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Cognition and the Evolution of Music: Pitfalls and Prospects

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Abstract

What was the role of music in the evolutionary history of human beings? We address this question from the point of view that musicality can be defined as a cognitive trait. Although it has been argued that we will never know how cognitive traits evolved (Lewontin, 1998), we argue that we may know the evolution of music by investigating the fundamental cognitive mechanisms of musicality, for example, relative pitch, tonal encoding of pitch, and beat induction. In addition, we show that a nomological network of evidence (Schmitt & Pilcher, 2004) can be built around the hypothesis that musicality is a cognitive adaptation. Within this network, different modes of evidence are gathered to support a specific evolutionary hypothesis. We show that the combination of psychological, medical, physiological, genetic, phylogenetic, hunter–gatherer, and cross-cultural evidence indicates that musicality is a cognitive adaptation.

Keywords: Music cognition; Evolutionary psychology; Musicality; Innateness; Adaptation; Relative pitch; Beat induction

1. Introduction

Why do we have music? Is it a mere cultural phenomenon or is music biologically constrained? And if the latter is the case, is it possible to identify which traits make us musical animals?

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While it became quite popular to address such questions from an evolutionary perspective (Justus & Hutsler, 2005; McDermott & Hauser, 2005; Vitouch & Ladinig, 2009; Wallin, Merker, & Brown, 2000), there is still little agreement on the idea that music is in fact an adaptation, that it influenced our survival, or that it made us sexually more attractive. Music appears to be of little use. It does not quell our hunger, nor do we live a day longer because of it, so why argue that music is an adaptation?

For Charles Darwin it was clear: Neither the perception nor the production of music were “faculties of the least use to man” (Darwin, 1871, p. 878). It is a position that resonated in much later work such as that of Steven Pinker, who wrote: “As far as biological cause and effect are concerned, music is useless. (...) Music could vanish from our species and the rest of our lifestyle would be virtually unchanged” followed by “... it is a technology, not an adaptation” (Pinker, 1997; pp. 528–529). These statements—and the reference to music as “auditory cheesecake,” a mere pleasure-generating substance—did not increase Pinker’s popularity among those studying music. Nevertheless, Pinker succeeded well in starting up a discussion among music scholars and cognitive scientists on why we have music, and why it could be relevant for cognitive science to study music at all (Ashley et al., 2006; Mithen, 2005; Zatorre, 2005). Pinker’s main argument is that music is a by-product (a so-called spandrel) of two adaptations: a motivational system related to adaptive outcomes, and a technological system that is adaptive for other outcomes but can be used to produce and appreciate sounds that we consider as music (Pinker, 2007).

How convincing is this position? Are there indeed no arguments to show that music has played a more direct and shaping role in man’s evolutionary development? Or should music be considered as a sexually selected trait, a trait that evolved to attract partners rather than to improve survival chances (Darwin, 1871; Miller, 2000)? Or could it instead be an exaptation (Gould & Vrba, 1982) in which existing traits are put to new use? Or is music, as Pinker suggested, no more than a pleasant side effect of more important functions, such as speech and language?

In this paper we will outline and discuss a strategy that emphasizes *cognitive traits* that could have contributed to the origins of music (for an extensive overview of the debate about the evolution of music, see Patel, 2010). Despite the criticism of the possibility of studying the evolution of cognition (Bolhuis & Wynne, 2009; Lewontin, 1998), we will show that, next to the study of “music as biology,” addressing “music as cognition” might put constraints on existing theories of music and evolution. We will start with a brief introduction to the study of the evolution of cognition and potential pitfalls in this endeavor.

2. The study of the evolution of cognition

In 1992, a book was published called *The Adapted Mind*, which can be marked as the start of the field of evolutionary psychology (Barkow, Cosmides, & Tooby, 1992). In this book, evolutionary psychology is defined as “psychology that is informed by the additional knowledge that evolutionary biology has to offer, in the expectation that understanding the process that designed the human mind will advance the discovery of its architecture” (Cosmides & Tooby,

1992). The tenets of evolutionary psychology are that the human mind has evolved by natural selection, and that the human mind consists of many different cognitive mechanisms, each evolved to solve a specific problem that our ancestors encountered in the evolutionary past. The rise of evolutionary psychology has resulted in a new research area that has led to new empirical discoveries inspired by evolutionary thinking (for an overview, see Buss & Reeve, 2003). However, this rise has also led to many criticisms, with some theorists arguing that our knowledge about the evolution of cognitive mechanisms is too limited (Richardson, 1996, 2007), some arguing that evolutionary psychology will not add anything to our current knowledge (Davies, 1996), and some even arguing that we will *never* know how cognition evolved (Lewontin, 1998). The latter criticism was particularly harsh, and we will discuss this one first, in order to unravel whether the study of the evolution of music can be a fruitful enterprise at all.

