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Full Length Review

The psychoneuroimmunological effects of music: A systematic review and a new model

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ABSTRACT

There has been a growing interest over the past decade into the health benefits of music, in particular examining its psychological and neurological effects. Yet this is the first attempt to systematically review publications on the psychoneuroimmunology of music. Of the selected sixty-three studies published over the past 22 years, a range of effects of music on neurotransmitters, hormones, cytokines, lymphocytes, vital signs and immunoglobulins as well as psychological assessments are cataloged.

Research so far points to the pivotal role of stress pathways in linking music to an immune response. However, several challenges to this research are noted: (1) there is very little discussion on the possible mechanisms by which music is achieving its neurological and immunological impact; (2) the studies tend to examine biomarkers in isolation, without taking into consideration the interaction of the biomarkers in question with other physiological or metabolic activities of the body, leading to an unclear understanding of the impact that music may be having; (3) terms are not being defined clearly enough, such as distinctions not being made between different kinds of stress and 'music' being used to encompass a broad spectrum of activities without determining which aspects of musical engagement are responsible for alterations in biomarkers.

In light of this, a new model is presented which provides a framework for developing a taxonomy of musical and stress-related variables in research design, and tracing the broad pathways that are involved in its influence on the body.

1. Introduction

Research into the health benefits of music has rapidly expanded over the last decade, driven both by a desire to understand more about the inner workings of music on the brain and body and in order to see how music can be better applied in community, educational and, in particular, healthcare settings (MacDonald et al., 2012). The scientific study of music has gradually probed deeper into the mechanisms underlying the perception and processing of music, exploring the psychology of music (Hallam et al., 2008) and the cognitive neuroscience of music, sometimes referred to as 'neuromusicology' (Peretz and Zatorre, 2003). This depth of enquiry has included the neurological basis for music-induced emotions (e.g. Trainor and Schmidt, 2003; Juslin, 2009), the neurobiology of certain aspects of music such as harmony (e.g. Tramo et al., 2003) and the neuroanatomy of music performance (Parsons, 2003). And breadth of study has ranged from the perception of folk songs inside the womb (Lemos et al., 2011), to the performance of opera on concert platforms (Kenny et al., 2004), and the use of pop music in operating theatres (Pluyter et al., 2010).

Recently, there has been interest in the chemical and biological effects music, summarized in two reviews. Chanda and Levitin (2013) presented an overview of the neurochemical effects of music, in which they made reference to immunological changes. Their research has gained attention in the popular press as apparent evidence that music can boost the immune system and hold the key to wellbeing. However, their overview was not systematic and due to the focus specifically on neurochemical responses, it only reviewed half the studies pertaining to the psychoneuroimmunology of music and referred to a third of the immune biomarkers that have been tested with respect to music.

A second recent article, (Kreutz et al., 2012), overviewed the psychoneuroendocrinological effects of music in order to test the assumption 'that psychological processes associated with musical experiences lead to changes in the hormonal systems of brain and body' (Kreutz et al., 2012, p. 457); something they label as 'perhaps one of the most fascinating areas of future research'

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(Kreutz et al., 2012, p. 471). But as with the study by Chanda and Levitin (2013), their overview was not systematic and examines the impact of music on just five biomarkers (cortisol, oxytocin, testosterone, beta-endorphin and immunoglobulin A). And neither study discussed parallel physiological or psychological findings. This led Kreutz et al. (2012, p. 471) to conclude that 'much more research efforts should be undertaken to ascertain the emerging patterns of changes that were reported in the available literature'.

Consequently, a comprehensive systematic review into music and psychoneuroimmunology is timely. This would aim to consolidate key findings to date, compare theories concerning the mechanisms behind music's effect, and highlight gaps in current knowledge, helping to guide the focus of future studies. In particular, a systematic review could identify any challenges currently hindering the progress of research and, by presenting a new model, help overcome these obstacles.

As the term 'music' can be used broadly to refer to the materials and approaches used in a number of different interventions, it is relevant to define some of its parameters more specifically. This is because the style of music, the way it is delivered and personal attitudes to it may be crucial variables with the potential to alter psychoneuroimmunological responses. So as well as discussing these variables in relation to specific studies, it is useful for clarification to set them out up front.

The degree of involvement of a participant in music can vary substantially. Passive involvement may consist of a participant sitting in silence to listen to either live or recorded music. Active involvement can range from music education (such as instrumental lessons), to participatory sessions (such as group workshops), to therapy (where music is used as a tool for communicating thoughts or emotions) (Ockelford, 2013). The music used in any of these interventions can be compositions in a wide range of genres (including classical, jazz or popular), specially composed (such as designer relaxation music) or improvised in different styles. It can be selected either by participants or investigators. Some music may be arousing, involving faster tempi, louder volume and disjunct melodic patterns. Other music may be inherently calming, involving slower tempi, a quieter volume and more even patterns (Scherer and Zentner, 2001).

