How Musical is Man? – An Evolutionary Perspective

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John C. Bispham

Centre for Music and Science
Faculty of Music
University of Cambridge
11 West Road, Cambridge, CB3 9DP, UK

Department of Psychology
Macquarie University
NSW 2109
Australia

john.bispham@gmail.com
+44 7733 432894
www.johnbispham.com

Introduction

"*There is so much music in the world that it is reasonable to suppose that music, like language and possibly religion, is a species-typical trait of man. Essential physiological and cognitive processes that generate musical composition and performance may even be genetically inherited, and therefore present in almost every human being*." (Blacking, 1973 p.7)

Debates on the role of music in the course of human evolution are, in essence, addressing the question posed by Blacking (1973) – How musical is man? Framed by his socioanthropological/ethnomusicological investigation of the Venda people, Blacking's writings communicate clearly an empathic understanding and philosophical acuity of undiminishing pertinence. In fact many of his statements, such as those used to frame this brief article, have not only pre-empted subsequent theoretical and empirical research but have been strengthened by their results. This is perhaps particularly of note when we consider that a great deal of progress has been made, particularly over the last 15 years or so. Numerous conferences, articles, theses, journal special issues, and books have been devoted to understanding music from an evolutionary perspective (e.g. Wallin, Merker & Brown, 2000; Balter, 2004; Deliege & Vitouch, 2010; Morley, forthcoming). Researchers from a multitude of hugely diverse academic backgrounds have made valuable contributions addressing essential biological (e.g. Merker, 2000; Fitch 2006); developmental (Falk, 2004; Trehub, 2003); neuroscientific (e.g. Peretz, 2006); archaeological (e.g. Morley, forthcoming; Blake, 2010); and comparative (e.g. McDermott & Hauser, 2005) concerns. Models of music's biological and culturally contingent meanings (Cross, 2008/2009) and arguments for a myriad of putative rationales and scenarios regarding music's adaptive or exaptive evolutionary functionalities (e.g. Miller, 2000; Dissanayake, 2000; Huron, 2001; Brown, 2007; Livingstone & Thompson, 2009; Kirschner & Tomasello, 2010; Patel, 2010) have been published. Indeed, in many ways evolutionary theory appears to have provided an ideal framework for mutually beneficial discussion and debate between multiple perspectives on music. As such, it has additionally contributed to a broader, more complete, understanding of music and to a clearer understanding of the relevance of music to other fields of academic study (Cross, 2003).

A World of Musics

"It is the activities of Man the Music Maker that are of more interest and consequence to humanity than the particular musical achievements of Western man" (Blacking, 1973, p. 4).

A consistent difficulty with *some* research in this area has been a view of music that has perhaps focused too heavily on culturally-specific manifestations of musical activity. In particular, arguments grounded in a view of music as a pre-existing commercial commodity available for passive, private, and pleasurable consumption have proven unhelpful (see Cross 2007). A full account of the evolution of music and its manifest functionalities needs to be equally applicable to a western concert-goer as it is to all musics and to the full range and diversity of human musical experience. Distinguishing, for example, between "active" music-making and "passive" listening is, for our current purposes in particular, somewhat artificial[1]. Equally the concept of musical "works" is not of any primary importance. What is significant is elucidating a generalizable capacity for music and understanding the various structures, meanings and functions inherent in musical interaction. "Musicianship" is thus understood, in this paper, as the full set of capabilities – innate and/or learned – required to engage appropriately with music.

Definitional Issues

*To understand "music" as a human capability, as a species-specific set of cognitive and sensory capacities, we must begin by treating the definition of "music" as problematic... ... but not only must we be able to incorporate in a general theory of "music" the characteristics of all different musical systems, or "musics"; we must also account for the many different ways in which individuals and social groups make sense of what they or someone else regard as "music" (*Blacking, 1995, p.225).

