible and less risky than the latter. Performance training where musicians are encouraged to behave as they would in a real performance setting offers greater scope to build upon strengths and to address weaknesses in performance, such as improving stage presence without having to suffer career threatening failure or other negative consequences.

Ways of improving simulation training

The final theme stresses the potential that the musicians identified to enhance the simulations, focusing on the procedure and facility, as well as the prospects for simulation training to improve music education more generally.

Procedure and facility. The importance of sensory feedback in simulations to create an authentic performance experience has been addressed extensively (Sherman & Craig, 2003). Less, however, has been written on how the simulation facility (e.g. the room and furniture) and the procedures by which simulations are accessed can be tailored to the specific field of use. In this study, the musicians pointed to the need for a longer waiting time in the backstage area and a more spacious performance area on stage:

> I felt there needed to be a longer wait before the performance to replicate real life. (RC 9)
>
> Increase the time spent in the backstage area. Personally, I find that the longer I have to wait, the more nervous I get. (RC 7)
>
> Sometimes you have to wait around a while before you go on, and this time, for me it was quick. (FG 3)
>
> I get nervous when I have to wait. (FG 5)

The points raised draw attention to the disparity between the musicians' experiences of real performances and those in the simulations, notably with regard to the amount of time spent waiting in the backstage area: in this study, just two minutes. Another point was the small size of the room in which the simulations are currently housed:

> The lack of space on stage did not pose any problems during the audition simulation, since auditions are held in a variety of venues. ... However, this had an impact on my experience of the recital simulation. (RC 4)
>
> I would make sure that the size of stage used is a larger performance space. (RC 6)
>
> It would be useful if the room was bigger because ... we don't perform in little spaces. ... When the stage is bigger, you feel exposed. (FG 2)

The restricted stage area was noticed particularly in the recital simulation, which in a real performance setting would be more spacious than in the simulation space. This was not, however, a problem for the performances in the audition simulation, as auditions can occur in smaller rooms.

Intervention. Finally, the participants highlighted the potential for the simulations to be used as a form of intervention, to help musicians overcome challenges and manage anxieties that can impair performance quality:

> It would be interesting to see which thoughts and emotions would keep our heart rate at a slower level. Maybe then, we musicians could finally train ourselves to be fully prepared for performance. (RC 3)
>
> As an example, it would be very useful to perform in the simulations with a particularly distracting and difficult virtual audience to prepare us for all eventualities that may occur in a performance. (RC 2)

> I think "okay, I can do that", and then if something happens in a real life situation when I might not expect it … it's fine because I have experienced it before. … It's about having the right mental state. (FG 5)

The musicians suggested the use of training emotional regulation by means of a gradual increase of distraction caused by the virtual display. In addition, they suggested that simulation training could be usefully paired with other performance enhancement interventions in order to optimise physical and mental responses to performance situations. Indeed, research has shown that interventions such as biofeedback and mental skills training can directly improve performance quality and anxiety management skills (Arora et al., 2011; Gruzelier & Egner, 2004; Thurber et al., 2010). However, due to the cost of accessing real concert halls, these techniques are often applied away from the contexts in which performances take place. Simulation opens entirely new modes of delivery for such interventions, allowing researchers and practitioners to put them to the test by applying them in the situations where they are most needed.

General discussion

With respect to the study's research question and areas of enquiry, the results demonstrate that: (a) while students' level of immersion in simulation training differed, context and environment contributed to an immersive experience, enhanced through the use of key auditory and visual cues such as background noise and spotlights, as well as the degree of interaction with the virtual displays; (b) the musicians acknowledged the safety available in simulation training and its potential for developing, experimenting with and enhancing a wide range of performance skills, in addition to reducing performance-related anxiety.

Effective simulations should provide adequate sensory feedback and graphical reality, which should both be displayed precisely and with low time latency (Mazuryk & Gervautz, 1996). The simulation training in this study was able to present realistic visual and auditory feedback to an extent that allowed the musicians to experience feelings of immersion. Immersion experiences in this study were enhanced by auditory and visual cues (background noise and spotlights), and the interaction with the virtual audience and audition panel as well as a combination of high-resolution human computer interface and prompt and fluent feedback, synchronised within and between different modalities (e.g. visual and auditory feedback).

