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Dean Keith Simonton
Department of Psychology
One Shields Avenue
University of California, Davis
California 95616-8686.

Biomusicology, and three biological paradoxes about music

Steven Brown
University of Texas Health Science Center

Biomusicology is a new scientific discipline whose subject matter is the evolutionary origins, brain mechanisms, and universal cultural properties of music and musical behavior. It is a synthetic discipline that sits at the interface between science and art, and between biology and culture. The term biomusicology was coined by Nils Wallin in the title of his 1991 book *Biomusicology: Neurophysiological, Neuropsychological and Evolutionary Perspectives on the Origins and Purposes of Music*. Although there had been more than a century of research into the evolutionary origins, brain mechanisms, and universal cultural properties of music before 1991, *Biomusicology* was the birth of a new approach to music. In it, Wallin outlined a neurobiological theory of music based on the properties of the central and peripheral auditory systems, and most especially on their interaction with the attentional and reward systems of the brain that mediate behaviors important for survival. A central focus of Wallin's discussion was lateralization of function in the brain and the importance of this phenomenon to the perception of musical sound patterns. In discussing the evolutionary origins of music, Wallin capitalized on his upbringing in the Jämtland region of Sweden by highlighting the relevance of ancient animal-herding calls – and most especially the *kölning* – to the origins of musical communication.

Biomusicology is comprised of three main branches (see Brown, Merker and Wallin, 2000). *Evolutionary musicology* deals with the evolutionary origins of music, both in terms of a comparative approach to vocal communication in animals and in terms of an evolutionary approach to the emergence of music-making in the hominid line. *Neuromusicology* deals with the neural and cognitive mechanisms of musical perception, production and emotion, as well as with the development of musical capacity from the fetal stage through to old age. *Comparative musicology* deals with the functions, uses, and control mechanisms of music in all human cultures, including such considerations as the contexts and contents of music events, the advantages and costs of music making for collective survival, and the comparative features of musical systems, musical forms, and musical performance styles throughout the world.

The biological approach to music has met many critics in musicology, ethnomusicology, and even music psychology. The point of this article is to demonstrate that biomusicology does indeed offer great promise in illuminating features of music that are not traditionally addressed by musicological, humanistic or cultural approaches. This article will discuss three biological paradoxes about music, one associated with each of the three major branches of biomusicology just mentioned. The issues raised by these three paradoxes are so fundamental to the nature of music that we could scarcely hope to develop a true understanding of music without addressing them.

The Evolutionary Paradox: Music's Apparent Lack of Survival Value

Charles Darwin set down the first biological theory of music in a 10-page passage of his 1871 book *The Descent of Man, and Selection in Relation to Sex*. In doing so, he addressed what he saw as the fundamental biological paradox about music: music has many costs for the individual but no obvious survival benefits. "As neither the enjoyment nor the capacity of producing musical notes are faculties of the least direct use to man in reference to his ordinary habits in life, they must be ranked amongst the most mysterious with which he is endowed," stated Darwin in a famous passage. The kinds of costs that evolutionists talk about are not those involved in purchasing concert tickets or CD players but rather the investment in time and energy required to produce music. In tribal cultures, rituals involving music and dance can last for several days on end. Spending this amount of time and energy singing and dancing does nothing to help you find food or fight off predators. If anything, it does exactly the opposite: it consumes great amounts of resources and announces your presence to potential predators.

Darwin's solution to the evolutionary paradox was to argue that music evolved by "sexual selection" as a form of courtship behavior, akin to the vocal courtship displays of insects, frogs, and birds. Darwin pointed out that many of these animal vocalizations were performed exclusively by the male of the species, and that they tended to be expressed primarily during the breeding season. His basic hypothesis was that music too evolved by sexual selection as a means of "charming the opposite sex". This idea was revived and given all the accoutrements of modern biological theorizing by Geoffrey Miller in his book *The Mating Mind: How Sexual Selection Shaped the Evolution of Human Nature* (2000).

