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Social pleasures of music

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Humans across all societies engage in music-listening and making, which they find pleasurable, despite music having does not appear to have any obvious survival value. Here we review the recent studies on the social dimensions of music that contribute to music-induced hedonia. Meta-analysis of neuroimaging show that listening to both positively and negatively valenced music elicit largely similar activation patterns. Activation patterns found during processing of social signals and music are however remarkably similar. These similarities may reflect the inherent sociability of music, and the fact that musical pleasures are consistently associated with autobiographical events linked with musical pieces. Brain's mu-opioid receptor (OR) system governing social bonding also modulates musical pleasures, and listening to and making of music increase prosociality and OR activity. Finally, real or simulated interpersonal synchrony signals affiliation, and accordingly music-induced movements increase social closeness and pleasant feelings. We conclude that these links between music and interpersonal affiliation are an important mechanism that makes music so rewarding.

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Introduction

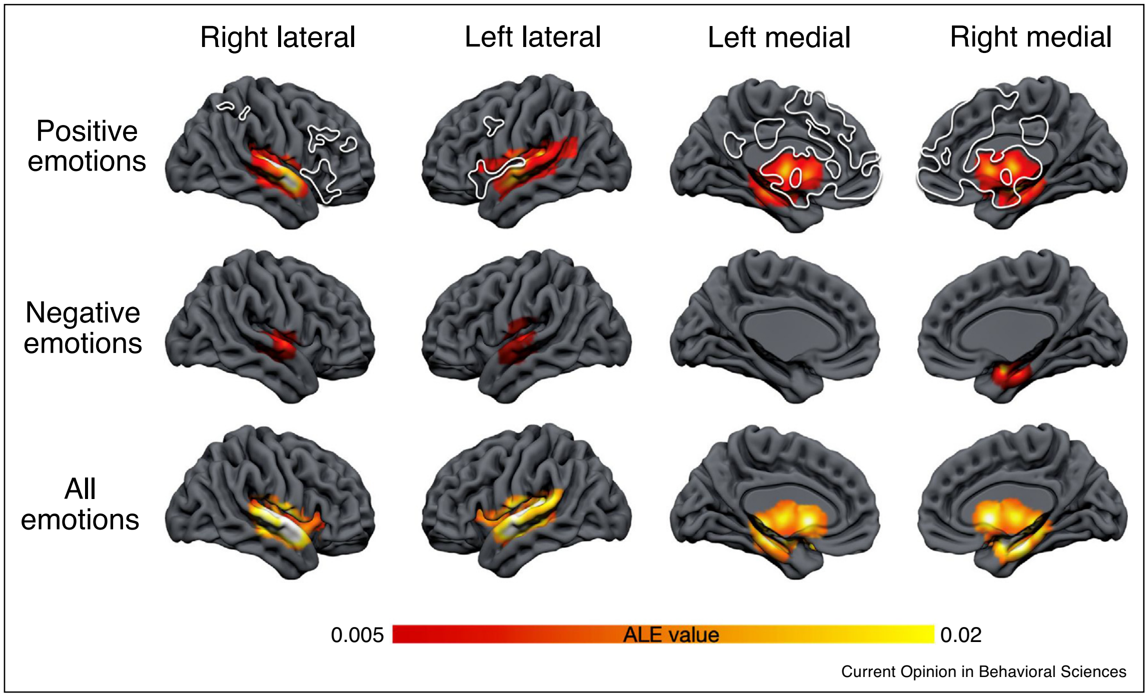
Human life is embedded in music. We sail through the streets with headphones on our ears, sit in the office with music blasting from the speakers, and sing, dance and party through the evenings in the midst of a never-interrupting emotional soundtrack of our life. Emotions support survival by motivating adaptive behaviors and help maintaining physiological homeostasis [1], and positive emotions specifically promote approach motivation towards opportunities for improving survival odds, such as shelter, feeding, and increasing chances for reproduction. Music is however a curious pleasure. Emotional responses to music show many hallmarks of emotions in general including distinct subjective experience, emotional expression, action tendencies, changes in the autonomic nervous system activation [2] and distinct effects on thought and judgement [3], despite the fact that music itself serves no obvious adaptive value. Here we review recent studies on the social dimensions of music that contribute to music-induced hedonia, and discuss how sociability is an important candidate reasons for the pleasure imbued in music.

