A JOURNAL OF THE ASSOCIATION FOR PSYCHOLOGICAL SCIENCE aps

# What Can Experiments Reveal About the Origins of Music?

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**ABSTRACT**—*The origins of music have intrigued scholars for thousands of years. In this article I discuss the role of experiments in discussions of these issues. I argue that potentially useful kinds of evidence are those that address the innateness and the specificity of different components of musical behavior. At present there is some evidence for innate influences on music, but little evidence for capacities that are clearly specific to music. Although future experiments could potentially alter this picture, there is currently little unambiguous support for the notion that music is an adaptation.*

**KEYWORDS**—*music; evolution; innate; domain-specific; rhythm; pitch; syntax; universality*

Music is a popular pastime around the world, but it is also a source of some consternation to those who study the mind. The puzzle is this: Music is universal, a significant feature of every known culture, and a major investment of resources, and yet it does not serve an obvious, uncontroversial function for those who create it or listen to it. In this regard, it stands in contrast to many other universal human behaviors (eating, drinking, talking, sex, and so forth) that have clear adaptive functions.

The last decade has seen a resurgence of interest in the origins of music, and although we have moved no closer to consensus, there is no shortage of hypotheses. These include the notion that music is merely an accidental byproduct of traits that evolved for other purposes, but also various proposals for potential adaptive functions, ranging from the promotion of social cohesion to the facilitation of infant–parent interactions (Wallin, Merker, & Brown, 2001). These ideas are interesting to entertain, but are also vulnerable to the usual criticisms of "just-so" stories in evolutionary biology, as there is little empirical basis on which to decide between them. Many in the field have recently attempted instead to advance the debate by conducting experiments. In this article, I discuss how empirical results can constrain accounts of music's origins and review some recent interesting findings.

## EMPIRICAL CONSTRAINTS

What sorts of evidence might be useful? Many of the standard methods of evolutionary biology are of limited use. The fossil record leaves few clues, as there are few preserved physical signatures of music. Another key approach, testing the adaptive value of physical traits by removing or altering them, is also impractical for music and other complex behaviors. Such behaviors may not depend on an easily altered bit of brain, and even if they did, experimenting on humans is generally precluded by ethical concerns. One might in principle examine reproductive success of tone-deaf individuals, but the world today is different in many ways from that in which music evolved, so the fitness benefits that would have been relevant to evolution are difficult to measure.

Despite these challenges, at least two sorts of empirical evidence seem likely to be informative. First, for something to have an evolutionary history it must have a genetic basis. Such a basis for music is by no means obvious; music varies dramatically from culture to culture, lending plausibility to the notion that it is mostly a cultural invention. On the other hand, the mere fact that music of some sort occurs in every culture is evidence for innate underpinnings. Experiments can help identify the components of musical behavior that might be partially innate.

Of course, any innate component of music might well be a side effect of traits that evolved for other functions. A second potentially useful research direction is thus to explore whether musical traits are specific to music. If some aspect of music were shown to functionally overlap with something that had a clear adaptive function, the likelihood that its function in music is a convenient side effect would be increased (McDermott & Hauser, 2005). Conversely, capacities specific to music might be candidates for a music-related adaptation.

## INNATENESS

Determining the degree to which complex behaviors are innate is far from straightforward, as such behaviors generally result from

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interplay between genetic and environmental influences (Trainor, 2006). Nearly everyone listens to music from birth, and this exposure critically alters the developing brain. Over time, for instance, young children become more adept at perceiving structures prevalent in their musical culture, often at the expense of those structures that are not prevalent (Trehub & Hannon, 2006). Thus, asking whether a trait is innate or learned in general may present a false dichotomy. Nonetheless, some musical traits may arise largely independent of musical input.

A useful subject pool in this regard can be found in human infants, whose musical experience is limited. Experiments in infants indicate that several important perceptual abilities are present as early as a few months of age (e.g., Trehub & Hannon, 2006). These include the ability to encode melodies with relative pitch, preferences for consonant combinations of notes over dissonant ones, and perhaps the ability to perceive periodic rhythmic structure in music. Although it is difficult to rule out the contribution of music exposure that even young infants have inevitably had, there is at least a chance that some music-related traits are already present in the brain at birth, independent of musical input.

Genetic influences on music might also be evidenced by properties of music that are common to many cultures. Commonalities present across the considerable musical variation found around the world likely indicate biological constraints. Completely universal properties are considered by ethnomusicologists to be rare (Nettl, 2000), but a number of features occur repeatedly across diverse musical traditions. These include the importance of music in rituals, the propensity to dance to the beat, the existence of lullabies, and several structural properties of music: periodic rhythms, scales with unequal step sizes, and uneven pitch-occurrence distributions that give a privileged role to particular notes.

