Musicality was not selected for, rather humans have a good reason to learn music

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Abstract

We propose that not social bonding, but rather a different mechanism underlies the development of musicality: being unable to survive alone. The evolutionary constraint of being dependent on other humans for survival provides the ultimate driving force for acquiring human faculties such as sociality and musicality, through mechanisms of learning and neural plasticity. This evolutionary mechanism maximizes adaptation to a dynamic environment.

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Both Mehr et al. and Savage et al. agree that music supports social behaviors. Although Mehr and colleagues propose that musicality evolved to support specific behaviors, Savage et al. construct a general framework, suggesting that musicality evolved to promote sociality at large. These ideas rely on the assumption that sociality, in itself, was selected for in evolution as an inborn faculty. However, in contrary to a cumbersome evolutionary solution implementing inborn faculties, the brain could have evolved with one ultimate feature: to be able to wire ad hoc to the environment, optimizing survival in any cultural nice. Such an evolutionary plan is sufficient to ensure the acquisition of profound human characteristics through learning if they are relevant for survival, including (but not limited to) sociality (Atzil, Gao, Fradkin, & Barrett, 2018) and musicality.

Learning is guided by the need of an organism to optimize the internal milieu (Pezzulo, Rigoli, & Friston, 2015). *Allostasis* is the ongoing adjustment of the internal milieu necessary for survival, growth, and reproduction (Sterling, 2012). In social animals, allostasis is fundamentally social because of one evolutionary constraint: offspring cannot survive alone (Atzil et al., 2018). They depend on a conspecific, a caregiver, to regulate their allostatic processes, including energy expenditure, temperature (Winberg, 2005), immunity (Arrieta, Stiemsma, Amenyogbe, Brown, & Finlay, 2014), and arousal (Cirelli, Jurewicz, & Trehub, 2019). By providing these needs, the caregiver's allostatic support is rewarding and reinforces bonding. Moreover, infants learn to regulate allostasis via social interactions (Atzil & Gendron, 2017). At first, social regulation is physical, relying on touch (Feldman, Keren, Gross-Rozval, & Tyano, 2004) and vocalizations (Cirelli et al., 2019). With development, cultural constructs are prone to be learned and become salient and rewarding as well. Gradually, guided by allostatic motivation, young humans acquire social behaviors and concepts, and become social experts (Atzil et al., 2018). Consequently, any behavior or concept secondary to sociality, such as musicality, would be further learned rather than genetically selected for.

Not only social stimuli, but rather any concrete or abstract stimulus that impacts allostasis will be stabilized through learning. These include natural rewards such as food, but in humans also abstract cultural products such as language, art, religion, money, and most relevantly-music. These abstract constructs become meaningful to humans' survival through learning and stabilize across societies and generations, even though they are not heritable in a domain-specific manner. Yet, music is special because it is dual-valued, and holds both concrete physical faculties and abstract information, which was culturally imbued. For example, an anthem, which contains both concrete sensory input and abstract information about group identity, is extremely powerful in regulating humans (Konečni, Wanic, & Brown, 2007). This dual concrete–abstract effect of music on allostasis aligns with Savage et al.'s idea that musicality is more powerful than grooming (concrete stimulus) or language (abstract stimulus). It is also in line with Mehr et al.'s hypothesis on the role of musicality in parental care. As infants develop and acquire abstract knowledge, musicality provides a developmental bridge between concrete and abstract regulation.

Savage et al. propose that musicality and sociality share an underlying mechanism of prediction and reward. However, prediction and reward are domain-general processes of learning. In any context, the brain learns statistical regularities in the environment to actively generate predictions (Clark, 2013; Friston, 2005). Prediction is crucial for survival and partly what separates the terms *allostasis* from *homeostasis* (Sterling, 2012). Although in homeostasis a deviation from a set-point elicits reaction, allostasis is a process where the brain integrates prior knowledge to anticipate upcoming needs, preparing the organism to react in advance (McEwen & Wingfield, 2003). Thus, the evolutionary development of domain-general functions such as prediction and reward, can underlie the learning of any statistical pattern relevant for predicting allostasis. In social context, infants rely on statistical regularities of parental care for allostasis. For example, for a hungry infant, the parent is a reliable predictor for an upcoming increase in glucose levels, which is in turn rewarding and reinforces further interaction. Similarly, listening to a fast bit tune predicts changes in levels of arousal (Bernardi, Porta, & Sleight, 2006). Thus, beyond the idea that music is rewarding because it improves social predictions, suggested by Savage et al., music is rewarding because it directly improves allostatic predictions. In this sense, sociality and musicality can be considered cultural patterns, learned because they are useful to improve allostatic predictions.