Music can also influence our brains and bodies in different ways: aurally, via direct auditory perception; physically, through the movements of muscles and sensory experience of vibrations involved in the production and reception of music; socially, as many musical activities can bring with them additional psychosocial experiences such as increases in confidence, social participation and self-esteem; and personally, as music will be approached differently by each individual, depending on whether they like or dislike the music; whether they are familiar with the style, genre or work; or whether they feel any particular emotional connection to it (Juslin et al., 2001).

The effects of music will vary enormously depending on how it is employed. Consequently, it is necessary to be rigorous in identifying which of its features are responsible for sensitive psychological and biological changes. In light of this, more details on the nature of interventions are given when discussing the studies included in this review.

2. Methods

To assess the current state of research on the interactions between music and psychoneuroimmunology, systematic database searches were conducted of Cochrane, Web of Science, PubMed, PsychINFO, Science Direct and Sage Journals, as well as manual searches of personal libraries. These sources were chosen as they were felt to give a comprehensive overview of the subject area, including in their compass journals from the disciplines of psychology, immunology, music therapy, music psychology, neuroscience, medicine, life sciences, social sciences and nursing, among others. Searches were made using the keyword 'music' paired with other keywords pertaining to psychoneuroimmunology, including 'immune', 'psychoneuroimmunology', 'endocrinology', 'cortisol', 'cytokine(s)', 'lymphocyte(s)', 'immunoglobulin(s)', and 'interleukin(s)'. The search returned 1938 articles, ranging from 1953 to 2013. After removing 567 duplicate studies, a total of 1371 studies remained. (see Fig. 1).

Titles, abstracts and keywords were considered, and selection for inclusion in the review was made on the basis of five criteria. First, articles had to pertain to a new study. Reviews were read for their references which brought to light some additional relevant studies to be considered, but were not included themselves. Second, studies had to be controlled in order that the significance of alterations in biomarkers could be accurately assessed. Third, studies pairing music simultaneously with other stimuli such as exercise, progressive relaxation or guided imagery were only included if they also contained a test incorporating just music on its own, as it was felt that the other stimuli could confound results. Fourth, studies had to be testing for potential positive effects of music, even if their results were negative or nonsignificant. Studies were excluded if they deliberately tried to cause negative responses or distress through the use of noise, loud volumes or heavy beats. Finally, it was decided that studies involving animals rather than humans should be omitted from the review. Although working with animals can enable highly controlled trials to be undertaken and address specific research questions, as advocated by Rickard et al. (2005), even they acknowledge that extrapolating results from animal studies back to humans carries a number of limitations. Overall, this search was 'data-driven' in that a large number of keywords were included to identify a broad spectrum of studies, which were then scrutinized more closely against the inclusion criteria to assess their relevance to this review.

The selected studies that satisfied these criteria were then reviewed in full for key information including year of publication, country of origin, study design, sample size, biomarkers monitored, genre of music used, mode of music delivery, and depth of immunological discussion. There was a great deal of variation in the methods applied in these studies. In light of this, it was decided

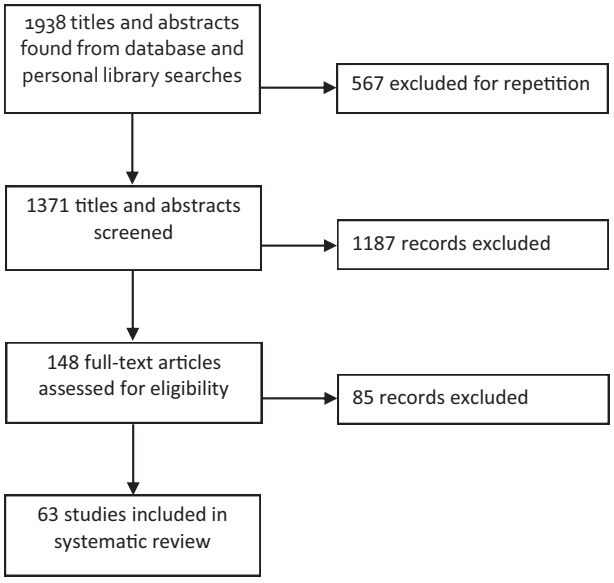

Fig. 1. Collection of studies for inclusion in systematic review.