3. Pitfalls in studying the evolution of cognition

Lewontin (1998) argued that evolutionary theory stands on three principles: variation, heredity, and natural selection. In order to understand the evolution of cognition, we first need to know how much variation in cognitive traits was available in ancestral times. Because cognition does not fossilize, we will never be able to find this piece of evidence, according to Lewontin. Second, we need to know whether cognitive traits are heritable. Although there are many studies that provide evidence for the heritability of cognitive traits (for a review, see Plomin, DeFries, McClearn, & McGuffin, 2008), it is particularly hard to know which genes are involved, because cognitive traits are polygenic (e.g., Kovas & Plomin, 2006). For example, the search for specific genes that are involved in intelligence has not been successful (Plomin, Kennedy, & Craig, 2006). Third, we need to gather evidence for the hypothesis that cognitive traits have been naturally selected. This implies that we need to know whether there were two groups among our ancestors, one group without certain cognitive traits, and one group that possessed these cognitive traits. In addition, we need to know that the group without the cognitive traits was less able to survive and reproduce than the group that possessed these traits. According to Lewontin, there is no way to gather this evidence. Lewontin finished his article by arguing that we should “give up the childish notion that everything that is interesting about nature can be understood. (...) It might be interesting to know how cognition (whatever that is) arose and spread and changed, but we cannot know. Tough luck” (p. 130).

In the study of the evolution of music cognition, we have to take into account this criticism. Do we better stop right now, or is there a way to deal with this criticism? We start again with pitfalls, and then we discuss the prospects.

4. Pitfalls in studying the evolution of music cognition

Just like in the study of the evolution of cognition, in the domain of music cognition several pitfalls can be identified. We argue that the critical points raised by Lewontin (1998)

can be addressed by two research strategies: (a) distinguishing a very general cognitive trait such as musicality from fundamental components that make up the cognitive trait and (b) collecting accumulative evidence that is necessary to show that a cognitive trait is an adaptation. We start with addressing the first point.

4.1. What are the fundamental components of music?

Many studies of the evolution of music concern the question of what defines music (Cross, 2007; Vitouch & Ladinig, 2009; Wallin et al., 2000). Can birdsong, the song structure of humpback whales, a Thai elephant orchestra, or the interlocking duets of Gibbons be considered music?

In trying to answer this question, it is important to separate the notions of “music” and “musicality.” Since a definition of music can easily be stretched to include all types of sound, noises, and even plain silence, it makes the discussion of what is and what is not music one of the most noticeable pitfalls in the study of music and evolution. We define musicality as a natural, spontaneously developing trait based on and constrained by our cognitive system, and music as a social and cultural construct based on that very musicality. *Without musicality no music.* With this important distinction, it is possible to talk about musicality without being trapped into the discussion of what is or is not meant by “music.” In order to know the evolution of music, we will need to know the basic cognitive components that make up musicality. We refer to this as the “music as cognition” hypothesis (Honing, 2011a).

Of course, the definition of musicality as a natural, spontaneously developing trait based on and constrained by our cognitive system is still too general to be useful in the current context. We have to demarcate precisely what makes up this trait we call musicality. What are the cognitive mechanisms that are essential to perceive, make, and appreciate music? Only when we have identified these fundamental mechanisms are we in a position to see how these might have evolved. In other words, the study of the evolution of music cognition is conditional on a characterization of the basic mechanisms that make up musicality (we will mention some candidates below).

Furthermore, it is important to separate between the biological (or genetic) and cognitive (or functional) aspects that might contribute to musicality. While it is common to assume that there is a mapping between specific genotypes and specific cognitive traits, more and more studies show that genetically distantly related species can show similar cognitive skills—skills that more genetically closely related species fail to show (De Waal, 2009). For example, humans and birds seem to share their musicality up to a certain level, whereas humans and chimpanzees do not (Fitch, 2009).