Fortunately, some much needed theoretical progress towards a broad and non-ethnocentric definition of "music" has been made in last decade or so[2]. Publications by Cross (e.g. 2003) in particular, have been influential in stressing the essentially interactive; multi-modal; embodied; meaningful; and social nature of music-making worldwide[3]. His work has also been instrumental in merging biological and cultural perspectives on music (2003), and in theoretically delineating between interacting (and possibly overlapping) biological, social, and cultural components of musical meaning and emotion (2008; 2009). Cross argues that music encapsulates broad biological cues resulting from basic correlations between global structural features and motivational states; as well as social and cultural cues that are rooted in the specificities of human interaction (partially innate, partially learned) and personal, culturally rooted learning processes. Theoretical research of this nature provides a useful framework for positioning music within wider interdisciplinary discussions and debates and, as such, is an essential step towards a complete and informed debate on the evolution and functions of music.

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[1] Even seemingly "passive" and "private" listening is upon closer inspection both active and social. Listening to music involves activation of motor systems (Janata & Grafton, 2003); activates brain areas involved in active laryngeal and pharyngeal articulation (Koelsch et al., 2006); and is facilitated by an attribution of social intentionality (Steinbeis & Koelsch, 2009).

[2] Following a stress on *music as action* in ethnomusicological literature and the lack of semantic differentiation in many cultures, Cross views "music" and "dance" as '*intrinsically related or simply as different manifestations of the same phenomenon*' (Cross, 2007, p.12). I strongly support this view, so "music" in this article should please be interpreted as referring to both "music" and "dance".

[3] Cross (2003) offers the following definition: '*Music embodies, entrains, and transposably intentionalises time in sound and action*'. In short **embodiment** refers to musics' inseparable connection with the body and movement (see Thaut, 2005); **entrainment** refers to mechanisms that allow us to follow a pulse and act together 'in time' (see Clayton et. al, 2004); and **transposable intentionality** refers to the argument that meaning in music is both culturally constructed and individually flexible.

Is music an evolutionary adaptation?

"In a world such as ours,... it is necessary to understand why a madrigal by Gesualdo or a Bach Passion, a sitar melody from India or a song from Africa, Berg's Wocceck or Britten's War Requiem, a Balinese gamelan or a Cantonese opera, or a symphony by Mozart, Beethoven or Mahler may be profoundly necessary for human survival, quite apart from any merit they may have as examples of creativity and technical progress. It is also necessary to explain why, under certain circumstances, a "simple" "folk" song may have more human value than a "complex" symphony (Blacking, 1973, p. 116).

The question of whether musical abilities have arisen as a result of natural or sexual selection – as an **adaptation** - or whether they emerged as an indirect consequence of evolutionary pressures towards other human abilities – as an **exaptation** – has a long, albeit until recently sporadic, history. Spencer (1858) and Darwin (1871) presented opposing views in the literature. Spencer argued that music originated in the prosodic features of emotional speech whereas Darwin, conversely, argued that music preceded language (providing the basis for "impassioned speech") and evolved from animal mating calls by processes of sexual selection[4]. In '*The Principles of Psychology*' (1890), James argues for a non-adaptionist origin of music, describing it as 'a mere incidental peculiarity of the nervous system' (p.417). However, it was not until Pinker's (1997) provocative description of music as "auditory cheesecake" – "a pure pleasure technology, a cocktail of recreational drugs that we ingest through the ear to stimulate a mass of pleasure circuits at once" (ibid., p. 528) - that music started to feature regularly in the evolutionary literature and in academic debates. Without denying the possibility of a non-adaptive origin of music, Pinker's original argument has been widely dismissed as being grounded in a narrow and ethnocentric view of music (e.g. Cross, 1999). However, it does, in retrospect, seem to have been of benefit in provoking response and interest in questions regarding the evolution of music.