Testing whether any of these potentially innate aspects of musical behavior are specific to music (and might therefore be candidates for music-related adaptations) involves standard methods for probing mechanistic overlap between cognitive processes. I will discuss two recent examples in depth.

## RELATIVE PITCH

The ability to hear relative pitch is one trait that seems likely to have an innate basis, as evidenced by the tendency of infants to notice when the notes of a melody are rearranged in time but not when they are transposed (shifted; Fig. 1a) to a different pitch range (Plantinga & Trainor, 2005). Transposition preserves the contour of a melody—the sequence of ups and downs from note to note (Fig. 1b)—but not the absolute pitches of the notes. It seems that infants, like adults, rely predominantly on the contour when recognizing melodies. Perhaps surprisingly, the nonhuman animals that have been tested (ranging from birds to monkeys) seem to be different in this respect. Nonhuman animals trained to recognize particular melodies typically have trouble generalizing to pitch-shifted versions of the same melodies (D'Amato, 1988; McDermott & Hauser, 2005). These and other considerations have led some to propose that pitch contours result from a music-specific, uniquely human process rather than a general-purpose auditory mechanism (Peretz & Coltheart, 2003; McDermott & Hauser, 2005).

Some recent work of my own argues against this hypothesis (McDermott, Lehr, & Oxenham, 2008) by demonstrating contour perception in dimensions other than pitch. Loudness contours, for instance, can be generated by altering a sound's intensity while holding its pitch constant. Contours can also be generated with brightness, a sound attribute determined by the relative proportion of high and low frequencies in a sound—as controlled by the treble knob on a stereo, for instance (Fig. 1c). We tested subjects' ability to recognize contours in pitch, brightness, and loudness when patterns in these dimensions were transposed—that is, replicated in a different range of the dimension, forcing subjects to rely on relative representations (Fig. 1a).

We found that subjects could easily recognize transpositions in brightness and loudness, indicating that they extract contours in these dimensions just as they do for pitch. Subjects could also match contours in one dimension to those in another, suggesting similar representations for different dimensions. The results indicate that contour perception is a fairly general ability of the auditory system (loudness contours might play a role in speech intonation, for instance). Pitch may be special in other respects, for instance in supporting fine-grained interval perception (McDermott & Oxenham, 2008), or in permitting the detection of fine-grained stimulus changes, but contours do not seem to be pitch-specific, and hence not music-specific. The mechanisms of relative pitch, at least as far as contours are concerned, thus seem unlikely to have evolved exclusively to support music perception. The apparent difficulty that nonhuman animals have in perceiving relative pitch may indicate a more general difficulty with perceiving relations between stimuli.

## MUSICAL SYNTAX

Syntax classically refers to the principles by which the elements of language are combined into more complex structures. Music is also constructed by organizing elements according to rules; these rules are often termed musical syntax. Some of these rules govern how pitches (notes) are distributed within a piece; typically, some pitches are used more prominently and more frequently than others are. In Western music, for instance, there is generally a restricted set of pitches from which the notes of a piece are drawn. Within this set, a particular note, termed the tonic, has a privileged status. Pieces tend to end on the tonic note and to use the tonic most frequently throughout the piece. Many other cultures appear to utilize pitch sets in qualitatively similar ways.

With repeated exposure to a culture's music, listeners acquire expectations for how pitch sets will be used. These expectations