And finally, in support of the “music as cognition” hypothesis, there is ample research available that suggests musicality to be largely of a cognitive nature (for a review, see Trehub & Hannon, 2006). We could therefore expect to find explicit clues for the origins of music in specific cognitive functions. Some of the candidates that are mentioned in the recent literature are, for instance, relative pitch (Justus & Hutsler, 2005), tonal encoding of pitch (Peretz & Coltheart, 2003), beat induction, and metrical encoding of rhythm (Honing, Ladinig, Winkler, & Haden, 2009).

4.2. *Is music an adaptation?*

At least three schools of thought can be identified in the scholarly search for an evolutionary role for music. Despite the criticism mentioned earlier, the first school remains intent to show that music is indeed an adaptation (e.g., Levitin, 2006; Mithen, 2005) and aims to develop strategies to empirically underpin the cognitive and biological role of musicality (Fitch, 2009). In particular, there's a lot of support for Darwin's suggestion (Darwin, 1871) that sexual selection must have played a role in the origin of music. Miller (2000) expands on this idea in considering music as one of the many effective ways people use to try to impress other members of their species.

But there are also alternative views, such as the one that considers music as beneficial play (Honing, 2011a): It challenges our cognitive functions and promotes diversity, resulting in an evolutionary advantage. In this case, rather than being viewed as a product of natural selection, musicality is thought to be a trait resulting from exaptation, that is, without special selection having taken place. Once this trait exists, it is further perfected by natural or sexual selection and as such passed on to successive generations.

Another school believes music plays a secondary or indirect role in evolution, namely as a means of strengthening the social cohesion of the group (Cross, 2007; Merker, 2000). Here, music is seen as the "social glue" that keeps the group together, promotes cooperation, and consequently strengthens the group feeling. As the "language of emotion," music is also thought to play a crucial role in the vitally important bonding between parent and newborn (Dissanayake, 2008), and it is frequently associated with the musical language (*infant-directed speech*) parents speak with their newborn babies (Honing, 2011b). In short, music strengthens the social and emotional bonds within the group and is selected evolutionarily as a result.

A third school views music as a "transformative invention": a skill or function that is not adaptive, but that has had and continues to have a major impact on our biology and culture (Patel, 2010). The idea of "music as invention" can be compared with the irreversible effect that making fire had on such things as our eating behavior and culture, as discussed in Wrangham (2009).

However, the arguments brought forward in all three schools demand some refinement. First of all, the strategy of having to show that music in all its forms and functions is an adaptation is obviously unrealistic. Music easily covers a wide range of social, cultural, biological, and psychological factors that do not allow it to be reduced to one single explanatory source. Furthermore, as we argued in the previous section, the notion of music should be replaced by musicality. As such, the question can be more precisely formulated: What are the fundamental mechanisms defining musicality, and can a case be made that these mechanisms (or cognitive functions) are a result of evolution?

Interestingly, while there are several aspects of musicality that emerge spontaneously, early in life, and with minimal exposure to music, and as such suggesting heritability (cf. Lewontin, 1998), none of them need to be specific to music (Trehub & Hannon, 2006). The latter authors actually argued against the idea of musicality as a biological adaptation ("music as biology"). However, from the perspective of "music as cognition" the

challenge remains to identify those cognitive functions that can be shown to be fundamental in developing musical behavior (Trainor, 2006).

4.3. *An example: Beat induction*

A concrete example of a basic cognitive mechanism that can be argued to be fundamental to musicality is “beat induction.” It is a cognitive skill that allows us to hear a regular pulse in music to which we can synchronize (hence it is also referred to as “beat perception and synchronization” or BPS; Patel, 2008). Perceiving this regularity in music allows us to dance and make music together, and it is therefore considered a fundamental cognitive mechanism that might well have contributed to the origins of music (Honing, 2011a; Honing et al., 2009).

Several authors consider beat perception to be acquired during the first year of life (e.g., Hannon & Trehub, 2005), suggesting that infants being rocked to music by their parents is the most important factor in developing a sense for pulse. In contrast, recent empirical studies show that beat induction is already active in newborns and young infants (Winkler, Háden, Ladinig, Sziller, & Honing, 2009; Zentner & Eerola, 2010). This can be taken as support for beat induction as an innate bias, rather than as a result of learning.

In addition, it was recently suggested that we might share the cognitive skill of beat induction with a selected group of bird species (Fitch, 2009), and, somewhat surprisingly, not with more closely related species such as nonhuman primates (Zarco, Merchant, Prado, & Mendez, 2009). This offers a rich basis for comparative studies of this specific cognitive function.