The musicians' preference to use simulation training to enhance specific performance skills, rather than merely to reduce performance anxiety, is a new finding not previously observed in studies using simulation (e.g. Orman 2003, 2004; Bissonette et al., 2011). While the training may indeed be able to reduce performance anxiety, the results of this study expand the potential of simulation training as a tool to acquire and practise specific performance skills, providing more routes for optimising preparation for (high-pressure) performances of all types. Future studies are therefore encouraged to elaborate on these findings by considering exactly how simulation training may be employed for the development of widely defined musical, technical and communicative performance skills.

This study offers implications for practice, identifying several areas in which student experience can be enhanced and the effectiveness of simulation training improved. The results provide evidence that students experience simulation training as an opportunity to strengthen positive attitudes towards the preparation, delivery and review of performance, reporting an interest in simulation training as an intervention to facilitate a deeper awareness of the physical and psychological processes underpinning successful performances. To this end, simulation training may be provided alongside real-life feedback of musicians' physical and psychological responses (e.g. heart rate, breathing, state anxiety) before, during and after their performances in order to facilitate increased performance awareness while practising performing in a relatively safe and low-exposure performance environment. Similarly, students emphasised using simulation training in combination with mental preparation strategies. Indeed, recent research has shown that elite musicians under high-stress performance scenarios particularly focus on positive thinking and self-talk in order to build up sufficient performance confidence (Buma, Bakker, & Oudejans, 2015). During mental rehearsal, musicians are encouraged to apply aural, visual and kinaesthetic visualisation, as well as cognitive and motivational strategies (emotional regulation) that are believed to lead to a performance sensation similar to a real (and ideal) performance (Connolly & Williamon, 2004). Future work should, therefore, address these points by developing new protocols for mental rehearsal that make use of performance simulation in order for musicians to experience and experiment with their "optimal zone of functioning" (Hanin, 2003).

This study is not without limitations. First, only women who were enrolled in an optional performance psychology module took part. This means that no information of the experience of simulation training for men was gathered, and through their enrolment on the module, students may have pursued different solutions to help improve their performances, which in turn may have increased the risk of a sampling bias. Still, the study is the first detailed analysis of simulation experience in the musical domain, and in this respect, no predicted differences in the quality of experience between men and women can be gleaned from the extant literature. Furthermore, students were encouraged to evaluate critically both advantages and disadvantages of their experience using simulation training. This was hoped to not only counteract sampling bias but also to reduce the influence of the order of interview and reflective commentaries. Second, the feedback provided by the virtual displays was of a neutral nature. This was to avoid a first experience of simulation that was overshadowed by particularly positive or negative responses from the virtual audience and audition panel. Subsequent studies should employ the full range of interactive potential of these simulations: for instance, distracting coughing, sneezing, phone ringing in the audience, and different degrees and intensities of feedback as shown through applause, facial expressions and gestures of different valence. Nonetheless, given the multifaceted nature and impact of performance experiences on musicians and the personal significance it holds even for highly experienced performers, simulation training can be seen as an important tool in identifying, training and improving performance-related skills.

Acknowledgements

We wish to thank the nine musicians who took part in this study, as well as Sara Ascenso and Louise Atkins for help with the observations during the focus group interview and comments provided on the study design.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The research reported in this article was supported by the Peter Sowerby Foundation.

References

Abel, J. L., & Larkin, K. T. (1990). Anticipation of performance among musicians: Physiological arousal, confidence, and state-anxiety. *Psychology of Music*, *18*, 171–182. doi:10.1177/0305735690182006

Arora, S., Aggarwal, R., Sirimanna, P., Moran, A., Grantcharov, T., Kneebone, R., ...Darzi, A. (2011). Mental practice enhances surgical technical skills: A randomized controlled study. *Annals of Surgery*, *253*, 265–270.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology*, *88*, 87–99.

Bernard, H. R., & Ryan, G. W. (2010). *Analyzing qualitative data: Systematic approaches*. Los Angeles, CA: Sage.

Bissonette, J., Dube, F., Provencher, M. D., & Moreno Sala, M. T. (2011). The effect of virtual training on music performance anxiety. In A. Williamon, D. Edwards, & L. Bartel (Eds.), *Proceedings of the International Symposium on Performance Science 2011* (pp. 585–590). Utrecht, the Netherlands: European Association of Conservatoires.