The argument for an adaptionist view of the evolution of music has been built upon four main sources of evidence: The universal appearance of music in all known human cultures[5]; Archaeological and paleoanthropological evidence suggesting a long history for music[6] (Morley forthcoming); neuroscientific studies suggesting neurological domain-specificity for music (Peretz, 2006)[7]; and developmental research into predispositions for musicality in infancy (see Trehub, 2003). While, each of these represent large bodies of research each with their own sets of complications and debated issues, the wealth of evidence has convinced many that '*an adaptive model for music should be the default hypothesis*' (Foley, quoted in Balter, 2004). Correspondingly, numerous and diverse hypotheses regarding putative rationales for the emergence of musical abilities have appeared in the literature. These have variously viewed music as a means of coalition signaling (Merker, 2000; Hagen & Bryant, 2003); achieving group cohesiveness (Roederer, 1984; Brown, 2000b; Kirschner & Tomasello, 2010); and as a quasi-playground for exploring and learning key social skills (Cross,

[4] Miller (2000) has more recently reopened the debate on a sexual selection model of evolution for music. However, his argument has been criticised for an ethnocentric bias and for failing to account for the specificities of music. We cannot discount that sexual selection may have played a significant role in the evolution of musical capabilities. However, to date the evidence appears slim.

[5] As noted by Huron (2001), music is not only a universal feature of human culture, but also a feature that universally consumes a large amount of time and resources.

[6] The oldest uncontroversial evidence comes in the form of flutes/pipes from the Geissenklösterle site that were been dated to 36'800 +/- 1000 years[6] BP (see Blake, 2010; Morley, forthcoming; for recent reviews)[6]. Crucially it must be assumed that musical behaviour and even the use of musical instrumentation considerably predates these findings. The flutes are highly complex in design and are hence unlikely to represent the first instance of material objects for musical engagement. Furthermore, ancient societies would, as is the case in modern-day hunter-gatherer societies, most likely have produced music primarily vocally and percussively employing biodegradable materials (see Morley, 2003).

[7] In particular, studies of congential and acquired "amusia" (see Peretz, 2006) have been interpreted as demonstrating a "double-dissociation" between music and language. This view has notably been challenged by a study by Patel et al (2008) indicating that some amusic individuals also have difficulty in processing speech intonation patterns and remains a debated issue.

1999). Notable for a wealth of supporting evidence is Dissanayake's (2000) argument that increased infant altriciality in the human lineage (e.g. Joffe, 1997) provided evolutionary pressures for proximate physiological and cognitive mechanisms to ensure longer and better maternal care. Human music is thus seen to have originated in the multi-modal affiliative interactions between mothers and infants under six months of age. However, a possible restriction in the extent of the theory's explanatory scope is that, while it would appear to account for quasi-musical features inherent in mother-infant interactions (see Papousek, 1996), it does not explain how we got from that to full manifestations of "music".

Others remained unconvinced by an adaptive origin of music. Livingstone and Thompson (2009) argue that music emerged as an exaptation from the acquisition of the ability to attribute mental states to self and others, whilst Panksepp (2009) views the emotional power of music as being rooted in the evolution of basic motor and emotional systems of the brain. Patel (2008; 2010), describes music as a "biologically powerful human invention" – a "transformative technology of the mind". Patel uses the example of the invention of fire-making to demonstrate that universality need not imply biological adaptation and interprets the available neuroscientific literature on music as suggesting that music can have lasting beneficial effects on nonmusical, pre-existing brain functions within an individual lifespan rather than originating via natural selection processes.