Musical pleasures in the brain

Vivid emotional terminology is used for describing music by both laypersons (e.g. 'triumphant', 'bluesy', or 'uplifting') as well as professional musicians ('maestoso', 'allegrezza', 'scatenato'). Music evokes a wide array of subjective feelings, and large-scale cross-cultural work shows that some features of emotions are described and understood in similar fashion across distant cultures [4••,5]. But if music does not serve any immediate adaptive value, does it consistently engage the brain's emotion circuit similarly as survival-salient hedonic signals? To test this, we conducted a meta-analysis (**Supplementary Methods** and **Figure S-1** in Supplementary material) of BOLD-fMRI responses to (i) music-evoked pleasure, (ii) music-evoked displeasure and (iii) music-evoked emotions in general.[6] Altogether 51 studies, 1038 subjects, and 786 activation foci were included in the analysis **Table S-1** in Supplementary material). This analysis (Figure 1) revealed positive-emotion-related activations in bilateral temporal auditory cortical areas, ventral and dorsal striatum and amygdala, and hippocampus. Negative musical emotions elicited a similar activity pattern, with the exception of no activations in striatum and thalamus, and with auditory-cortical effects being right-lateralized. When all musical emotions were analysed together the results were similar to those for the positive emotions, with the exception of lacking thalamic cluster. This analysis yielded two important findings. First, negative and positive music-induced emotions evoke remarkably similar activations, with the exception of striatal activation. Second, the effects of

[6] Existing data did not pertain a finer-grained meta-analyses of for example, specific discrete emotion categories.

Figure 1



Brain regions responding consistently to music-evoked positive **(a)** and negative **(b)** emotions and to all emotions irrespective of valence **(c)** in activation likelihood estimation (ALE) meta-analysis. The white outline shows brain regions responding to *reward* per NeuroSynth meta-analysis ($p < 0.01$, retrieved June 23rd 2020).

music-induced positive emotions are distinct from those triggered by other rewards (white outline on the figure); most salient feature being the lack of pleasurable-music-induced activations in fronto-cingular and parietal areas as well as midbrain activations.

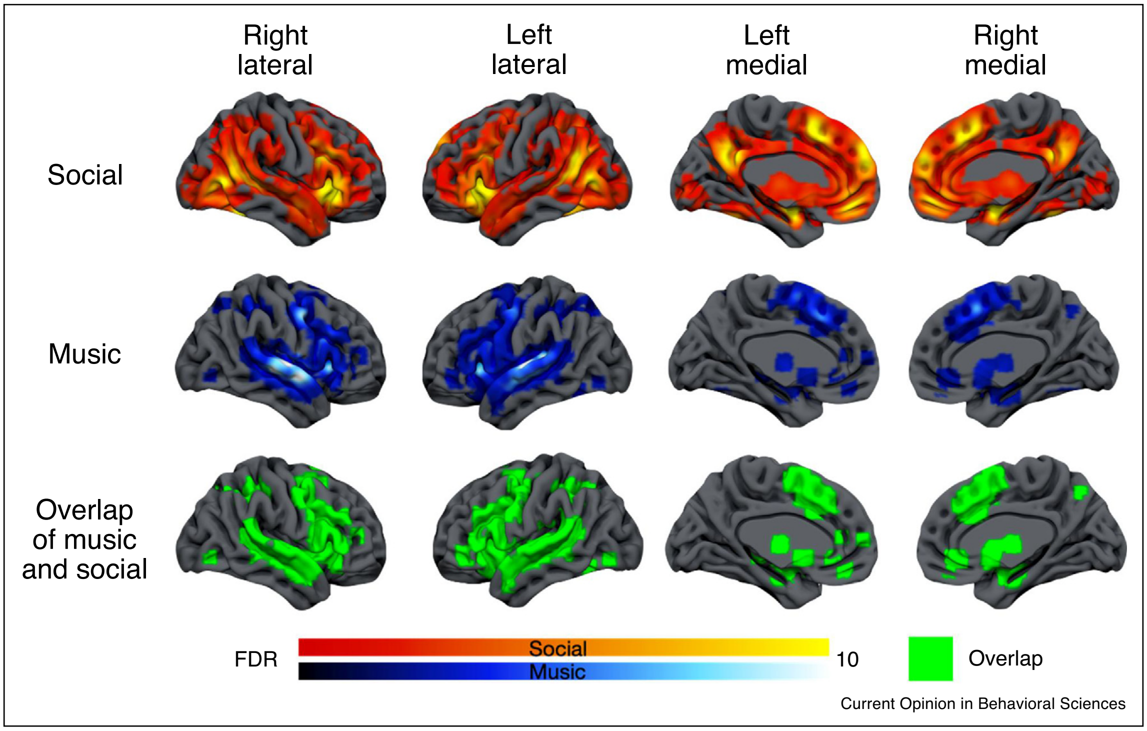
This relative unspecificity of brain basis of positive and negative emotions accords with statistical pattern recognition studies. This line of work shows that emotions evoked by non-musical stimuli [20–22] as well as spontaneously occurring emotional states during resting state [23,24] are associated with discrete neural activation patterns in the cortex and in limbic and paralimbic structures. In contrast, even in high-powered pattern recognition studies cannot decode emotions beyond the, auditory and motor cortex [25•,26,27]. Studies on vocal emotional expressions yield comparable results, with above-chance level classification accuracy primarily in the auditory cortex [28–30]. This suggests that, outside the auditory cortices, musical emotional representations emotional are less categorical in the brain than those for biologically more salient emotions. This obviously begs the question 'why'?