However, there are critical problems with Darwin's courtship hypothesis of music. The entire motivation behind Darwin's theory of sexual selection was to explain so-called sexual dimorphisms. Think about the peacock's spectacular, multi-colored tail. This is a feature of peacocks that is noticeably absent in peahens. It is one of a large number of traits found in one sex but not the other, traits such as singing in many singing species. Darwin proposed that sexually-dimorphic traits evolved to serve a role in courtship, and this has indeed been borne out for many such animal traits by behavioral ecologists.

The fundamental problem with Darwin's theory of music is that *music is not a sexually-dimorphic trait at all*. With the exception of their higher-pitches voices, women are just as capable as men of producing and perceiving music, and girls develop musical competence in parallel to boys during childhood and adolescence. This alone should force us to reject Darwin's solution on face value. Consistent with this absence of sexual dimorphism for musical capacity is the corresponding absence of any specific role for music-making in human courtship in a manner resembling such a role in insects, frogs, and birds.

Are there other possible solutions to Darwin's paradox? One which is much more in line with ethnomusicological research and theory is to say that music evolved as a cooperative device to enhance group survival (Brown, 2000a). By this "group selection" scenario, the individual fitness costs involved in making music are offset by survival benefits to the whole group, where the group serves as a vehicle for individual survival. As music in traditional cultures is associated with virtually every function of collective importance – including hunting, harvests, rainfall, births, deaths, marriages, religious ceremonies, healing, trance, and the like – then music's association with these activities and events could explain its survival advantages. People invest time and energy in making music because it promotes activities that support collective survival. It must be mentioned that the concept of "group selection" – predicated on the idea that natural selection can act a level higher than the individual organism – has been a pariah notion in evolutionary biology since the 1960's but that it is making a comeback with a vengeance in recent years (e.g., Sober and Wilson, 1998). While I don't have the space to discuss this controversy here (see Brown, 2000a), I believe that group selection is not only the sole theory capable of explaining the emergence of music in the human species but also that music is probably the strongest piece of evidence for group selection in human evolutionary biology.

A solution to the first biological paradox about music states that music's survival value lies not at the level of the individual but instead at the level of the group, and that music evolved as a cooperative device to support group survival. There is an abundance of ethnographic evidence in support of this role in all human cultures. Music evolved not principally as a means for men to compete with one another for mates but, quite the opposite, as a means for groups of individuals to cooperate with one another for collective and coordinated action. But don't be fooled into thinking that this is some kind of feel-good theory of music. It isn't. Group solidarity is a completely double-edged sword. Music can be just as effective in bringing out people's most ethnocentric urge to annihilate outgroup members as it can in promoting universal love and tolerance (Brown, 2000a). Music can promote group warfare as much as group welfare.

The Neural Paradox: Music's Neurocognitive Specificity

Darwin's analysis of musicality as one of the most "mysterious" faculties with which humans are endowed is really a damnation of music as a kind of vestige. A similar view has been echoed in more recent times by cognitive psychologists, who see music in equally mysterious terms. They are quick to suggest that music is an ancillary add-on, not a primary cognitive function like language (Pinker, 1997). Not only is music inessential for survival in the Darwinian sense but it seems to be equally irrelevant for cognition in general. In my opinion, the large propaganda movement that has emerged in recent years dedicated to persuading the public that music enhances intelligence has only added fuel to the fire that music is little more than a "support" for other more significant cognitive capacities, like mathematical reasoning. In any case, we all know that people can develop psychologically with little intellectual impairment in the absence of music. Music seems to be inessential for human cognitive functioning.