Patel (2008; 2010) argues that the available evidence fails to challenge a null hypothesis that assumes no natural selection for musical abilities. Conversely he argues that the available evidence for linguistic abilities is sufficient to reject a corresponding null hypothesis. Either or both views may well turn out to be correct. However, a comparison of the evidence he gives to support these contrasting views is not entirely convincing. In support of the case for an adaptive origin of language Patel draws on ten principal sources of evidence: Babbling; anatomy of the human vocal tract; vocal learning; precocious learning of linguistic sound structure; critical periods for language acquisition; commonalities of structure and development in spoken and signed language; robustness of language acquisition; adding complexity to impoverished linguistic input; fixation of a language-relevant gene; and a biological cost of failure to acquire language. My reading of the literature is that the first eight of these sources of evidence are at least equally valid for music or have corresponding parallel evidence in psychological studies of music[8]. Furthermore the specificity of the FOXP2 – a gene whose mutation has been linked to hereditary language impairment - to linguistic capabilities is not completely clear[9]. I would argue that it is far too early to suggest that there is no biological cost of failure to acquire musical abilities[10]. Crucially, just as it has proved difficult to define "music", it is currently unclear what constitutes a generic failure to acquire musical abilities. Despite some anecdotal accounts of cerebro-vascular accidents resulting in a lost interest in music (Griffiths et al., 2004) and a recent study reporting specific difficulties in pulse detection (Philips-Silver et al, 2011), neurological studies of individuals identified as being "amusic" have almost exclusively dealt with deficits in fine-grained pitch perception (see Peretz, 2006;). Many "amusic" individuals are able to engage appropriately with other important aspects of music and retain strong emotional connections to music. Furthermore, it remains to be seen if the results of studies of "amusia" are applicable across cultures (see Cross 2010).

It is important to note that where music and language would appear to share common psychological resources (see Patel, 2008) this need not imply a weakness to an argument for an adaptive origin of

[8] With reference to Patel's description of similarities between spoken and sign language, I am, first of all, unaware of any evidence suggesting that the reapplication of a behavioural trait in a different modality is indicative of adaptive evolution. Furthermore it is worth noting that some individuals with acquired deafness have continued to perform and compose music at very high levels. Clearly audition is a crucial and primary component of most musical engagement. However, music is, in essence, a *multi-modal* activity in which sound and movement are intrinsically linked from early developmental stages onwards (Bahrick & Lickliter, 2004; Philips-Silver & Trainor, 2005; Thaut, 2005). Linking in with this, another interesting question for future research could be how much benefit deaf individuals derive from rhythmic dancing.

[9] Alcock et al., 2000 have, for example, reported significant detriment to musical rhythmic capabilities in affected members of the "KE" family.

[10] An additional point worth making is that even if this were shown to be the case, it need not necessarily imply that a loss of musical ability would not have been biologically costly at an earlier stage of human evolution.

music. It is entirely plausible that music came first. Conversely to nonadaptionist accounts of music, some authors (e.g. Vaneechoutte and Skoyles, 1998) have argued, that language is constructed in part upon features that were originally selected for music. The prevalent view and that which perhaps appears most likely, however, is that musical and linguistic capabilities share a common foundation in the form of a shared ancestral communicative medium (Brown, 2000; Huron, 2001; Morley, forthcoming). Whilst reaching a definite consensus in the near future is perhaps optimistic, further theoretical, psychological, and neuroscientific research comparing the underlying mechanisms involved in music and language will hopefully advance this discussion.

Unresolved Issues

"Music" is both the observable product of intentional human action and a basic mode of thought by which any human action may be constituted. The most characteristic and effective embodiment of this mode of thought is what we call "music" but it may also be manifested in other human activities, and even in the organization of verbal ideas, such as Martin Luther King's famous "I have a dream" speech or in the poetry of Gertrude (Blacking, 1995, 224-225).

The complete human capacity for music is a vast conglomerate of abilities. Many essential perceptual and physiological abilities are present across species, whilst others are likely shared with other human communicative repertoires (in particular language). It can safely be assumed that music evolved as a complex "mosaic" of skills, some of which may individually have evolved at varying times and/or for various reasons. It is therefore crucial that putative evolutionary rationales and debates on music and evolution are grounded in a broad comparative understanding of music's "design features" – components of the human capacity for music that generically distinguish it from other forms of animal and human communication. Alternately, it is unclear, in evolutionary or comparative discussions, whether aspects of "music" are not more precisely attributable to broader categories of relevance. In a recent attempt to address this concern and to describe putative "design features" of music (Bispham, 2009), I present a model of the psychological and physiological specificities of engaging with "musical pulse" (see also Bispham, 2006); "musical pitch"; and "musical motivation". I hope to build on this work in forthcoming publications.

