Chapter 5

The evolution of music: Theories, definitions and the nature of the evidence

Ian Cross and Iain Morley

5.1 Introduction

It is nowadays uncontroversial among scientists that there is biological continuity between humans and other species. However, much of what humans do is not shared with other animals. Human behaviour seems to be as much motivated by inherited biology as by acquired culture, yet most musical scholarship and research has treated music solely from a cultural perspective. Over the past 50 years, cognitive research has approached the perception of music as a capacity of the individual mind, and perhaps as a fundamentally biological phenomenon. This psychology of music has either ignored, or set aside as too tough to handle, the question of how music becomes the cultural phenomenon it undoubtedly is. Indeed, only over the past 10 years or so has the question of the 'nature' of culture received serious consideration, or have the operations of mind necessary for cultural learning explicitly engaged the attention of many cultural researchers (D'Andrade 1995; Shore 1996). The problem of reconciling 'cultural' and 'biological' approaches to music, and indeed to the nature of mind itself, remains.

One way of tackling this problem is to view music from an evolutionary perspective. The idea that music could have evolutionary origins and selective benefits was widely speculated on in the early part of the twentieth century, in the light of increasing bodies of ethnographic research and Darwinian theory (e.g., Wallaschek 1893). This approach fell rapidly out of favour in the years before the Second World War, for political as much as for scientific reasons, with the repudiation of biological and universalist ideas in anthropological and musicological fields (Plotkin 1997). However, evolutionary thinking has again become central in a range of sciences and in recent philosophical approaches, and music's relationship to evolutionary processes has been increasingly explored over the past two decades (see also Dissanayake, Chapters 2 and 24; Brandt, Chapter 3; Merker, Chapter 4, this volume).

5.2 Music in evolutionary thinking

Previous writings on the evolution of capacities for music have made one of two assumptions: either music is a by-product of other cognitive and physiological adaptations, or there are benefits associated with musical behaviour in its own right. Views advocating non-adaptive roots for music have been prominent over the past 20 years. A widely publicized view (Pinker 1997) proposes that the complex sound patterns of music make stimulating use of adaptations for language, emotion and fine motor control, which evolved independently through selective pressures not associated with any functions peculiar to music.

Music may not be essential for survival, as eating or breathing are, but, like talking, may confer a selective benefit and express a motivating principle that has great adaptive power. Music may have developed from functions evolved for particular life-supporting purposes as a specialization that elaborates and strengthens those same purposes. As Huron (2001, p. 44) puts it, 'If music is an evolutionary adaptation, then it is likely to have a complex genesis. Any musical adaptation is likely to be built on several other adaptations that might be described as pre-musical or proto-musical.'

Let us consider the theories that have been proposed to explain how our capacity for music may have evolved.

5.2.1 Music promotes group cohesion

Roederer (1984), like H. Papousek (1996) and Dissanayake (2000; and Chapters 2 and 24, this volume), proposes that music developed from mother–infant communication. The musical manner of their interaction, he suggests, strengthens emotional bonds between mother and infant, and practices the extraction of speech information from the musical components of talk, such as vowels, inflections and the pitch cues cultivated in some oriental languages. Roederer notes that music can transmit emotional information to many people at once, equalizing the emotional state of the group, which results in a bonding effect between the group members. This is an effect clearly identified earlier in Blacking (1969).

Sloboda (1985) observes that all cultures require the cognitive and social organization of practices and mental techniques for survival, and that while modern cultures have 'many complex artefacts that help us to externalize and objectify the organizations we need and value' (Sloboda 1985, p. 267), in non-literate societies the 'organizational structures' must be evidenced and expressed primarily in terms of the expressive ways that people interact with one another. For example, music can provide a mnemonic framework for the knowledge of a community, as well as a way of expressing the structure of social relations (Dissanayake, Chapters 2 and 24; Merker, Chapter 4, this volume).