With this backdrop in mind, the neural paradox of music becomes a statement about the amazing neurocognitive specificity that has been demonstrated for music over the course of more than one hundred years of research. Neurological studies have documented numerous interesting brain lesions that lead to specific losses of musical function while sparing other cognitive capacities, and conversely, brain lesions that destroy much cognitive functioning but that preserve music. The most spectacular example of the latter phenomenon was the Russian composer Vasaly Shebalin (1895-1963) who, after losing virtually all of his language function following a stroke, was able to compose one of his most powerful musical works, the Fifth Symphony (op. 65), in this condition. But why should such specificity exist for a function that seems so irrelevant both evolutionarily and cognitively?

The neural paradox becomes even more intense when we consider that music might not merely be a form of artistic expression but a way of thinking. The psychologist Howard Gardner, in his 1983 book *Frames of Mind: The Theory of Multiple Intelligences*, classified music as one of only seven "intelligences" that characterize human cognition. Much cognitive evidence suggests that music is a self-contained syntactic system akin to speech, involving combinatorial generative principles and culture-specific codes of meaning. But why should there be such a large investment in neural and cognitive space for a function whose utility seems so dubious?

As before, I believe that an answer to this paradox requires us to consider the adaptive value of music at a level higher than the individual. Accepting the earlier argument that music evolved as a group-cooperation device allows us to recognize two specific "design features" that reflect a unique role for music in promoting group participation and synchronization, namely *harmony* and *meter*. These are probably the two most human-specific and domain-specific features of music compared to other forms of communication in animals and other forms of cognition in humans, and they are in no way explained by Darwin's courtship hypothesis.

Whereas speech always involves an alternation of parts (i.e., you speak then I respond, and so on), music very often involves a simultaneous blending of parts. This is the basis for such important musical features as polyphony, homophony and heterophony. The musical system seems to be particularly well-designed to accommodate acoustic blending in a manner that is inconceivable for conversation, and this promotes collective participation in music. But in addition, if one watches the evening news on television, one never fails to see that when groups of people chant slogans at a political rally, they invariably do so in a metric fashion. While meter is never used in face-to-face conversation it is the major means by which people verbally express themselves in a collective fashion. Meter is a means of coordinating people. In group rituals, this coordination is found not only in verbal communication but, more importantly, in group singing, instrument playing, and dancing. Music is the ideal synchronization device, and it is quite reasonable to assume that it evolved as a cooperative mechanism to coordinate action and promote cohesion at the group level.

Neuroscientific studies, and especially neuroimaging studies, have done much to shed light on the nature of the musical brain. Studies over the last decade have provided evidence for a role of the right superior temporal lobe in melodic processing (Zatorre, Evans and Meyer, 1994; Zatorre and Belin, 2001), the inferior part of Broca's area for both monophonic singing and vocal harmonization (Perry et al., 1999; Brown et al., submitted), and the cerebellum and basal ganglia for rhythmic processing (Penhune, Zatorre and Evans, 1998; Rao, Mayer and Harrington, 2001). In addition, playing and listening to music are strong sources of positive emotion for people. Music unquestionably stimulates the attentional and reward systems of the brain, as Nils Wallin so amply discussed in *Biomusicology*. Studies from the Montreal neuroimaging group confirmed everyone's deepest intuitions that music listening does indeed activate parts of the "limbic" brain involved in emotional processing, areas such as the parahippocampal gyrus and orbitofrontal cortex (Blood et al., 1999; Blood and Zatorre, 2001). Finally, I have argued elsewhere that language, far from being a scaffold upon which music developed, is truly a sister function to music, and that the two co-evolved from a common communicative precursor during the course of human evolution (Brown, 2000b). Evidence that could lend support to this speculative thesis is a demonstration of "neural parallelism" between music and language, in part reflected in reciprocal hemispheric specialization (Brown, 2001; Brown et al., in preparation; see also Zatorre, Belin and Penhune, 2002).

Studies of the musical brain are still very much in their infancy. By comparison to studies of language processing, very little is known about the localization of musical function in the brain. However, a combination of neurological and neuroimaging studies give us grounds for believing that a fair degree of specificity for music exists in the brain, and that this specificity encompasses, at the very least, the uniquely-human features of harmony and meter.