Two further unresolved issues relate to proposed putative functionalities of music that describe its emotional nature and ability to engender group cohesiveness. There appears to be a widespread consensus that both are central components of music and crucial to any evolutionary account of music. However, an understanding of how music is functional in these regards and solid arguments as to the evolutionary significance of these connections has proved somewhat elusive, possibly reflecting a bias of attention in related fields of academic investigation.

The overwhelming focus of experimental research in the study of music and emotion (see Juslin & Sloboda, 2010) appears to be on the *expression* of emotion. However, In terms of expressing semantically decodable emotional states, music appears to achieve very little, if anything, that is not equally realizable through other means of communication (Juslin & Laukka, 2003). Instead, a specific function of music - which is notably effective in the induction of "mood" (see Juslin & Vastfjall, 2008) - is perhaps rooted in its connection to the *regulation* of emotion. My understanding (following Trehub et al., 2010) is that musical engagement creates a temporally sustained framework for interaction that allows participants to efficiently co-regulate affect and achieve a group convergence of emotional and motivational states. I would argue that it is this facet of music, together with its floating intentionality (Cross, 2005), that enables it to be particularly efficacious in supporting ritualistic ceremony. Crucially, from this basis, it may be possible to construct a biologically valid argument of musical functionality with reference to models that view emotion regulation as being meditated by mechanisms of cardiovascular vagal regulation (Porges, 2007) and as being biological

costly (Thayer & Lane, 2007)[11]. A shift of focus towards interaction and emotion regulation in studies of music and emotion would, I believe, potentiate a considerable advance in our understanding of music and evolution.

Specific characteristics of music (e.g. Brown, 2007; Bispham 2009), the universal use of music in ritualistic ceremony (e.g. Nettl, 2000), and quite simply the experience of musical interaction, strongly support a connection to group level functionalities and social connectedness. As such a group-level selection argument for music (Brown, 2000b; see Wilson & Wilson, 2007) may appear attractive. However, it has proved difficult to find a non-contentious theoretical framework for understanding these aspects of music within the available expositions of evolutionary theory. The study of music in evolution would appear to me to support the case that evolutionary theory needs to find ways of more satisfactorily accounting for positive human traits of compassion, empathy, and cooperativity.

A final note

The function of music is to enhance in some way the quality of individual experience and human relationships; its structures are reflections of patterns of human relations, and the value of music as music is inseparable from its value as an expression of human experience (Blacking, 1995, p.31)

Music is clearly functional in many different ways in modern-day society. Studies of "homeless choirs" (e.g. Bailey & Davidson, 2005) are testament to the transformative and life-affirming potential of music; Musical classroom games and improvisation have been showed to be instrumental (and particularly so) in the development of empathy in children (Rabinowitch, forthcoming); and music has been of much benefit in the treatment of affective disorders (e.g. Koelsch et al, 2010). Of course, this represents only an extremely small number of the many cultural, social, personal, and experiential uses and functions of music in modern-day society and it is important to note that not all these need necessarily be directly reflective of an evolutionary history. However, what appears to be very clear from an evolutionary perspective is that music is an integral biological and cultural component of who we – homo sapiens - are. Not only does the study of music in evolution support a long history, it has also provided a framework for discussing and understanding complementary views that seek to explicate putative functionalities at genetic, behavioural, organismic, and/or inter-personal or group interactional levels (Cross, 2003). Coming back to Blacking's question posed in the title of this paper, it seems that, at all available levels of investigation and explanation, there is strong evidence to support the view that "man" is indeed highly "musical". My hope is that a continued study of the role of music in evolution will be able to contribute to arguments that promote the role of music in society and education and, in particular, to arguments promoting the importance of simple, active, social, exploratory, and inclusive means of making music.

