Attending a concert reduces glucocorticoids, progesterone and the cortisol/DHEA ratio

SHORT COMMUNICATION

There is a fast-growing interest in the impact of the arts on the health and wellbeing of individuals. The past two decades have seen a burgeoning of studies exploring how arts engagement, from therapy to education to everyday settings, can impact on psychological and physiological health parameters [1]. In particular, there have been increasing numbers of studies examining the impact of both making and listening to music on biological response, with recent reviews highlighting the effects of music variously on hormones, neurotransmitters, and cells and proteins within the immune system [2].

Over 30 controlled studies examining biological responses to music listening have been reported in the literature [2]. However, these have all been carried out either under laboratory conditions or in clinical settings, such as hospital waiting rooms, and have nearly all involved recorded music rather than live performance. To date, there have been no studies exploring the impact of listening to live singing through attending a public concert. This is despite the significant attention given to the impact of attending cultural events and visiting cultural venues among policy makers [3,4].

Our study aimed to explore the impact of attending a live, public concert on steroid hormone response. As this was the first study to investigate the impact of listening within a cultural space, we ran the experiment twice, four months apart, in two separate venues. For both concerts, the performers, conductor, length of concert, genre of music and key pieces within the programme were kept the same in order to replicate the listening experience as closely as possible.

Immediately before each concert and in the interval 60 minutes later, participants recorded demographic data such as their age, sex and musical experience. They were also asked to provide a saliva sample through a straw into a polypropylene cryovial. Subsequently, samples were stored at -20°C for 3 weeks prior to analysis using high performance liquid chromatography-tandem mass spectrometry (LC-MS/MS) with Atmospheric Pressure Chemical Ionization (APCI) coupled with on-line solid phase extraction (SPE), for the steroid hormones cortisol, cortisone, dehydroepiandrosterone (DHEA), progesterone and testosterone. Cortisol and cortisone are both glucocorticoids involved in stress response; DHEA is a steroid hormone involved in immune enhancement; and higher ratios of cortisol/cortisone and cortisol/DHEA are indicative of higher stress levels. Progesterone and testosterone are both sex hormones also involved in stress response. Biological data were logarithmically transformed to correct for positive skew and analysed using a repeated measures analysis of variance (ANOVA) comparing changes across time (pre- versus post-performance) and, in the case of DHEA, between men and women. Correlation analyses were performed using Pearson's product-moment correlation coefficient.

Concert 1. Forty-nine adults attending a performance of music by composer Eric Whitacre were recruited for the study: 15 men and 34 women (mean age=38.6 years, SD=15.0, range 18-59). They were volunteers from among an audience of 700 people at the London concert venue Union Chapel. The participant group was representatively mixed in their musical backgrounds and experiences, comprising regular concert-goers attending up to 120 concerts per year and those who had not attended a concert in the previous six months, as well as people who had no

experience making music themselves and some with as long as 57 years' experience. When asked to rate how familiar they were with the music of Eric Whitacre, the mean familiarity was 6.79 (of 10, SD=2.92, range 1-10).

Across the 60 minutes, there was a drop in glucocorticoid levels, with significant decreases in cortisol ($F_{1,39}$=23.251, p<0.001), cortisone ($F_{1,48}$=27.286, p<0.001) and the cortisol/cortisone ratio ($F_{1,39}$=9.604, p=.004) (see figure 1A). There was no significant change in DHEA nor for the cortisol/DHEA ratio, but there was a near-significant time x sex interaction for DHEA, with men experiencing an increase across the performance and women a decrease. However, retrospective power calculations indicated there were insufficient participant numbers to assess DHEA robustly. No significant changes were found in testosterone and progesterone, although the latter showed signs of a downwards trend from pre- to post-performance. Overall, correlation analyses revealed that these results were not statistically related to age, sex, familiarity with the music, musical experience or frequency in attending concerts.

Concert 2. Sixty-eight adults volunteered to take part from among an audience of 800 attending a matched performance of Eric Whitacre's music at Gloucester Cathedral, given as part of the 2015 Cheltenham Music Festival: 26 men and 42 women (mean age=55.01 years, SD=13.8, range 18-82). The sample size was increased intentionally to allow for greater power in the statistical analyses. Again, the participant group was representatively mixed in their musical backgrounds and experiences, comprising regular concert-goers attending up to 40 performances per year and those who had not attended a concert in the previous six months, as well as people who had no experience making music themselves and some with as long as 73 years' experience. When asked to rate how familiar they were with the music of Eric Whitacre, the mean familiarity was 5.31 (of 10, SD=3.10, range 1-10).