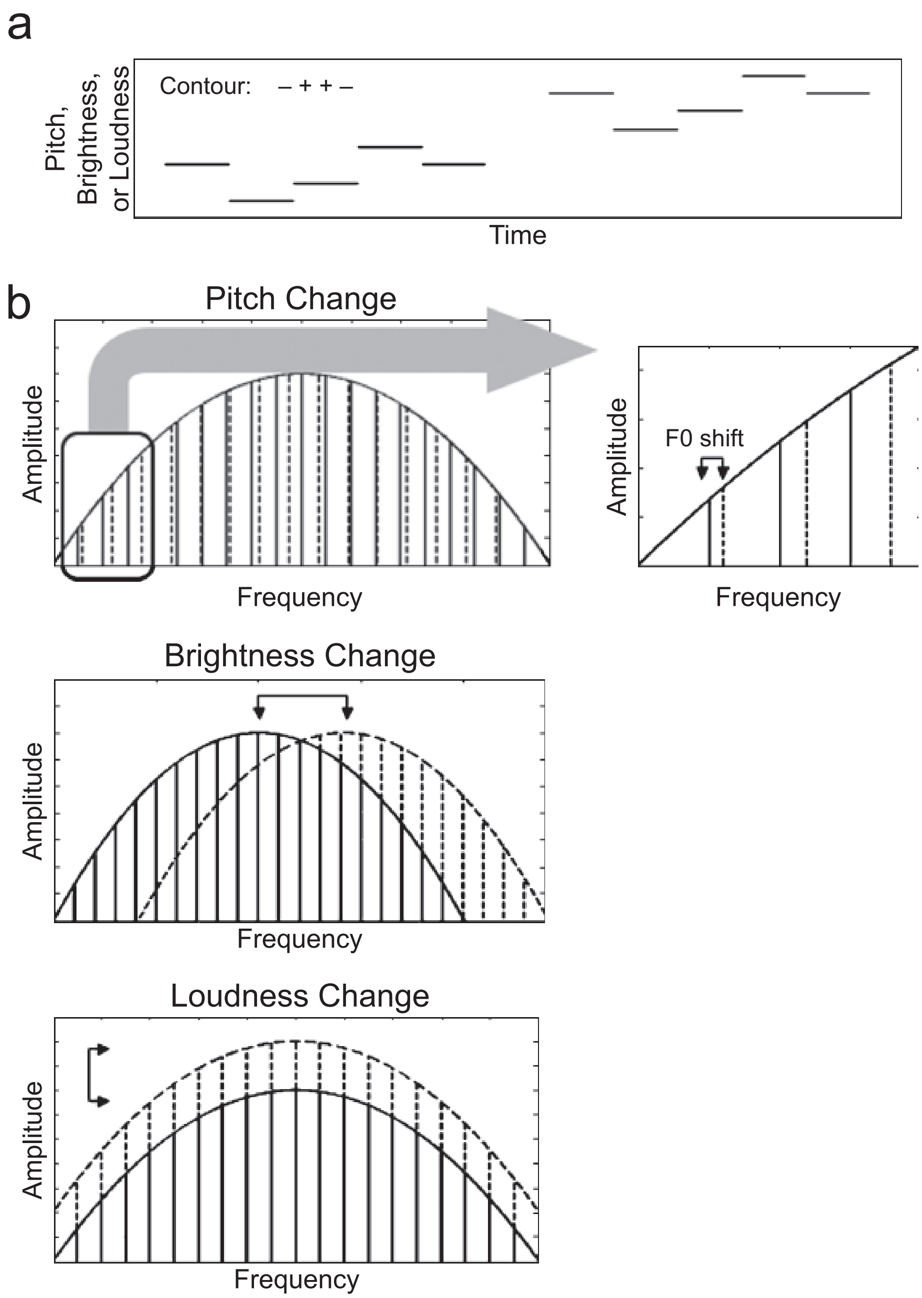


**Fig. 1.** Illustrations of a transposed melody (a) and manipulations of pitch, brightness, and loudness in a complex tone (b). The diagram in (a) depicts an example melody, followed by a transposed version of that same melody. In a conventional melody-recognition task, the stimuli vary in pitch, and subjects judge whether the contours of the two melodies are the same or different. In this example they are the same (the contour, or the sequence of up/down changes in pitch from one note to the next, is indicated for the example melody with + and − symbols). In our experiments, subjects performed this task with ''melodies'' that could vary in one of three dimensions (pitch, brightness, or loudness). The diagrams in (b) depict schematic frequency spectra for tones whose pitch, brightness, or loudness is manipulated independently. Vertical lines denote frequency components; the curved line is the spectral envelope (the shape of the spectrum, formed by the relative amplitudes of the different frequency components). Solid and dashed lines denote two different sounds. Small black arrows indicate the stimulus change producing each perceptual change. Sounds that have a pitch, such as are produced by instruments or the vocal cords, have spectra whose frequencies are integer multiples of a fundamental frequency (F0), the value of which determines the tone's pitch. The pitch of a tone is thus altered by changing its F0, keeping the spectral envelope fixed. The top right panel of (b) shows an enlarged portion of the spectrum for the pitch change. The brightness of the same tone can be altered by shifting the spectral envelope of the tone, keeping the F0 fixed. The loudness can be altered by changing the intensity of the tone, keeping the F0 and spectral envelope fixed.

partially underlie the perception of tension and release in music. Tension is perceived when our expectations are defied, and resolved when they are met; this ebb and flow helps make music compelling (Huron, 2006). The parallel occurrence of this phenomenon in many different musical systems suggests the possibility of an innate mechanism, the neural circuitry for which could conceivably be specialized for music (Peretz & Coltheart, 2003). Studies of the domain specificity of musical syntax are thus potentially relevant to music's origins.

The most obvious candidate for functional overlap with musical syntax is linguistic syntax (Patel, 2008). Although syntax in language and music operate on different kinds of representations (words vs. notes, chords, or beats), it has seemed conceivable that the syntactic computations might rely on common resources or share certain principles (Patel, 2003). The story is still emerging, but there are indications of significant overlap in the neural resources that subserve linguistic and musical syntax.