Braden, A. M., Osborne, M. S., & Wilson, S. J. (2015). Psychological intervention reduces self-reported performance anxiety in high school music students. *Frontiers in Psychology*, *6*, 195.

Buma, L. A., Bakker, F. C., & Oudejans, R. R. D. (2015). Exploring the thoughts and focus of attention of elite musicians under pressure. *Psychology of Music*, *43*, 459–472. doi:10.1177/0305735613517285

Clark, C., & Williamon, A. (2011). Evaluation of a mental skills training program for musicians. *Journal of Applied Sport Psychology*, *23*, 342–359.

Clark, T., Lisboa, T., & Williamon, A. (2014). An investigation into musicians' thoughts and perceptions during performance. *Research Studies in Music Education*, *36*, 19–37.

Clayton, J. M., Butow, P. N., Waters, A., Laidsaar-Powell, R. C., O'Brien, A., Boyle, F., ...Tattersall, M. H. (2013). Evaluation of a novel individualised communication-skills training intervention to improve doctors' confidence and skills in end-of-life communication. *Palliative Medicine*, *27*, 236–243. doi:10.1177/0269216312449683

Connolly, C., & Williamon, A. (2004). Mental skills training. In A. Willamon (Ed.), *Musical excellence: Strategies and techniques to enhance performance* (pp. 221–246). New York, NY: Oxford University Press.

Davidson, J. W. (2012). Bodily movement and facial actions in expressive musical performance by solo and duo instrumentalists: Two distinctive case studies. *Psychology of Music*, *40*, 595–633. doi:10.1177/0305735612449896

Downtown, A., & Leedham, G. (1991). *Engineering the human–computer interface*. London, UK: McGraw-Hill.

Emmelkamp, P., Krijn, M., Hulsbosch, L., & de Vries, S. (2002). Virtual reality treatment versus exposure in vivo: A comparative evaluation in acrophobia. *Behaviour Research & Therapy*, *40*, 509–516.

Gruzelier, J. H., & Egner, T. (2004). Phsyiological self-regulation: Biofeedback and neurofeedback. In A. Willamon (Ed.), *Musical excellence: Strategies and techniques to enhance performance* (pp. 197–220). Oxford, UK: Oxford University Press.

Hanin, Y. L. (2003). Performance related emotional states in sport: A qualitative analysis. *Forum: Qualitative Social Research*, *4*(1), 5. Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/747/1618

Kassab, E., Tun, J. K., Arora, S., King, D., Ahmed, K., Miskovic, D., ...Kneebone, R. (2011). "Blowing up the barriers" in surgical training: Exploring and validating the concept of distributed simulation. *Annals of Surgery*, *254*(6), 1059–1065. doi:10.1097/SLA.0b013e318228944a

Kenny, D. (2005). A systematic review of treatments for music performance anxiety. *Anxiety, Stress & Coping*, *18*, 183–208.

Kenny, D. T. (2011). *The psychology of music and performance anxiety*. Oxford, UK: Oxford University Press.

Krijn, M., Emmelkamp, P. M., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical Psychology Review*, *24*, 259–281.

Krüger, R. A., & Casey, M. A. (2000). *Focus groups*. Thousand Oaks, CA: Sage.

Lendvay, T. S., Brand, T. C., White, L., Kowalewski, T., Jonnadula, S., Mercer, L. D., ...Satava, R. M. (2013). Virtual reality robotic surgery warm-up improves task performance in a dry laboratory environment: A prospective randomized controlled study. *Journal of the American College of Surgeons*, *216*, 1181–1192.

Liertz, C. (2007). *New frameworks for tertiary music education: A holistic approach for many pyramids of experience*. Paper presented at the 8th Australasian Piano Pedagogy Conference, Australian National University, Canberra, Australia.

MacNamara, A., Button, A., & Collins, D. (2010). The role of psychological characteristics in facilitating the pathway to elite performance part 1: Identifying mental skills and behaviors. *The Sport Psychologist*, *24*, 52–73.