And lastly, beat induction seems to be limited to music and is inexistent in everyday language (Patel, 2008, p. 404). It even appears that there are cases of “beat deafness” in people that have normal language and normal music perception (Phillips-Silver et al., 2011). As such, beat induction is unlikely to be simply a by-product of speech and language (Pinker, 1997).

4.4. *Is music human-specific?*

Yet another pitfall in music and evolution research is to contrast the cognition of humans with that of other animals (cf. Fitch, 2009). While it is not uncommon to see certain cognitive functions as typically human (such as language), it could well be that there are more species than just humans that have the proper predispositions for music to emerge, species that share with us one or more basic mechanisms that make up musicality. The mere fact that music did not emerge in some species is no evidence that the trait of musicality is absent. In that sense a “bottom-up perspective” (De Waal & Ferrari, 2010) that focuses on the constituent capacities underlying a larger cognitive trait, in our case musicality, is a feasible alternative strategy to follow. Instead of studying a complex cognitive trait (such as intelligence), one explores the basic processes that make up that trait. And in the case at hand: Instead of asking which species are musical, the question becomes, How does musicality actually work? What are the necessary ingredients of musicality, and how did these evolve?

4.5. *Is music modular?*

A final issue worth mentioning is the search for modularity or domain-specificity of musicality. Several authors have stressed this as an important criterion for an evolutionary explanation of music (Honing et al., 2009; Justus & Hutsler, 2005; Peretz & Coltheart, 2003). However, other authors suggested that the basic mechanisms that are involved in perceiving and appreciating music tend to be essentially domain-general (Hannon & Trainor, 2007; Patel, 2008). While musical skills might become more modularized during a lifetime, they start out as a result of domain-general mechanisms. Or, as Karmiloff-Smith (1998) argued more generally: All cognition might actually start general and gets automated and modular over time. Hence, finding a set of neurally isolable processing components, each having the potential to be specialized for music (Peretz & Coltheart, 2003), does not mean we are born with such modularity.

Nevertheless, this pitfall could also be a prospect. Brains are great learners, in humans and non-human animals alike. In that sense it is more informative when a certain behavior develops spontaneously, without explicit learning, such as is clearly the case with human infants' predisposition for music (Trehub, 2003).

Lastly, it is important to note that a natural attraction to music seems to be crucial in development, even more so than the capability of learning by itself. This natural motivation to be engaged with music (e.g., infants preferring *infant-directed song* over *infant-directed speech*; Trainor, Clark, Huntley, & Adams, 1997) could well be an important key to the understanding of the origins of music.

To conclude: if musicality is modular in nature, this would be consistent with the hypothesis that musicality is an adaptation. However, this does not imply that musicality is a modular structure present at birth—this may develop from a domain-general structure into a modular structure by gradual modularization.

5. Prospects in studying the evolution of music cognition

Despite the pitfalls mentioned above, recently several authors have proposed alternative ways to be able to study the evolution of cognition.

5.1. *Alternative strategy*

Most scientists agree on the fact that a theory can never be fully proved—it is always possible that evidence is found that disproves the theory (Popper, 1959). Hence, instead of trying to fully prove a theory, one tries to build a nomological (or “lawful”) network of evidence around a candidate theory (Cronbach & Meehl, 1955). This network is based on well-reasoned theories and is filled with the empirical evidence that is available. Evolutionary psychologists, more often than other psychologists, gather evidence from a wide variety of sources to build a nomological network around their theories.

Schmitt and Pilcher (2004) outlined such a nomological network with eight basic modes of evidence that evolutionary psychologists use to support their theories. The center of the network is a putative psychological adaptation, in our case “musicality.” Around this putative adaptation, first of all a theory has to be defined that explains why it is likely that the adaptation arose in the first place. This theory can be based on theories borrowed from evolutionary biology, cost-benefit analyzes, game theory simulations, and computer modeling. For musicality, there are numerous candidates, including sexual selection (Darwin, 1871; Miller, 2000), bonding between parent and child (Dissanayake, 2008), promoting mental and social development (Cross, 2007), increasing social cohesion (Merker, 2000), a powerful human invention (Patel, 2010), or as beneficial play, challenging our cognitive functions and promoting diversity (Honing, 2011a). All these theories motivate the role that evolutionary processes could have had on the origins of music.