The combined solution to the first two paradoxes is that music evolved as a group cooperation and coordination device, and that specific neural areas devoted to harmony and meter evolved in the human brain to mediate these processes while maintaining tight links to the reward centers of the brain, thereby fostering group participation, interpersonal cohesion and social coordination during music-related rituals.

The Cultural Paradox: Music's Lack of Autonomy at the Social Level

The solution to the neural paradox involved a demonstration of the cognitive autonomy of music from other cognitive functions. The cultural paradox of music is, in stark contrast to this, a statement about music's lack of social autonomy. Music never seems to stand alone; it is always a part of other activities. This point will certainly seem counterintuitive to people raised in Western culture because the notion of a "concert" is so ingrained in our own way of thinking about music. In addition, ever since the 19th century, the concept of "absolute music" – music for its own sake, music devoid of external referents or meanings – has assumed a central position in European musicological thinking, and this has been accompanied by a strong rise of purely instrumental forms in Western classical music. However, it is essential to realize that the condition of Western classical music is quite removed from music's ancient roots. Concerts are a very recent human invention; the first music hall was built only in the 17th century. In many cultures of the world, and most especially in tribal cultures, music is not performed for its own sake; there are no public concerts and there is no listening to music with a Walkman in the privacy of one's bedroom. Music is inextricably associated with other activities, and most universally with group ritual activities. In addition, music is strongly associated with language, where it serves as a vehicle for the transmission of history, ethical codes, and sacred texts. It is no accident that scriptures such as the Torah and the Qur'an are never spoken but only ever chanted. Music is an important device for making words sacred and memorable, for setting them apart from our regular manner of speaking about everyday things. It is for this reason that vocal music takes precedence over instrumental music in most cultures; it is an important means of reinforcing collective ideologies. How can music be so autonomous at the neurocognitive level and be so lacking in autonomy at the social level? Let me add here that my questioning of the social autonomy of music is not a descent into either Darwin's skepticism about the utility of music behavior or cognitive psychologists' skepticism about the cognitive autonomy of musical capacity, because the link that I propose below between music and culture is quite specific in nature.

I believe that the simplest solution to this paradox is to say that music *co-evolved* with ritual during the course of human evolution: music and ritual were linked together from their inception. Rituals are special group-wide behaviors that are set apart from the more mundane behaviors of daily living. They are characterized by their formal nature and highly structured organization. They serve many important functions for a group, including event marking, time marking, transmission of group history and identity, planning and decision making, preparation for group action, social bonding, and conflict resolution. Music's role in ritual is quite unique: music is a generalized *emotive manipulator* that acts to reinforce and give emotional meaning to those things with which it is associated (Brown, in press). Music is an enhancer of cultural objects, especially in the context of ritual events. Music's capacity to serve as an enhancer permits it to act as a potent device for persuasion, and this capacity is put to use as readily in television commercials and political propaganda as it is in religious rituals. Music's ability to enhance, persuade, transform, motivate and move can be used for both socially-positive and socially-negative ends. It can support hate as much as tolerance, destruction as much as healing. The important social consequence of this is that music is one of the most politically controlled features of any society, and this has been well documented by the onslaught of musical propaganda and musical censorship in the 20th century and today.

One way to understand music's role in ritual is by analogy to a similar mechanism at the individual level: music is a type of *reward system*. In the same way that neuroscientists talk about neural reward systems reinforcing individual behavior – for example those that underlie feeding, sex, drug addiction and the like – we can think about music as type of *social* reward system that makes group-ritual behaviors into individual necessities. This is consistent not only with the ubiquitous association of music to ritual activities in all human cultures but to the pleasurable and rewarding feelings that music evokes when people engage in such activities. Seeing music in this way forces to rethink the evolution of human ritual, which has been traditionally explained with reference to the emergence of language. Music has clearly played an essential role in this evolution, as it performs a function that language does only inefficiently: group-level emotive manipulator and reward system.