[11] For a recent paper on the relevance of models of autonomic nervous system function (and dysfunction) to music see Ellis & Thayer, 2010.

References

Alcock, K., Passingham, R., Watkins, K. & Vargha-Khadem, F. (2000). Pitch and timing abilities in inherited speech and language impairment. Brain and Language, 75:34-46.

Bachorowski, J. & Owren, M. (2003). Sounds of emotion: The production and perception of affect-related vocal acoustics. Annals of the New York Academy of Sciences, 1000, 244-65.

Bahrick, L., & Lickliter, R. (2004). Infants' perception of rhythm and tempo in unimodal and multimodal stimulation: a developmental test of the intersensory redundancy hypothesis. Cognitive, Affective, and Behavioral Neuroscience, 4, 137-47.

Bailey, B., & Davidson, J. (2005). Effects of group singing and performance for marginalized and middle-class singers. Psychology of Music, 33, 269-303.

Balter, M. (2004). Seeking the key to music. Science, 306, 1120-22.

Bigand, E., and Poulin-Charronnat, B. (2006). Are we "experienced listeners"? A review of the musical capacities that do not depend on formal musical training. Cognition, 100, 100–130.

Bispham, J. (2006). Rhythm in music: What is it? Who has it? and Why? Music Perception, 24, 125-34.

Bispham, J. (2009). Music's "design features" - musical motivation, musical pulse, musical pitch. Musicae Scientiae, special issue on music and evolution, 29-44.

Blacking, J. (1973). How musical is man? Seattle: Univ. of Washington.

Blacking, J. (1995). Music, culture and experience. Cambridge: Cambridge University press.

Blake, E. (2010). Stone "tools" as portable sound-producing objects in Upper Palaeolithic contexts: The application of an experimental study. PhD Thesis, Department of Archaeology, University of Cambridge.

Brown, S. (2000[a]). The "musilanguage" model of music evolution. In: N. L. Wallin, B. Merker, and S. Brown (Eds.), The Origins of Music, 271-300. Cambridge, MA: MIT Press.

Brown, S. (2000[b]). Evolutionary models of music: From sexual selection to group selection. In: F. Tonneau and N. S. Thompson (Eds.) Perspectives in Ethology. 13: Behavior, Evolution and Culture (pp. 231-281). New York: Plenum Publishers.

Brown, S. (2007). Contagious heterophony: A new theory about the origins of music. Musicae Scientiae, 11, 3-26.

Clayton, M., Sager, R., & Will, U. (2004). In time with the music: The concept of entrainment and its significance for ethnomusicology. ESEM counterpoint, 1, 1-45.

Cross, I. (1999). Is music the most important thing we ever did? Music, development and evolution. In S. Yi (Ed), Music, mind and science (10-39). Seoul: Seoul National University press.

Cross, I. (2003). Music and biocultural evolution. In M. Clayton, T. Herbert, & R. Middleton (Eds.), The cultural study of music, A critical introduction, 19-30. London: Routledge.

Cross, I. (2007). Music and cognitive evolution. In R. Dunbar & L. Barrett (Eds.) Oxford Handbook of Evolutionary Psychology, 649-667. Oxford, Oxford University Press.

Cross, I. (2008). Musicality and the human capacity for culture. Musicae Scientiae, Special Issue: Narrative in music and interaction, 147-167.

Cross, I. (2009). The evolutionary nature of musical meaning. Musicae Scientiae special issue on music and evolution, 179-200.

Cross, I. (2010). The evolutionary basis of meaning in music: some neurological and neuroscientific implications. In Frank Clifford Rose (Ed.), The Neurology of Music, 1-15. London, Imperial College Press.