5.2.2 Music is a product of group selection

The potential function of music in selection at the level of the group needs to be assessed in the light of the extensive debate within recent evolutionary thinking on the nature and existence of mechanisms of selection at the group level. Shennan (2002), in a comprehensive evaluation of models of evolutionary selection applicable to theories of human prehistory, observes that selection can occur at numerous levels, including that of the group. Group behaviours affect the social environment in which individuals live, feed and breed. As Shennan puts it,

> All theoretical schools, including those that are sceptical about other levels of evolutionary process than that of individual inclusive fitness, recognize that such [individual] interests may often be served by co-operating rather than competing with other individuals of the same species.
>
> (2002, p. 213)

In consequence of frequent interaction with the same people, an individual's behaviours are likely to acquire the form of approved prosocial norms that emerge within a population. Adherence to these norms can benefit the members of the group by giving additional rewards for behaviours that they choose to undertake as individuals (Bowles and Gintis 1998). In other words, optimal behaviours for the well-being of an individual can be determined through engagement with conspecifics, as well as between each individual and their non-human environment. In a social species, the likelihood that individuals will survive to procreate or have a

high rate of procreation depends on their 'cultural fitness'—how they behave in relation to others in their social group, not just their physical fitness.

Behaviours that contribute to 'group cohesiveness' may make other cooperative behaviours more likely. Bowles and Gintis (1998) have demonstrated through their game theory model that 'populations [without a centralizing control] whose interactions are structured in such a way that coordination problems are successfully overcome will tend to grow, to absorb other populations, and to be copied by others' (Shennan 2002, p. 216).

It can be seen that the emergence of musical behaviours as a prosocial norm assisting coordination within a group could lead to the growth of such groups and the spread of those behaviours. Not only could musical behaviours become a behavioural norm in their own right, but, because of their foundations in powerful motives for social awareness and expressive behaviours, those individuals with well-developed capacities for musical action and perception should also be best at identifying and engaging with *other* norms of social interactive behaviour. Therefore, in theory, musical behaviours fit well with the models of selection, at both individual and group levels, that demonstrate how the development and spread of musical behaviours is possible.

5.2.3 Socio-emotional bonding is favoured by evolution of musical signalling

Brown (2000a) proposes that music and language have common origins in a single communicative system (see also Scherer 1991). According to Brown, both music and language can be conceived of as functioning at 'phonological' and 'meaning' levels. The stream of sonic events that constitutes spoken language is interpreted as lexical items by means of a 'phonological system', the output of which feeds into a 'propositional system' for the production of speech, within which units have both relational (syntactical) and referential (semantic) value. Analogously, a phonological system can be conceived of as transforming a stream of musical sounds into discrete entities (e.g., motifs, harmonic configurations), that is, 'fed into a system of pitch-blending syntax that specifies a set of relationships between sound patterns and emotions … [which] deals with the issues of sound emotion, tension and relaxation, rhythmic pulse and the like' (p. 274). In this model, systems for dealing with sound information in both music and speech are identified as dissociated but employing comparable tiers of 'processing', each derived from a common set of hypothetical principles for interpreting and generating phrasing in action and experience (see also Brandt, Chapter 3, this volume).

Brown proposes that this common set of principles arose first as a unitary vocal communicative medium, 'musilanguage', and that language and music then became separate capacities though a process of divergence and functional specialization. Language came to fulfil propositional functions such as the expression of 'truth values', whereas music came to constitute a pre-eminently social or interpersonal phenomenon. He suggests that, 'the principal function of music making is to promote group cooperation, coordination and cohesion' (p. 296).

Brown subsequently (2000b) adds the notion of music as reinforcing 'groupishness', which he defines as a 'suite of traits that favour the formation of coalitions, promote cooperative behaviour towards group members and create the potential for hostility towards those outside the group' (p252). Music supports these traits through the opportunities that it offers for the formation and manifestation of *group identity*, for the conduct of *collective thinking* (as in the transmission of group history and planning for action), for group coordination through *synchronization* (the sharing of time between members of a group), and for *group catharsis* (the collective expression and experience of emotion). Ultimately, Brown sees music as having become established

in human cultures through its role as 'ritual's reward system'; music, for him, is a type of 'modulatory system acting at the group level to convey the reinforcement value of these activities … for survival' (p. 257). For Brown, music's survival value is thus not immediate and individual, but lies in its ability to promote group cohesion.

