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The joy of heartfelt music: An examination of emotional and physiological responses

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ABSTRACT

Music-listening can be a powerful therapeutic tool for mood rehabilitation, yet quality evidence for its validity as a singular treatment is scarce. Specifically, the relationship between music-induced mood improvement and meaningful physiological change, as well as the influence of music- and person-related covariates on these outcomes are yet to be comprehensively explored. Ninety-four healthy participants completed questionnaires probing demographics, personal information, and musical background. Participants listened to two prescribed musical pieces (one classical, one jazz), an "uplifting" piece of their own choice, and an acoustic control stimulus (white noise) in randomised order. Physiological responses (heart rate, respiration, galvanic skin response) were recorded throughout. After each piece, participants rated their subjective responses on a series of Likert scales. Subjectively, the self-selected pieces induced the most joy, and the classical piece was perceived as most relaxing, consistent with the arousal ratings proposed by a music selection panel. These two stimuli led to the greatest overall improvement in composite emotional state from baseline. Psycho-physiologically, self-selected pieces often elicited a "eustress" response ("positive arousal"), whereas classical music was associated with the highest heart rate variability. Very few person-related covariates appeared to affect responses, and music-related covariates (besides self-selection) appeared arbitrary. These data provide strong evidence that optimal music for therapy varies between individuals. Our findings additionally suggest that the self-selected music was most effective for inducing a joyous state; while low arousal classical music was most likely to shift the participant into a state of relaxation. Therapy should attempt to find the most effective and "heartfelt" music for each listener, according to therapeutic goals.

1. Introduction

Music forms an integral and powerful part of human experience (Trappe, 2012a). Not only can music invoke a large spectrum of emotions, but it can regulate arousal, enhance executive skills and concentration, improve sleep quality, and strengthen social connectedness (Harmat et al., 2008; Koelsch, 2010; Lesiuk, 2010). Indeed, neuroimaging and lesion studies have confirmed responses to music extending far beyond the auditory cortex, activating a complex neural network critical to the regulation of emotion and cognition (Ball et al., 2007; Brown et al., 2004; Gosselin et al., 2006; Koelsch et al., 2006).

Music has a therapeutic tradition dating back to antiquity (Maratos et al., 2008). Simply listening to music has documented effects on mood and wellbeing in healthy adults (Sandstrom and Russo, 2010), and on mood regulation in adolescents (Saarikallio and Erkkilä, 2007). Music-listening has also been found to be particularly helpful in improving emotional states for those with low physical and psychosocial functioning, including older patients (Gotell et al., 2002; Lou, 2001), the medically ill (Li and Dong, 2012; Nilsson, 2009; Voss et al., 2004; Freeman et al., 2006), in the context of surgery (Bringman et al., 2009), and patients with depression (Riganello et al., 2010; Trappe, 2012b). The neural mechanisms underpinning the effects of music-based therapies across a range of clinic contexts are increasingly being explored (Särkämö et al., 2008; O'Kelly et al., 2016; Särkämö et al., 2016).

The most salient goal of music-listening in therapy is a change in mood-state (North et al., 2000; Sloboda, 2011). As it is predominantly non-intrusive, non-harmful, inexpensive, and useful for both short- and long-term treatment, patients often prefer music-listening to pharmaceutical alternatives, which maximises compliance (Silverman, 2008). Moreover, its impressive adaptability across individuals and contexts can empower individuals to take control of their own therapy outside of the medical setting (Brandes et al., 2010; Chan et al., 2009).

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Despite reports that music-listening can be a powerful remedial tool (Silverman, 2008), quality evidence supporting its utility in the treatment of psychiatric conditions (including depression) is surprisingly scarce (Ellis et al., 2012). In this context, music has predominantly been evaluated as an adjunct to pharmaceutical and behavioural interventions, or to 'care as usual' (e.g. Erkkilä et al., 2011), and often as a last resort (Trappe, 2012a). This bias might be justified by the limited number of well-controlled studies confirming music-listening as a valid treatment in its own right, and those exploring the effects of music on the individual beyond self-report (Chanda and Levitin, 2013; Iwanaga and Moroki, 1999; Orini et al., 2010; Silverman, 2008). This point is highlighted by a Cochrane review (Maratos et al., 2008) that failed to find a sufficient number of suitable studies to enable a meta-analysis.

Many studies have examined autonomic responses to music, including heart rate (HR), and galvanic skin response (GSR), as sensitive markers for emotional arousal (Bernardi et al., 2006; Hodges, 2009; Christensen et al., 2014; O'Kelly, 2016); however, these studies have yielded inconsistent findings (Ellis et al., 2012; Koelsch and Jancke, 2015). It has been suggested that simply employing *average* measures of autonomic activity (e.g., average HR) fails to capture the complexities of dynamic physiological responding (Ellis et al., 2012). More recently, studies utilizing parameters of beat-to-beat heart rate variability (HRV) have claimed to more adequately capture the dynamic responsivity and adaptability of the listener (Roque et al., 2013; Orini et al., 2010).