One explanation is that there is no innate coupling between specific musical exemplars and survival-salient responses, except perhaps some very low-level universals in harmony, rhythm and acoustics [31]. Thus music-evoked emotions have a significant learning-based component. This leads to more idiosyncratic emotional responses in the brain, and due inconsistent brain responses across individuals their classification is impossible at group level. Another possible explanation is the ubiquitous pleasantness of music: even though music can be described in a wide variety of positive (e.g. tender, romantic, joyful) and negative (sad, fearful, suspenseful, creepy) terms, all these categories typically receive high 'liking' ratings [27], thus the intrinsic coupling between music and pleasure makes the music-evoked emotions categorically diffuse. We next explore the possibility that this ubiquitous pleasantness of music stems from role in social bonding.

Social pleasures of music

Music listening has been fundamentally social until fairly recently when storing acoustic information became possible. First mechanical musical instruments were developed around as late as 1000AD, music boxes become available around late 1700, and analogue recording and playback of voice was invented by Thomas Edison in 1877. Social and music processing engage remarkably overlapping areas in the human brain, as evidenced in the meta-analytic maps derived from NeuroSynth database [32] shown in (Figure 2). Overlap is observed not just

Figure 2

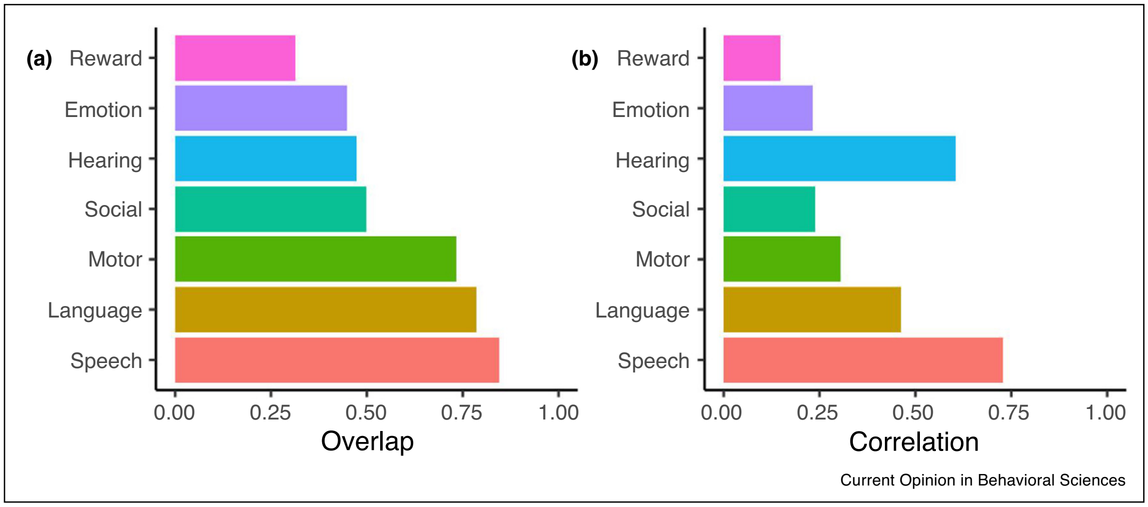


Meta-analytic maps for brain regions involved in social processing (hot colours), music perception (cool colours) and their overlap (green). The data show uniformity test maps thresholded at $p < 0.05$ retrieved from NeuroSynth on May 8th 2020.

in the auditory cortices, but also in posterior temporal polysensory areas, motor cortex, thalamus, amygdala, midcingulate cortex, anterior insula and ventral striatum. Music and social processing thus recruit partially similar neural subsystems, which however go significantly beyond sensory and associative cortices (Figure 3): When music-evoked activations are compared with meta-analytic activation maps for language, socioemotional and motor functions, clearest overlap is obviously found for motor and language functions; however overlap with the regions involved in social processes is also substantial and also larger than with, for example, emotions or reward. Such parallels in the brain can be accounted by multiple factors, and similarity of activations across tasks does not obviously mean that the tasks would recruit similar neural mechanisms. First, music might bolster interpersonal bonds, as music preferences serve as cues for similar values [33,34]. Experiments using artificial 'music markets' have indeed found that peer preferences shape musical tastes strongly – when people know their peers' music preferences (such as playlists), they have a tendency to follow them somewhat independently of their own tastes or the population-level appeal of the songs [35]. Yet, musical emotions are present in the