A different position is adopted by Hagen and Bryant (2003), who suggest that rather than causing social cohesion, music and dance signal social cohesion achieved by other means. Hagen and Bryant's overall thesis is that

> For humans and human ancestors, musical displays may have … functioned, in part, to defend territory (and perhaps also to signal group identity), and that these displays may have formed the evolutionary basis for the musical behaviours of modern humans.
>
> (2003, p. 25)

They propose that music and dance act as indicators of group stability and the ability to carry out complex coordinated actions (as exemplified, perhaps, in the New Zealand All Blacks' football cry, *haka*). They propose that the time needed to create and practice music and dance corresponds to the quality of the coalition performing them, indicating how much time they have devoted to preparing their skill.

Hagen and Bryant justify their position, and reject other explanations, on the grounds that musical behaviours cannot contribute directly to the cohesion of a group, because they are not a good indicator of an individual's ability to contribute to the group's survival. However, this view of group cohesion purely in terms of immediately perceived costs and benefits of group membership ignores emotional bonding and the loyalty engendered by a mutual emotional experience. Individuals may already have established their credibility within a group, in terms of their ability to contribute to its survival, but this provides no indication of their likelihood of doing so, or to whom they will direct their assistance. The ability of music to act as a forum for the practice of integrated, complex, coordinated group activities resulting in a powerful sense of membership and trust provides a coherent explanation as to why these behaviours persisted at a group level. One of the manifestations of this role may have been 'coalition signalling', and this may even have led to its perpetuation; however, this is unlikely to have been the primary selective force for music's development.

At a psychobiological and individual level, rather than a behavioural and social level, musical experience has been linked with the release and action of life-sustaining regulatory hormones. Freeman (1995) reports that the neuropeptide transmitter oxytocin aids in the formation of strong positive emotional memories and in the supplanting of negative emotional memories, having its strongest effects during trauma or ecstasy. Oxytocin is released into the brain in females during lactation, and is produced by males and females following sexual orgasm. It mediates in interpersonal bonding, both pair-bonding and mother–infant bonding. Critically, Freeman suggests that oxytocin is likely to be released while a person is merely listening to music. This would provide a strong neurological rationale for the role of music in the formation of social bonds, both in intimate interactions between people and in group musical activities such as crowd chants (Huron 2001; see Panksepp and Trevarthen, Chapter 7, and Osborne, Chapter 25, this volume)

5.2.4 **Music promotes sexual selection**

Charles Darwin proposed that the evolution of music in humans has its roots in courtship songs. He believed that the vocalizations with the greatest pitch changes made by apes tend to be produced by males when soliciting mates (Darwin 1871). Miller (2000, 2001) argues that musical

behaviours can indicate sexual fitness, signalling status, age, physical well-being and fertility. He suggests that dancing reveals aerobic fitness, coordination, strength and health; voice control may reveal self-confidence and status; rhythmic ability may indicate the 'capacity for sequencing complex movements reliably', whist virtuosic performance per se, 'may reveal motor coordination, capacity for automating complex learned behaviours, and having the time to practise' (Miller 2000, p. 340). The last characteristic may also, in young adults, signal sexual availability, as it implies a lack of parenting demands. These properties of musical and dramatic displays could lead to aesthetic preferences for particular forms of those behaviours, which leads Miller (2000) to propose that

> Any aspect of music that we find appealing might also have been appealing to our ancestors, and if it was, that appeal would have set up sexual selection pressures in favour of musical productions that fulfilled those preferences.
>
> (2000, p. 342)

This logic, however, implies that *any* musical trait for which there is a preference will subsequently be selected for by sexual selection. To this, an important qualifier should be applied: by definition, selection, sexual or otherwise, for a particular trait can occur only if that trait can arise by mutation of a gene and can be inherited. Behaviours and skills (for example, a particular language or music) can be transmitted in other ways. In addition, if sexual selection was responsible for the evolution of motives that cause most humans to find features of music aesthetically appealing, then we would expect convergence in behaviours of musical expression, and in the aspects of them that give pleasure. While musical behaviours are found in all cultures and share dynamic features and social motivations and uses, aesthetic preferences are often culture-specific.