HRV reflects the interaction of and balance between sympathetic and parasympathetic branches of the autonomic nervous system (ANS), which both innervate the heart. As conceptualised in a model of "neurovisceral integration" (Thayer and Lane, 2009) their interaction is part of a complex, dynamic network of afferent and efferent signals, which causes the inter-beat interval to be in constant flux. In healthy individuals, autonomic functions are flexible and adaptive to environmental change, reflected in relatively high HRV. Conversely, low HRV indicates a rigid system, and has been linked to a growing spectrum of pathologies, including psychiatric, inflammatory, and cardiovascular conditions (Beaumont et al., 2012; Kemp et al., 2010; Ellis et al., 2012). HRV is thus understood to provide a valid and sensitive measure of wellbeing. In the context of studying the beneficial effects of music on health, HRV measures may provide a useful means to reveal the dynamic autonomic forces underlying such benefits (Ellis et al., 2012).

A number of studies have included HRV in their exploration of the effects of music-listening on cardiac parameters (Akar et al., 2015; Bernardi et al., 2006; Da Silva et al., 2014; Krabs et al., 2015; Olsson and Von Scheele, 2011; Orini et al., 2010; Pérez-Lloret et al., 2014; Roque et al., 2013; Wang et al., 2011; White, 1999; Zhou et al., 2010). Yet studies comparing the effects of music on both HRV and mood are scarce. Limited studies have suggested that increased HRV with music-listening precedes, or even mediates, changes in mood-state (Ellis et al., 2012; Sokhadze, 2007). Others have reported correlations between the two and attempted to interpret findings that might reflect sympathetic versus parasympathetic activation (Chiu et al., 2003; Iwanaga et al., 2005; Iwanaga and Tsukamoto, 1997; Lee et al., 2012; Li and Dong, 2012). Of concern is the paucity of studies in this area that have employed standardised methodologies, adequate sample-sizes, consistent musical categories/descriptions, and generalizable findings. Furthermore, none has adequately addressed the influence of person-related (e.g., stress level, personality, musical preference and familiarity) or music-related (e.g., arousal, valence) variables (Chamorro-Premuzic and Furnham, 2007; Do Amaral et al., 2015; Patel et al., 2013; Rentfrow et al., 2011; Vuoskoski and Eerola, 2011). Thus, while music has intuitive therapeutic potential, a stronger and more comprehensive evidence-base is needed before it may be incorporated more widely into medical care.

The aim of the current study was to investigate changes in emotional and physiological responses (including HRV) to different musical stimuli, and to examine the relationship between the two. Further, the study explored the influence of person- and music-related variables, including the effect of "self-selection" of music, on outcomes.

2. Material and methods

2.1. Participants

Ninety-four healthy participants were recruited from staff and students at the University of New South Wales (UNSW), Sydney. Exclusion criteria included self-reported hearing impairment, significant medical illness (e.g., heart disease), and use of medications known to affect autonomic functioning (e.g., beta-blockers, benzodiazepines, corticosteroids). The study protocol was approved by the relevant institutional Human Research Ethics Committee (Ref#HC13063) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Informed written consent was obtained from all participants prior to testing.

2.2. Study design

All participants completed the study individually under controlled laboratory conditions in the early afternoon between 1 PM and 4 PM. On arrival, participants completed self-report questionnaires before being seated in a semi-reclined lounge chair and connected to non-invasive physiological sensors. After completing a short baseline questionnaire probing their current emotional state, participants were instructed to sit back and close their eyes. Four acoustic pieces, each five minutes in duration, were presented in randomised order over headphones at a comfortable volume. Participants were instructed to "listen and experience" each stimulus, and afterwards to rate their current state (on Likert scales) regarding how relaxed, engaged, joyful, sad, and anxious they felt (0 = "not at all"; 10 = "extremely").

2.3. Self-report measures

Questionnaires were used to obtain demographic and health data, and information relating to musical background (e.g., musical preference, training, experience); the Perceived Stress Questionnaire (PSQ; Levenstein et al., 1993) measured current life stress; and the Kessler 10 (K10; Kessler et al., 2002) assessed current psychological distress. The NEO Five-Factor Inventory (NEO-FFI-3; Costa and Mccrae, 2010) provided a measure of personality traits along five continua: neuroticism/emotionality, extraversion, openness, agreeableness and conscientiousness.

2.4. Physiological measures

HR was monitored by via three-lead ECG with standard Ag/AgCl chest electrodes. Respiration was measured using a strain gauge transducer (Pneumotrace, California, USA) placed around the chest. Finger electrodes were placed around the index and ring fingers of the non-dominant hand to measure GSR (in microSiemens; μS). All sensors were connected to a computer-based data acquisition system (Power Lab 16/30SP, ADInstruments, Bella Vista, Australia) sampling at 1 kHz and analysed using LabChart Pro v7 and its HRV module. Raw data were used to calculate average responses to each stimulus. As recommended in the standard reference paper for the assessment of HRV for research and clinical use (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996), HRV was calculated from artefact-free ECG recordings of 5 min length. The high frequency spectral component (HF: 0.15–0.40 Hz; normalised units), a well-established marker of cardiac vagal activity used for analyses (Task Force, 1996).

2.5. Acoustic stimuli

To select appropriate musical pieces, a panel of five academics from