Sound sleep: lullabies as a test case for the neurobiological effects of music

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Abstract

Music is part of the cultural practice, and at the same time is interwoven with biology through its effects on the brain and its likely evolutionary origin. Studies on music, however, are traditionally based in the humanities, and often carried out in a purely historical context, without much input from neuroscience and biology. Here we argue that lullabies are a particularly suited test case to study the biological vs. cultural aspects of music.

Commentary

Music is traditionally studied in historical contexts as part of the cultural practice, but also regarding its social and cultural contexts (see amongst others Kramer, 1990, 2001). A fundamental question tapping into diverse fields of research is how music affects the listener. This has been examined from a historic and socio-cultural perspective (e.g. Kassabian, 2013), but gained particularly interest in psychology and biology (Prince, 1972). Three distinct underlying dimensions for listening to music have been proposed: to achieve self-awareness, to express social relatedness, and to regulate mood and arousal (Schäfer et al., 2013). In particular the latter requires biological investigations, which, however, are still sparse.

A well-known example of the effects music can have on the human mind, behavior, and brain are the soothing effects of lullabies, which are known and used across human cultures and historical ages. In their target articles, Savage et al. (2020) and Mehr et al. (2020) discuss lullabies for infants as examples for music that especially fosters bonding, showing evidence for both a one-by-one level bonding promoting group cohesion, and evidence that this effect can be found on a cross cultural level. Musical features in lullabies throughout centuries show cross-culturally consistent aspects fostering the feeling of being socially secure, which goes together with soothing effects for the babies, and they even work in the case of unfamiliar foreign lullabies (see e.g. Bainbridge et al., 2020; Sands & Sekaquaptewa, 1978; Spitz, 1979; Trehub et al., 1993). This suggests that musical effects likely involve a strong biological component. In fact, lullabies can be seen as particularly suited to be studied as examples for musical effects on the biological level: their intentional aim is a change in the physiological state of the recipient, from wakefulness to sleep.

Importantly, lullabies work for infants as well as for adults – the market for relaxation/relax music/sounds, sleep (aid) music or deep/easy/healing sleep music has again come into focus and is commercially growing with the COVID-19 crisis in 2020, being reviewed regularly also in major

newspapers (see e.g. Chow, 2020; Times Staff, 2020). From a practical research perspective, the effects of lullabies can thus conveniently be studied in the most easily available research population, namely young adults.

That music can indeed exert 'somnogenic' effects is backed up by a body of empirical research. A number of studies have demonstrated therapeutic effects of music in cases of sleep disorders (for a review and meta-analysis see Wang et al., 2014; Jespersen et al., 2015; Feng et al., 2018). Also in healthy volunteers, music has been shown to affect sleep quality as assessed by questionnaires (e.g. Lamboley, 1998; Field, 1999; Johnson, 2003; Lai & Good, 2005; Harmat et. al., 2007; Chang et al., 2012; Trahan et al., 2018).

As a more objective measure, several studies in recent years have used polysomnography to test the effects of music on the brain (e.g. Loewy et. al., 2005, DuRousseau et. al., 2011; Chen et al., 2014; Cordi et al., 2019). Sleep is a physiologically exceptionally well characterized state in which even subtle changes can be robustly detected, in absence of motor artifacts that would be difficult to avoid in awake music listeners. Oscillatory patterns in the sleep EEG such as an increase in theta activity and a disappearance of alpha activity can be used as objective markers of the process of falling asleep, while slow wave activity can be used as an objectively quantifiable indicator of sleep depth (Lazic & Ogilvie 2007; Chen et al. 2014; Cordi et al. 2019). Beyond the effects of music before sleep and during transition phases, different kinds of acoustic stimulation are increasingly used during sleep to enhance sleep depth (Ngo et al., 2013) or cognitive functions of sleep (Hu et al., 2020).

Beyond these advantages of lullabies as test cases for the neurobiological effects of music, two obstacles have to be noted. First, classical music repertoire includes an abundance of lullabies, and the contemporary music market provides an even broader plethora of soothing music. The choice for specific lullaby candidates is thus often based on heuristics rather than systematic evaluation (Cordi et al., 2019; Loewy, 2020; but see Trahan et al., 2018). Second, full polysomnography in the sleep laboratory as the gold standard of sleep research is effortful and costly, thus restricting the scope of a more systematic investigation. However, recent advances in sleep technology and computer science provide promising options to overcome these limitations: a growing market of sleep wearables including convenient sleep EEG headbands allow for the large-scale, low-cost acquisition of longitudinal sleep data with considerable samples sizes (Depner et al., 2019; Scott et al., 2020). Resulting big sleep data sets can in turn be processed with (semi-)automatic machine learning-based analysis pipelines (see e.g. sleeptrip.org). These possibilities enable novel interdisciplinary approaches to the study of music: historically, sociologically, and psychologically informed sets of candidate lullabies can be tested in large populations using wearable sleep recording technology. The resulting large-scale data sets can be analyzed with machine learning approaches to extract particularly effective somnogenic musical features, which in turn can be fed back into traditional musicological analysis. Overall, lullabies can thus be considered an ideal musical genre to elucidate the associations and differences between neurobiological and cultural aspects of music.

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Conflicts of Interest statement

none

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