Across the 60 minutes, there was a drop in glucocorticoid levels, with significant decreases in cortisol ($F_{1,64}$=27.055, p<0.001), cortisone ($F_{1,65}$=66.003, p<0.001) and the cortisol/cortisone ratio ($F_{1,64}$=6.024, p=.017), replicating the findings from Concert 1 (see figure 1A). Also as in Concert 1, there were no significant changes in DHEA from pre- to post-performance; however, with greater statistical power, the cortisol/DHEA ratio showed a significant decrease over time ($F_{1,62}$=27.846, p<0.001) (see figure 1C). Furthermore, the analyses showed a significant time x sex interaction for DHEA ($F_{1,62}$=6.295, p=.015), with post-hoc pairwise comparisons revealing a non-significant decrease for women (p=.144) but a significant increase for men (p=.047) (see figure 1B). Moving beyond glucocorticoids, there was also a drop in progesterone ($F_{1,59}$=14.832, p<.001) (see figure 1C); however, as in Concert 1, no changes were found in testosterone levels.

For the two concerts, our results suggest that attending a live performance leads to lower secretion of glucocorticoids and a reduced cortisol/cortisone ratio, indicating lowered biological stress. These results are in line with 22 previous studies showing that listening to music in the controlled setting of either a laboratory or a hospital can reduce cortisol levels [2]. However, this study has also extended previous results. Firstly, it showed that decreases are also found in the partner glucocorticoid cortisone, which demonstrates a wider glucocorticoid involvement. Secondly, this is the first time that such decreases have been found not only in tightly controlled laboratory settings but in the naturalistic setting of a public concert in a cultural space.

Furthermore, there are indications from these results that concert engagement can also lead to changes in more general steroid hormone response, including DHEA and progesterone. DHEA is the most abundant steroid hormone in the body. Acting as an antagonist of glucocorticoids, it leads to enhanced immune function, lowered cholesterol and improved muscle deposition and has been associated with emotional responses such as 'warm-heartedness' [5]. Under stressful conditions, as cortisol increases, DHEA has been found to decrease, leading to an overall increase in the cortisol/DHEA ratio. Conversely, as people relax, cortisol goes down, DHEA goes up and this ratio decreases [6]. The finding from Concert 2 of the decrease in the cortisol/DHEA ratio is further evidence of a general relaxation effect of attending a live performance. It is intriguing that, despite experiencing a decrease in this ratio, men actually

experienced an increase in absolute levels of DHEA while women's levels decreased. This may suggest that the women experienced greater relaxation than men when attending the concert, but as there was no sex differences in any of the other measures, this is clearly not the complete answer and further investigation is needed in future studies.

There has been less research into the effects of stress and relaxation on progesterone and more conflicting results. Some studies have proposed that progesterone increases in response to feelings of closeness [7], while others have found no association [8]. However, there have been suggestions that progesterone and cortisol increase and decrease together and are both released following adrenal activation, with progesterone being capable of acting as a negative feedback mechanism for down-regulating stress response [9]. In this study, there was no correlation between progesterone and cortisol, but the two did decrease together, supporting the idea that progesterone may have been involved in a relaxation response.

This is the first preliminary evidence that attending a cultural event can have an impact on endocrine activity. It is of note that none of these biological changes were associated with age, musical experience or familiarity with the music being performed. This suggests there is a universal response to concert attendance among audience members. Fancourt *et al.* have demonstrated that, for adults taking part in a 6-week music making intervention, reductions in glucocorticoid activity are matched with increases in immune response, most notably increases in cytokines and chemokines responsible for communicating between cells and within the brain [10]. Further research is needed to ascertain whether such an inverse response also occurs in participants attending a cultural event, such as a concert, and consequently whether such cultural engagement over time could lead not only to reductions in biological stress response but also to enhancements in immune activity.

There are several limitations to this study. It was uncontrolled and instead relied on replication to confirm findings. The study also focused solely on the effects of relatively calm, classical music; more research will be needed to ascertain whether other genres of music elicit different effects or whether attending other types of cultural events has different endocrine impact. Nevertheless, this study opens up the question of how engaging with music and the arts in cultural settings can influence biological and psychological states and, consequently, the potential of cultural events to enhance people's broader health and wellbeing.

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Ethical approval
The study was approved by Conservatoires UK ethics committee, and participants provided informed consent prior to participating.

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Competing interests
None declared.

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