Conclusion: Music Evolved as Ritual's Reward System

In discussing these three biological paradoxes about music, a rather unified view of music evolution emerges, a view that revolves around group function. Music's individual fitness costs are offset by group benefits, and there is little conflict between self-interest and music making, especially where there are strict social norms regarding musical participation – such as in all tribal cultures. During the course of expansion of the hominid brain, new areas evolved to mediate this human-specific function of music, and most especially its unique design features of harmony and meter, features that foster group participation and interpersonal synchronization. But music is a hedonic function as well, one which evolved as a type of collective reward system, making the execution of group actions into a cultural imperative. If I were to summarize this overall view of music, I would say it as follows: *music evolved as ritual's reward system*, a type of social neuromodulatory system and group-level adaptation (Brown, 2000a).

Such novel insights into music's cultural functions come about only through a biological view of music. Biomusicology is poised to shed new light on human social behavior, from its collective nature to its emotive foundations.

Dedication: Shortly after this article was completed, Nils Wallin died. Nils was one of my greatest inspirations. I dedicate this article to his memory.

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Steven Brown
Research Imaging Center
University of Texas Health Science Center
7703 Floyd Curl Dr. MSC 6240
San Antonio, Texas, 78229-3900

Précis to an integrated Absolute pitch: Review

Daniel J. Levitin
McGill University

Absolute Pitch (AP) is generally defined as the ability either to *identify* the chroma (pitch class) of an isolated tone, using labels such as C, 261 Hz, or Do, or to *reproduce* a specified tone, e.g. by singing, or adjusting the frequency of a variable tone generator, and to do so without reference to an external standard (Bachem, 1937; Baggaley, 1974; Ward, 1999). When someone with AP hears a car horn, they might say "That's E-flat!" In contrast, if you play a tone from the piano and ask people what you played, most cannot tell you (unless they watched your hand). People with AP can reliably tell you, "That was a D-sharp," and some can even do the reverse. Ask them to produce a middle C (the center key on a piano keyboard), and they will sing or hum or whistle the pitch for you. Those with AP have memory for the actual pitches in songs, not just the pitches in relation to one another. In fact, when most of them hear a song in a different key (and therefore with different pitches), it sounds wrong to them.

Identifying a tone in such a way can be thought of as *passive* AP, and reproducing the specified tone can be thought of as *active* AP. Whether or not they possess AP, some individuals are able to recognize whether a familiar piece is played in the correct key, and/or can sing a familiar song in the correct key. Note the parallel here between the active- and passive-AP described first: recognizing the key of a musical piece is passive, and reproducing a musical piece in the correct key is active. Because some people display these abilities only with respect to musical pieces and not individual tones, it is useful to distinguish between *piece-AP* and *tone-AP* (Parncutt and Levitin, 2000).

There exist some confusions and misconceptions in the literature that absolute pitch involves more highly developed *perceptual* mechanisms, whereas the preponderance of evidence is that absolute pitch ability is an ability of *long term memory* and *linguistic coding* (Deutsch, 2002; Levitin, 1996). Further, the term *perfect pitch* has also been used somewhat interchangeably with the term *absolute pitch* in the literature whereas in fact, absolute pitch possessors do not perceive pitch any better than non-absolute pitch possessors (Bachem, 1954; Burns & Campbell, 1994; Levitin, 1996). AP possessors can typically tune pitches to within 20-60 cents of target frequencies (Rakowski & Morawska-Büngeler, 1987). In passive tasks, they regularly make semitone errors (Lockhead & Byrd, 1981; Miyazaki, 1988), and are not necessarily better than other musicians at identifying octave register (Miyazaki, 1988; Rakowski & Morawska-Büngeler, 1987). Clearly, there is nothing "perfect" about AP, it is simply the ability to place or produce tones within nominal categories.

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Psychology of Music
Diana Deutch, Guest Editor

Josef Zenisek *Girl with a mandolin*