Miller argues that 'If one can perceive the quality, creativity, virtuosity, emotional depth and spiritual vision of somebody's music, sexual selection through mate choice can notice it too' (p. 355); however, he admits that such rationales are speculative. While his thesis is presented as a call for empirical testing, Miller's hypothesis of the fitness-display properties of music does intuitively make sense. It could provide a mechanism by which musical behaviours may have become refined, perpetuated and spread in human evolution. His theory attempts to explain how the forms of musical behaviour may have evolved in the species, rather than how musical forms became appealing. It may be that the core factor in the appreciation of the quality of the musical behaviour (and its creativity and virtuosity in artistically developed forms) is its very 'emotional depth', i.e., the extent to which its perception elicits a compelling emotional response, and that this experience of emotion might not be a product of sexual selection. (See Dissanayake, Chapter 2; Lee and Schögler, Chapter 6, on emotional expression in movement, this volume).

5.3 The need for a comprehensive definition of music

Clearly, theories of how music may have evolved are divergent. For Pinker, music is a technology, ultimately dispensable, with no evolutionary significance. For Roederer, Sloboda, Brown and Hagen and Bryant, music may have had significant adaptive roles in selection at the group level, while for Miller, music may well have played a part in sexual selection. Nevertheless, all of these theories rely on what Huron (2001, p. 44) has described as 'the nebulous rubric *music*'. They provide no clear demarcation of what is intended by the term 'music'. It seems that these authors are employing something like a standard dictionary definition of music, such as, 'the art of combining sounds of voices or instruments so as to achieve beauty of form and expression of emotion', and a 'pleasant sound', both from the *Concise Oxford English Dictionary* (Sykes 1982) or 'the art or

science of arranging sounds in notes and rhythms to give a desired pattern or effect' – from the *Penguin Dictionary of Music* (Jacobs 1972).

For contemporary musicologists and ethnomusicologists, these definitions are unsatisfactory. They could apply to, say, a CD recording of a Beethoven string quartet, or a live performance by a rock band such as Coldplay. It is unclear whether the dictionary definition would embrace either the musical intentions of a contemporary composer such as Brian Ferneyhough, the sonic surface of contemporary popular forms such as electronic dance music, or the drum and dance music of a shamanic ritual in Borneo. To the musicologist and ethnomusicologist, these phenomena are indubitably musical, but 'sounds combined so as to produce beauty of form and expression of emotion' scarcely captures what can be considered to be musical in them. Several of the scientific conceptions of how musical behaviours and appreciations arose in evolution (for example that of Miller, 2000 and 2001) appear implicitly to define music according to current Western musical practices, where music is produced by few and consumed by many.

All of these notions of music reveal themselves to be ideological constructs rooted in the workings of broader socio-economic and political forces, which are dynamic, changing processes. As Magrini (2000) notes, changes in the ways in which music is manifested result in the discouragement of alternative and often older ways of engaging with music, particularly as an active element in everyday life. An 'inhibition' of musical practices may occur through processes of the reification of elements in cultural models of engagement with music; this occurs as the role of the music consumer—as opposed to that of a participant or everyday practitioner in musical activity—is created, then enhanced and eventually enforced, by institutionalizing or commodifying the processes of knowledge acquisition. Music-making may thus be inhibited through the loss of roles, contexts, situations and practices and the impoverished models of music and its social roles that result may all too easily be taken by music scholars to represent all possible kinds of music. Before assessing the relationship between music and evolution, it is essential to frame the object of study in a different way—to perceive music in all of its manifestations.

5.3.1 Music across cultures and times

All known cultures have or have had something that can be regarded as music. To be more precise, in the words of John Blacking (1995, p. 224), 'every known human society has what *trained musicologists* would recognize as music' (our emphasis). Across cultures and over time, the forms and significances of music are extremely diverse. In many, perhaps most, non-Western cultures, music requires overt action and active group engagement; the differentiation and specialization of the roles of performer and audience might almost be considered a minority practice. In most cultures, music is employed not just in entertainment and courtship, but as an essential component of ritual, often marking transitions between different stages of life (e.g., from adolescence to adulthood), as well as consequential events such as funerary rituals and seasonal festivals. It may function in the maintenance of oral traditions by virtue of its mnemonic powers. And it seems that in most, if not all, cultures, interactions between caregivers and infants have features that can be interpreted as musical.