One recent study made a direct test of this hypothesis by examining brain responses recorded at the scalp (event-related potentials, or ERPs) to visually presented sentences that were accompanied by musical chord sequences (Koelsch, Gunter, Wittforth, & Sammler, 2005). The sentences could either contain a grammatical error, a semantically inappropriate word, or neither, and the chord sequences sometimes contained a chord that was unexpected given the musical context. If linguistic and musical syntax tap the same mechanisms, one might expect the processing of grammatically inappropriate words and chords to interfere with each other. Koelsch and colleagues indeed found that the size of the ERP elicited by syntactically inappropriate words was reduced when the words were accompanied by unexpected chords. This effect did not occur for the ERP elicited by semantic abnormalities. Moreover, no such reduction was observed when the critical word was accompanied by an acoustically deviant tone. The effect thus appears specific to linguistic and musical syntax. A recent study by Fedorenko and colleagues reported similar behavioral effects: Comprehension difficulties for syntactically complex sentences were worsened by simultaneous out-of-key notes but not other attention-grabbing stimulus changes (Fedorenko, Patel, Casasanto, Winawer, & Gibson, 2009). These results suggest there is something about the evaluation of tonal structure in music, and of grammar in language, that draws on common resources. At present, the extent and nature of the overlap is unclear, but the results raise the possibility that musical syntax co-opts mechanisms that evolved to enable language and perhaps other cognitive abilities.

## FUTURE DIRECTIONS

Several aspects of musical rhythm have recently become focal points in discussions of music's origins. Musical rhythms are noteworthy for being organized in patterns of beats—events that occur at regular temporal intervals. This periodic organization is particularly interesting because it is an apparently universal feature of music that does not seem to be present in speech, which largely lacks periodic rhythmic structure (though speech contains rich nonperiodic rhythmic structure; Patel, 2008). There is some evidence that young infants can perceive beats (Bergeson & Trehub, 2006), suggesting a potentially innate perceptual mechanism, but at present it is unclear if beat perception involves processes specific to music. Given the rhythmic motor behaviors that many organisms possess, the auditory system could plausibly have evolved general-purpose mechanisms to analyze periodicity (e.g., as produced by the sound of someone walking) that then function in music as well. Experiments investigating periodicity perception could help to shed light on this issue.

In addition to perceiving the temporal regularity of beat spacing, we generally hear beats as having a hierarchical organization, known as meter (London, 2004). Sets of beats are heard as grouped together, with each group producing a perceptible pulse. A waltz, for instance, has triple meter—beats are heard in groups of three, and when dancing to a waltz, we move on every third beat. A march, in contrast, has beats grouped in sets of two or four. It has been argued that meter perception is present in young infants (Hannon & Johnson, 2005), though this remains controversial (Patel, 2008). It is not obvious that metrical representations could result from general-purpose mechanisms for representing periodicity; meter is thus an obvious area of interest for future research, as is the tendency of people to move in time with metrical pulses.

Another trait that seems worth further study is the interest that young infants have in music (Nakata & Trehub, 2004; Trehub & Hannon, 2006). Motivation to attend to music could be critical in the acquisition of musical competence, but it could result from music's similarity to speech, to which infants are believed to be specially attuned (Vouloumanos & Werker, 2004). Experiments measuring infant interest in musical stimuli whose acoustic similarity to speech is titrated, for instance by manipulating instrument timbre or pitch-contour characteristics, could help to reveal whether there is a specific, independent interest in music. Such interest could constitute a simple and plausible music-related adaptation.

Finally, it is worth noting that much of the research in this area has focused on the perception or production of structural features of music. This in part reflects the usual scientific strategy of reducing complex phenomena to simpler parts that are tractable for study. However, music often occurs in the context of other activities, and to the extent that its function in these activities (religious rituals, celebrations, and other group events) may have played a role in how it originated, it may be foolish to neglect this. This likely means that, in addition to exploring how individuals hear or produce musical structure, we need to examine the effect of music on groups of people and on people engaged in other activities.

## SUMMARY

Empirical results have much to contribute to our understanding of the origins of music. There is some evidence for innate influences on several important components of musical behavior, including the perception of relative pitch, tonal structure, and periodic rhythm, as well as perhaps interest in music. There is, as yet, no compelling evidence that any of these represent traits that are specific to music, consistent with the notion that music is a side effect of traits that evolved for other functions. However, a definitive story for how these traits derive from more general abilities is lacking or incomplete in many cases. Several key research directions thus have potential to alter this general picture, and many interesting experiments await.

**Recommended Reading**

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