Darwin, C. (1871). The Descent of Man, and Selection in Relation to Sex. In: E.O. Wilson (Ed.). From so Simple a Beginning: The Four Great Books of Charles Darwin. New York: W.W. Norton (2006).

Dissanayake, E. (2000). Antecedents of the temporal arts in early mother-infant interaction. In N. Wallin, B. Merker & S. Brown (Eds.), The origins of music, 389-410. Cambridge; MA: MIT press.

Ellis, J. & Thayer, J. (2010). Music and Autonomic Nervous System (Dys)Function. Music Perception: An Interdisciplinary Journal, 27;4, 317-326.

Falk, D. (2004). Prelinguistic evolution in early hominins: Whence motherese? Behavioral and Brain Sciences, 27, 491-503.

Fitch, W. T. (2006). The biology and evolution of music: A comparative perspective. Cognition, 100, 173–215..

Griffiths, T., Warren, J., Dean, J. & Howard, D. (2004). When the feeling's gone: A selective loss of musical emotion. Journal of Neurology, Neurosurgery & Psychiatry, 75, 344-5.

Hagen, E., & Bryant, G. (2003). Music and dance as a coalition signaling system. Human Nature, 14, 21-51.

Huron, D. (2001). Is music an evolutionary adaptation? Annals of the New York Academy of Science, 930, 43- 61.

James, W. (1890). The Principles of Psychology. New York: Dover Publications.

Janata, P., & Grafton, S. (2003). Swinging in the brain: Shared neural substrates for behaviours related to sequencing and music. Nature Neuroscience, 6;7, 682-687.

Joffe, T. H. (1997). Social pressures have selected for an extended juvenile period in primates. Journal of Human Evolution, 32;6, 593-605.

Juslin, P. N., and Laukka, P. (2003). Communication of emotions in vocal expression and music performance: Different channels, same code? Psychological Bulletin, 129, 770– 814.

Juslin, P. & Sloboda, J. (Eds.), Handbook of Music and Emotion: Theory, Research, Applications. Oxford: Oxford University Press.

Juslin, P. N., and Västfjäll, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. Behavioral and Brain Sciences, 31, 559–621.

Kirschner, S. and Tomasello, M. (2010). Joint music making promotes prosocial behavior in four-year-old children. Evolution and Human Behavior. 31;5 354-364.

Koelsch, S., Fritz, T., Cramon, Y., Mueller, K., & Friederici, A. (2006). Investigating emotion with music, an FMRI study. Human Brain Mapping, 27, 239-50.

Koelsch, S., Kristin Offermanns, K. & Franzke, P. (2010) Music in the treatment of affective disorders: An exploratory investigation of a new method for music-therapeutic research. Music Perception, 27;4, 307-316.

Livingstone, S. and Thompson, W.F. (2009). The emergence of music from the Theory of Mind. Musicae Scientiae special issue on music and evolution, 83-115.

McDermott, J., & Hauser, M. (2005). The origins of music: innateness, uniqueness and evolution. Music Perception, 23, 29-60.

Merker, B. (2000). Synchronous chorusing and human origins. In: N. Wallin, B. Merker, and S. Brown (Eds.), The Origins of Music, 315–327. Cambridge, MA: MIT Press.

Miller, G. (2000). Evolution of human music through sexual selection. In: N. Wallin, B. Merker, and S. Brown (Eds.), The Origins of Music, 329–360. Cambridge, MA: MIT Press.

Morley, I. (forthcoming) *The Prehistory of Music: The evolutionary origins and archaeology of human musical behaviours*. Oxford: Oxford University Press.

Nettl, B. (2000). An ethnomusicologist contemplates musical universals. In N. Wallin, B. Merker & S. Brown (Eds.), the origins of music, 463-72. Cambridge, MA: MIT press.

Owings, D. H., & Morton, E. S. (1998). Animal vocal communication: a new approach. Cambridge: Cambridge University Press.