Accordingly, the neural mechanism underlying reward and prediction, which process music and social information, is not selective but rather underlies every motivated behavior that is relevant for allostasis (Kleckner et al., 2017; Seth, 2013), such as feeding (Feldstein Ewing et al., 2017), avoiding pain (Scott, Heitzeg, Koeppe, Stohler, & Zubieta, 2006), and seeking drugs (Volkow & Morales, 2015). In this domain-general circuit, cortico-limbic structures rely on prior knowledge to propagate prediction signals to sensory-motor cortices to regulate perception-action (Den Ouden, Daunizeau, Roiser, Friston, & Stephan, 2010; Pezzulo et al., 2015). Predictions also projects downstream to the body via the hypothalamus-pituitary-adrenal (HPA) axis and autonomic nervous system to regulate allostasis (Barrett & Simmons, 2015; Pezzulo et al., 2015) (Fig. 1). Although prediction and reward are domain-general functions that are relevant for survival in any niche, the particulars of a certain niche are dynamic. Accordingly, an adaptive brain is one that can learn them ad hoc. Given the plasticity of the brain, every statistical regularity that allows reliable prediction about allostasis will be represented in the cortex and neurally associated with allostasis through this circuit. Because social information and music are extremely useful for allostatic predictions, they efficiently attain this neural circuitry.

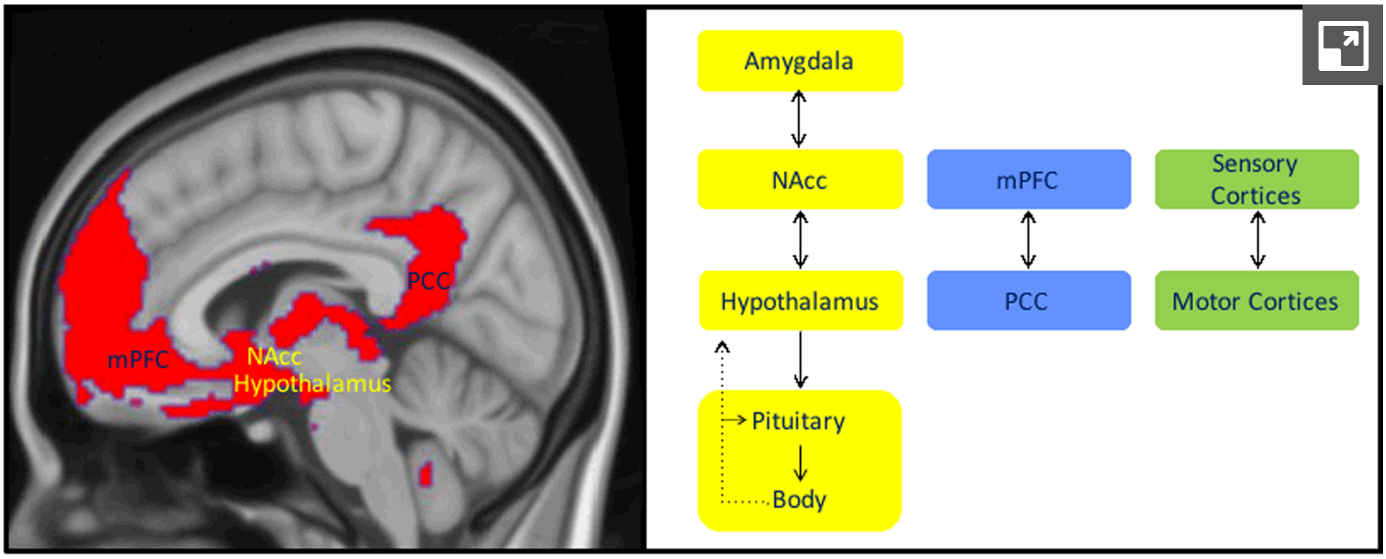

Figure 1. A domain-general neural system for motivated behaviors in humans. This domain-general neural system contains midline cortices in the medial prefrontal cortex (mPFC) (including the anterior cingulate cortex [ACC]), and posterior cingulate cortex (PCC); subcortical structures of the amygdala, nucleus accumbens (NAcc) and hypothalamus; and sensory-motor cortices. The mPFC and PCC represent abstract concepts (Baldassano, Hasson, & Norman, 2018), like a human or a song (in blue). These associative cortices, along with other cortico-limbic structures, rely on past experience to issue predictions to sensory-motor cortices (in green), to regulate behavior and perception (Den Ouden et al., 2010; Pezzulo et al., 2015). They also project downstream to the body, predicting and regulating allostasis (Barrett & Simmons, 2015) (in yellow). This circuitry is plastic and can associate any learned concept or behavior, which is relevant for reward and prediction, to allostasis regulation in the body. In that sense, this circuitry is not exclusively related to sociality or musicality, but rather is a domain-general mechanism, which can be wired to support any motivated behavior with allostatic consequences.

To conclude, music is a cultural product. Because of its rewarding and predictive values, humans are repeatedly reinforced to learn it and to pass it on to the next generations, not necessarily through specific genetic adaptations. All animals rely on prediction and reward to survive. Humans developed an especially wide and complex range of cues in multiple levels of abstraction that support prediction of allostasis. Although musicality and sociality rely on shared mechanisms, it does not mean that these mechanisms evolved specifically for them. Alternatively, a rather simple evolutionary constraint of social dependency for survival, along with neural plasticity, is sufficient to ensure the cross-generation transmission of both sociality and musicality. We propose an alternative mechanism, by which musicality and sociality are dynamic and were thus not genetically selected for in a domain-specific manner. Instead, a domain-general mechanism of reward and prediction was selected for to improve survival by being flexible and wired to the environment. This ensures that behavior is culturally sculptured in an ongoing process that maximizes adaptation. This theoretical approach provides a parsimonious explanation for the role of music in human culture.

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Conflict of interest

None.

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