absence of face-to-face social contact, and pleasant emotions evoked by music are not necessarily amplified in groups [36]. Second, humans spontaneously attribute mental states to others and even to inanimate objects [37], and social interaction might be the default mode via which humans communicate with their environmentt [38,39]. Music provides powerful ways of such social communication, and social features also influence music preferences. Vocal music is more popular than instrumental music, as clearly evidenced by Spotify playlists (e.g. https://spotifycharts.com/regional). This preference may stem from the capability of vocals for communicating emotional states effectively, but also from inherent craving for 'social stimulation' even in the form of song texts [40]. In line with this, sex and romantic relationships have remained the most common lyrical content of popular music throughout the past 50 years [41]. These and other semantic features of song lyrics are associated with the pleasantness of the mood evoked by the music [42]. Large-scale analysis also suggests a close link between harmony and lyrics, that is, presence of major/minor chords and concurrent emotional semantics of the lyrics [43], suggesting that musical and semantic features both contribute to the mood of a musical piece.

Third, the lyrical content of the songs also contributes to their emotional quality via the autobiographical memories they activate. One study found that on average a 30% of

Figure 3



Overlap (A; proportion of joint voxels) and spatial correlation (Pearson) between music-related activation and related socioemotional and sensorimotor processes. The results are based on uniformity test maps thresholded at $p < 0.05$ retrieved from NeuroSynth on March 10th 2020.

tested songs from a large corpus of popular music pieces evoked vivid autobiographical memories and often also concomitant strong, primarily positive emotions [44,45]. In a subsequent fMRI study, it was found that the saliency of these autobiographical memories was predictive of activity in the medial prefrontal cortex [46] — a brain region that is consistently associated with social cognition [47]. Because mPFC also responded to faster frequency of the musical stimulus features, it was proposed that mPFC would associate music with emotionally salient episodic memories. Functional theories of autobiographical memory postulate that this memory system is centrally involved in social bonding via retrieving and sharing personal memories [48,49], thus these data suggest that music and its lyrics might support social attachment functions via the emotional and autobiographical memories it evokes. Finally, due to the centrality of music in the social life, musical anhedonia (the inability to enjoy music) can be experienced as socially debilitating [50]. In line with this, anatomical studies have found that both lower enjoyment of music as well as musical anhedonia is associated with lowered connectivity between the auditory cortex and regions involved in socioemotional processing [50,51], further supporting the link between sociability and musical pleasures.