Music appears to be something of a universal social fact. However, as the continuation of the quotation from Blacking above makes clear, 'there are some societies [not confined to the African continent] that have no word for music or whose concept of music has a significance quite different from that generally associated with the word "music"'. It is notable, moreover, that where a term exists, in a non-Western society, that embraces the activities that a Western musicologist might conceive of as music, for example the Igbo *nkwa* (Waterman 1991), that meaning tends not to differentiate between music and dance.

In general, it seems that practices that are recognizable as music in societies beyond contemporary global Western culture are characterized by their use of sound and movement together. They tend to involve collective performance: that is, they are characterized in terms of not only sound and action, but interaction between the music makers. They are marked by (1) an apparent 'non-efficaciousness', in that their immediate and evident consequences are not observable through material change in the local environment or in the subsequent behaviours of the participants, and (2) 'embeddedness' in a wide range of everyday and special practices. In most, if not all cases, they also manifest significant hedonic value (Panksepp and Trevarthen, Chapter 7, this volume).

Accepting that something like music—even if not discretely identified as such by its practitioners—is in all human cultures, the definitions in our dictionaries seem clearly unsatisfactory. 'Music' as a universal human behaviour is marked by sound, action, interaction, non-efficacy, and a multiplicity of social functions and emotional effects. These characteristics will now be assessed in more detail, to arrive at an operational definition of music that might enable its relationship (if any) to evolutionary processes to be addressed comprehensively.

5.3.2 Music as embodied expressive movement

Since the advent of sound recording, listening, with no overt and observable behaviour on the part of the listener, has been the paradigmatic mode of engagement with music in Western societies. However, before the advent of sound recording, the notion of music as involving action would have seemed self-evident. While it may seem trivial to suggest that music entails activity in its making, there are many instances where music's sonic patterns are not just caused by actions, but have a structure and identity that is inseparable from the doing and regulation of the actions themselves. This is evident in the studies by Blacking (1961) of southern African *kalimba* thumb-piano music, where he showed that the melodies can, on occasion, depend more on the sequence of movements involved in the production of the melody than on the pitch patterns produced. Similar findings are reported by Baily (1985) for the repertoires performed on Afghani *dutars*, and Nelson (2002) for melodic patterns in blues guitar solos.

In these three instances, action on the part of a performer is an integral component of the identity of the music. Several instances can be cited where actions by participants, in situations where the performer–audience distinction is absent, constitute a framework essential for the intelligibility of musical sound patterning (e.g., Stobart and Cross 2000). A recent meta-analysis of neuroscientific studies of music perception (Janata and Grafton 2003) demonstrates that passive musical perception appears to involve areas of the brain associated with motor behaviour, perhaps elicited by the sound sequences of music mirroring aspects of physical movement (Scherer and Zentner 2001, pp. 377–78; Benzon 2001). Music seems better understood, not as abstract patterns of sound contemplated in immobility, but as a thoroughly embodied activity of human agents (Lee and Schögler, Chapter 6; Turner and Ioannides, Chapter 8, this volume)

5.3.3 Music as entraining others, and engaging them in movement

Most of the contexts in which music occurs are not only active but participatory, involving the overt and active engagement of people in musical group activities. An intrinsic component of this participation is 'entrainment' (Clayton *et al.* 2004), which involves the coordination in time of one participant's musical behaviours with those of others. This process appears to involve the perceptual inference or abstraction of a regular periodic pulse or beat from a sequence of rhythmic events, and the intuitive or cognitive organization of the timing of actions and sounds around the motivating pulse. It orientates attention prospectively to the time points presented in

the pulse, with a concomitant periodic modulation of the amount of attentional resources devoted to tracking the temporal flow of the music, again orientated around the pulse (Drake *et al.* 2000).

According to a cognitive interpretation, pulse abstraction facilitates an optimal use of attentional resources over time. Experiments show that events occurring in temporal alignment with the inferred pulse are detected and identified more easily than events that occur out of phase with the pulse (Jones and Yee 1993). What is conceived as the 'attentional load' is modulated in time in accordance with the pulse the subject infers. At a neurophysiological level, the experience of pulse seems intimately related to the different ranges of timing in the coordination of gross and fine movements (Thaut 2005). Entrainment to an external pulse may be either volitional (under conscious control) or preconscious (Stephan *et al.* 2002).