Papousek, M. (1996). Intuitive parenting. In I. Deliège, & J. Sloboda (Eds.), Musical Beginnings, 88-111. Oxford: Oxford University Press.

Panksepp, J. (2009). The emotional antecedents to the evolution of music and language. Musicae Scientiae, Special issue on music and evolution, 229-259.

Patel, A.D. (2008). Music, Language, and the Brain. New York: Oxford Univ. Press.

Patel, A. D., Wong, M., Foxton, J., Lochy, A., & Peretz, I. (2008). Speech intonation perception deficits in musical tone deafness (congenital amusia). Music Perception, 25;4, 357-368.

Patel, A.D. (2010). Music, biological evolution, and the brain. In: M. Bailar, (Ed.). Emerging Disciplines, 91-144. Houston, TX: Rice University Press.

Peretz, I. (2006). The nature of music from a biological perspective. Cognition, 100, 1–32.

Peretz, I. (2010). Towards a neurobiology of musical emotions. In: P. Juslin and J. Sloboda, (Eds.), Handbook of Music and Emotion: Theory, Research, Applications, 99-126. Oxford: Oxford University Press.

Philips-Silver, J., & Trainor, L. (2005). Feeling the beat: movement influences infant rhythm perception. Science, 308, 1430.

Phillips-Silver, J., Toiviainen, P., Gosselin, N., Piché, O., Nozaradan, S., Palmer, C. & Peretz, I. (2011) Born to dance but beat deaf: A new form of congenital amusia. Neuropsychologia , 49, 961-969

Pinker, S. (1997). How the Mind Works. London: Allen Lane.

Porges, S. (2007). The polyvagal perspective. Biological Psychology, 27;2 116-143.

Rabinowitch (forthcoming). Long-term musical group interaction has a positive influence on empathy in children. PhD Thesis, Faculty of Music, University of Cambridge, UK.

Roederer, J.G. (1984). The search for a survival value of music. Music Perception, 1, 350-356.

Steinbeis, N., Koelsch, S., & Sloboda, J. (2005). Emotional processing of harmonic expectancy violations. Annals of the New York Academy of Sciences, 1060, 458-62.

Spencer, H. (1857). On the origin and function of music. Fraser's Magazine, October edition.

Steinbeis, N., & Koelsch, S. (2009). Understanding the intentions behind man made products elicits neural activity in areas dedicated to mental state attribution. Cerebral Cortex, 19, 619-623.

Thaut, M. H. (2005). Rhythm, human temporality, and brain function. In D. Miell, R. MacDonald & D. Hargreaves (Eds.), Musical Communication, 171-191. Oxford: Oxford University Press

Thayer, J. & Lane, R. (2007). The role of vagal function in the risk for cardiovascular disease and mortality. Biological Psychology, 74, 224-42

Tomasello, M. (2008). Origins of Human Communication. Cambridge, MA: MIT Press.

Trehub, S. E. (2003). The developmental origins of musicality. Nature Neuroscience, 6, 669–673.

Trehub, S. Hannon, E. & Schachner, A. (2010). Perspectives on music and affect in the early years. In: P. Juslin and J. Sloboda, (Eds.), Handbook of Music and Emotion: Theory, Research, Applications (pp. 645-668). Oxford: Oxford University Press.

Vaneechoutte, M. and Skoyles, J.R. (1998). The memetic origin of language: modern humans as musical primates. Journal of Memetics - Evolutionary Models of Information Transmission, 2.

Vitouch, O. and Ladining, O. (2009). Music and Evolution. A special issue of Musicae Scientae, 2009-2010.

Wallin, N. L., Merker, B., and Brown, S. (Eds.) (2000). The Origins of Music. Cambridge, MA: MIT Press.

Wilson, D.S. and Wilson, E.O. (2007). Rethinking the theoretical foundation of sociobiology. The Quarterly Review of Biology, 82, 327-348.