Mazuryk, T., & Gervautz, M. (1996). *Virtual reality: History, application, technology and future* (Technical Report, TR-186–2–96–06). Retrieved from Vienna University of Technology, Institute of Computer Graphics website: https://www.cg.tuwien.ac.at/research/publications/1996/mazuryk-1996-VRH/TR-186-2-96-06Paper.pdf

Millar, A. (2012). Scepticism, perceptual knowledge, and doxastic responsibility. *Synthese*, *189*, 353–372. doi:10.1007/s11229-011-0005-7

Morina, N., Brinkman, W. P., Hartanto, D., & Emmelkamp, P. M. (2014). Sense of presence and anxiety during virtual social interactions between a human and virtual humans. *PeerJ*, *2*, e337.

Murray, C. D., Fox, J., & Pettifer, S. (2007). Absorption, dissociation, locus of control and presence in virtual reality. *Computers in Human Behavior*, *23*, 1347–1354.

Nieuwenhuys, A., & Oudejans, R. R. (2012). Anxiety and perceptual-motor performance: Toward an integrated model of concepts, mechanisms, and processes. *Psychological Research*, *76*, 747–759.

North, M. N., North, S. M., & Coble, J. R. (1997). *Virtual reality therapy: An effective treatment for psychological disorders*. Amsterdam, the Netherlands: Ios Press.

Ofer, G., & Durban, J. (1999). Curiosity: Reflections on its nature and functions. *American Journal of Psychotherapy*, *153*, 35–51.

Orman, E. K. (2003). Effect of virtual reality graded exposure on heart rate and self-reported anxiety levels of performing saxophonists. *Journal of Research in Music Education*, *51*, 302–315.

Orman, E. K. (2004). Effect of virtual reality graded exposure on anxiety levels of performing musicians: A case study. *Journal of Music Therapy*, *41*, 70–78.

Price, M., & Anderson, P. (2007). The role of presence in virtual reality exposure therapy. *Journal of Anxiety Disorders*, *21*, 742–751.

Rodebaugh, T. L., & Chambless, D. L. (2004). Cognitive therapy for performance anxiety. *Journal of Clinical Psychology*, *60*, 809–820.

Safir, M. P., Wallach, H. S., & Bar-Zvi, M. (2012). Virtual reality cognitive-behavior therapy for public speaking anxiety: One-year follow-up. *Behavior Modification*, *36*, 235–246.

Sas, C., & O'Hare, G. M. P. (2002). Presence and individual differences in virtual environment: Usability study. In *Proceedings Volume 2 of the 16th British HCI Conference*. London, UK: British HCI Group.

Satava, R. M. (1993). Virtual reality surgical simulator: The first steps. *Surgical Endoscopy*, *7*, 203–205.

Scalese, R. J., Obeso, V. T., & Issenberg, S. B. (2008). Simulation technology for skills training and competency assessment in medical education. *Journal of General Internal Medicine*, *23*(Suppl. 1), 46–49. doi:10.1007/s11606-007-0283-4

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence: Teleoperators and Virtual Environments*, *10*, 266–281.

Selvander, M., & Asman, P. (2012). Virtual reality cataract surgery training: Learning curves and concurrent validity. *Acta Ophthalmological*, *90*, 412–417.

Sherman, W. R., & Craig, A. B. (2003). *Understanding virtual reality: Interface, application, and design*. San Francisco, CA: Morgan Kaufmann.

Sutherland, L. M., Middleton, P. F., Anthony, A., Hamdorf, J., Cregan, P., Scott, D., & Maddern, G. J. (2006). Surgical simulation: A systematic review. *Annals of Surgery*, *243*, 291–300.

Thurber, M. R., Bodenhammer-Davis, E., Johnson, M., Chesky, K., & Chandler, C. K. (2010). Effects of heart rate variability coherence biofeedback training and emotional management techniques to decrease music performance anxiety. *Biofeedback*, *38*, 28–39.

Williamon, A. (2004). *Musical excellence: Strategies and techniques to enhance performance*. Oxford, UK: Oxford University Press.

Williamon, A., Aufegger, L., & Eiholzer, H. (2014). Simulating and stimulating performance: Introducing distributed simulation to enhance musical learning and performance. *Frontiers in Psychology*, *5*, 25. doi:10.3389/fpsyg.2014.00025

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence*, *7*, 225–240.

Zinchenko, Y. P., Menshikova, G. Y., Chernorizov, A. M., & Voiskounsky, A. E. (2011). Technologies of virtual reality in psychology of sport of great advance: Theory, practice and perspectives. *Psychology in Russia: State of the Art*, *4*, 129–154.