Musical social bodies

Our social bodies are embedded in music and we often have an irresistible urge to move with the beat of the music. Such rhythmic movements are evident already in young children [52] and also in some non-human primates [53••]. These movements are specific with respect to the emotions induced by the music [54], and meta-analysis point towards consistent activation of the motor system during passive music listening [55]. These embodied somatomotor responses to music might be a key pathway for eliciting the musical emotions, as it has been well established that different emotional states are associated with distinct 'bodily fingerprints' [56••,57]. Indeed, studies have shown that spontaneous dance movements during music listening enhance the subjective experience of pleasantness [58] and in line with this, music-induced emotional states can be reliably decoded from the activity of the motor cortex [27].

Humans automatically mimic each others' expressions and postures, and such synchrony is routinely interpreted as a signal of affiliation [59,60]. Music-induced movements and pleasures facilitate social bonding, as rhythmic movements during dancing and singing help individuals to synchronize their actions. Studies in nonhuman primates suggest a causal role of endogenous opioid receptor (OR) system in modulating social bonding [61,62]. Human experiments have found that both synchronous movements during dancing [63•,64] as well as joint music making heighten social closeness and increase pain threshold — a proxy of central opioid release [65,66], and experimental work shows that singing together significantly facilitates social bonding when compared to other social activities [67]. Making music together promotes spontaneous cooperation already in four-year old children, suggesting that this mechanism could be intrinsic or at least functional at very early age [68].

Specific midbrain dopamine neurons respond more strongly to unpredicted versus predicted rewards [69]. It has been proposed that such 'positive prediction error' responses to musical events contributes to music-induced pleasure via concomitant striatal dopamine release [70]. Yet, familiar and thus fully predictive music can retain its hedonic impact, and humans can easily listen their favorite songs for thousands of times and still enjoy them. Thus, positive prediction error processing cannot fully account for music-induced pleasure. Indeed, predictability (e.g. a steady beat) is crucial music's ability to induce social entrainment between listeners, and it is possible that this predictability-driven social entrainment is a central source of musical enjoyment [71].

It is tpossible music may tickle our social brains by providing a means for a feeling of 'simulated synchrony' with others – the pulsating beat of a song may trick our brains into thinking that we are actually synchronizing with another person, and this behavioural synchronization and concomitant opioid release could promote feelings of social contact [72]. Human positron emission tomography (PET) studies have indeed shown that OR activity during affiliative behaviors, such as touching or laughing, is an important molecular mechanism supporting social bonding in humans [73••,74], and the relaxing pleasurable sensations evoked by endogenous opioid peptides could act as a safety signal promoting establishment of social bonds. Opioidergic neurotransmission contributes to pleasures ranging from social laughter and physical exercise [73••,75], yet there exists no direct *in vivo* imaging data demonstrating OR involvement in musical hedonia. However, pharmacological studies indicate that blocking μ-opioid receptors dampens musical hedonia [76].

Conclusions

We conclude that the musical pleasures stem at least partially from the role of music in human sociability. Although on surface level music seems to serve no obvious survival function to make it pleasurable, we argue that the link between music, interpersonal synchrony and affiliation is an important factor that makes music so rewarding. Musical autobiographical memories and social and emotional lyrics in music further provide means for rehearsing and maintaining various social scripts. Because of their episodic nature, music-evoked autobiographical memories are oftentimes imbued with feeling of nostalgia [45,77]. Because such memories are activated automatically during low retrieval demands and as one key function of nostalgic feelings is counteracting loneliness [78], it is possible that music can even serve as an artificial social companion during moments of social isolation and distress. For these reasons, music is a fascinating tool and target for emotion researcher, as music allows bringing, real, naturalistic pleasures to the laboratory.

Conflict of interest statement

Nothing declared.

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Uncited references

[6–19,79••].

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.cobeha.2021.03.026.

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