Second, psychological evidence can be added to the network, for instance, data collected by means of behavioral tests and surveys. In the case of music, there is overwhelming evidence that human beings are musical in general and spontaneously develop musical behavior (Trehub, 2003; Trehub & Hannon, 2006). In addition, there is ample evidence for the cross-cultural use of music in mood regulation, what may have a long evolutionary history (DeNora, 2001; Saarikallio & Erkkila, 2007; Seeger, 1987).

Third, medical evidence can be added, based on fertility and fecundity studies, physical health and mortality studies, mental health and happiness studies, or studies on psychiatric disorders. The work by Peretz and her team (Peretz et al., 2002) has been pioneering concerning music. Stroke, traumatic brain damage, and congenital brain anomalies can lead to selective disorders of music processing. In addition, autistic savants and epilepsy can reveal the autonomous functioning and the selectivity, respectively, of the neural networks that are essential to music. The existence of such special-purpose cortical processes suggests that the (human) brain might be hardwired for music (Peretz, 2002).

Fourth, physiological evidence can be gathered based on neuroscientific studies. While there is still some disagreement on the granularity of musicality as a module distinct from those involved in language, most authors agree that there are at least some aspects of music perception (such as beat induction) that are special and can be expected to have distinct neural correlates (Patel, 2008; Peretz & Coltheart, 2003). In addition, a rapidly growing literature indicates that newborn infants are extremely sensitive to a number of sound features that are fundamental to music across cultures, supporting the idea of an innate bias to music (Winkler et al., 2009). Associating these neural correlates to specific musical functions will strengthen this component of the nomological network.

Fifth, genetic evidence can be added based on behavioral or molecular genetic studies. While the literature on this topic is mainly concerned with the role of genetics in the development of musicianship, a causal link has not been found (Coon & Carey, 1989). Nevertheless, there are a few studies suggesting at least an associative role between certain genes and musical aptitude (Ukkola, Onkamo, Raijas, Karma, & Järvelä, 2009).

Sixth, phylogenetic evidence can be added based on animal research, comparative studies, paleontologic studies, or antropologic studies. This is (in part) the research program of Hauser and Fitch, who both stress the importance of comparative research in studying the

evolution of language and music (Fitch, 2006; Hauser & McDermott, 2003), research that aims to identify the uniquely human aspects of the music faculty as well as the building blocks that provided the foundation for its evolution (in a framework similar to that laid out by Noam Chomsky for language).

Seventh, hunter–gatherer evidence can be added based on knowledge from cultural anthropology and paleoanthropological and ethnographic studies. While music cognition obviously does not fossilize, there are several pieces of evidence available on the remains of early instruments, such as bone and ivory flutes dated older than 35,000 years (Conard, Malina, & Münzel, 2009), that could provide empirical support for this component. In addition, the widespread use of music in still existing hunter-gatherer societies provides evidence for the importance of music in premodern societies (e.g., Rouget, 2004).

Eighth, cross-cultural evidence can be added based on research on human universals and ethnological comparisons. In the domain of music cognition several authors have stressed this potential (Thompson & Balkwill, 2009), most notably by Huron (2009), who stressed the importance (and urgency) of studying musical cultures yet not influenced by our Western culture—a case of cultural diversity that might be as informative to the study of music evolution as biodiversity is to biology.

To conclude, the eight modes of evidence (Schmitt & Pilcher, 2004) for the hypothesis that musicality is an adaptation form together a consistent nomological network, providing a strong indication that musicality is an adaptation.

6. Conclusion

We presented an alternative view in response to the position that we will never know the evolution of cognition (Lewontin, 1998). While we sympathize with Lewontin’s critique on a larger scale, that is, the apparent impossibility of studying the evolution of complex cognitive processes such as intelligence, we argued that a bottom-up approach, in which one looks for the basic mechanisms that combine into a complex cognitive trait—in our case musicality—is an alternative and potentially fruitful way to proceed.

While it is virtually impossible to underpin the evolutionary role of musicality as a whole, the apparent innateness, and the species and cognitive specificity of its hypothesized components (e.g., beat induction and tonal encoding of pitch) make it an ideal starting point for a research program aimed to tighten the nomological network of evidence around musical behavior. In that way we will be able to strengthen the argument for musicality as a result of evolution and put further constraints on existing evolutionary theories of music cognition.

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