We conclude that musical interaction between human participants is rooted in intuitive, mind-generated processes of pulse abstraction/generation within the individuals. These processes implement the optimal allocation (modulation in time) of attentional resources and may focus experience in hierarchical temporal structures. The perceptual processes are integral to the prospective temporal control of periodic motor behaviour. Music as an interactive social behaviour thus affords the means for synchronizing the deployment of a participant's experience of moving with that of other participants, facilitating the individual and the collective (intersubjective) focus on specific moments and sequential patterns in the temporal unfolding of the music.

5.3.4 The ambiguity of musical intentions and a definition of musical meaning

A broad interpretation of these entrainment processes, or the prospective perceptual control of socially engaged musical movements, might impute similar characteristics to language. Conversational language also relies on features that coordinate the timing of an individual's behaviours with those of others, as well as synchronizing the deployment of participants' attention (Auer *et al.* 1999). In language, however, the meaning of an utterance with reference to an object in the world can be specified with some precision; this is not the case for music.

The 'outside' meaning or denotational significance of music can rarely be pinned down unambiguously. As John Blacking noted (1995) 'the "same" sound patterns … can … have different meanings within the same society because of different social contexts' (p. 237); in Langer's (1942) words, in music, the 'actual function of meaning, which calls for permanent contents, is not fulfilled; for the assignment of one rather than another possible meaning to each form is never explicitly made' (p. 195). In effect, the same piece of music can bear quite different meanings for performer and listener; it might even bear multiple disparate simultaneous meanings for a single participant. Music, to a much greater degree than language, appears to have a 'floating intentionality' (Cross 1999), gathering meaning from the contexts when it happens, or where and how it is remembered to have happened, and in turn contributing meaning to those contexts.

While language can articulate complex propositions that can be interpreted as referring exclusively to particular states of affairs in the world, which may have 'truth value' in respect of these, this is not the case for music. Although possessing a similar potential to language for the articulation of complex syntactic structures in action and awareness of action, music never seems to achieve direct or unequivocally interpretable reference to things beyond itself. While music can be interpreted as referring both to itself and beyond itself (as possessing both 'sense' and 'reference', after Frege 1952), it is only in respect of its perceived reference to itself (its sense) that its ambiguity may be minimized or entirely resolved (Cross 2005; Brandt, Chapter 3, this volume).

As music flows in time, it presents rhythmic and melodic patterns that may give rise to expectations for listeners or participants as to how and when it will continue. In the rhythmic flow of the music, those expectations may be realized or abrogated. Thus, music can generate allusion to future possibilities of unfolding; when those future possibilities become actualities, the significance of those earlier musical events may become clear, their sense (at least partially) disambiguated, giving rise to what Meyer (1956) has called music's evident meanings.

Those patterns of evident meaning, together with the music's sonic and gestural qualities as it unfolds, may also yield a degree of reference, this time beyond the music itself. They may result in the elicitation of emotion or the evocation of specific conceptual–intentional complexes in the mind—complexes of ideas with which aspects of the music have become associated through individual experience or cultural convention, or because of biosocial predispositions (Cross 2005; Lavy 2001; Morley 2003, pp. 150–162). But while those conceptual–intentional complexes may themselves be complex, they are neither propositional nor decomposable in relation to definite objects of human thought and action. Their experience is likely to vary from participant to participant, taking form in what Meyer (1956) referred to as connotative complexes. Their sense and reference is not bound to a specific situation or set of circumstances, but rather to a range of situations, as a particular emotional or affective mind–brain–body state may be relevant to a range of circumstances for any one individual (Oatley and Johnson-Laird 1998). Hence, while aspects of music's sense may (retrospectively) be disambiguated, its objective reference cannot.

In certain circumstances, however, music can appear to bear meanings in much the same way as language. Results from functional brain imaging studies support this conclusion. Koelsch *et al.* (2004) demonstrated that music can elicit brain responses similar to those elicited by language in respect of 'semantic mismatches', although the responses following a musical context were less consistent than those following a linguistic context. Music and language both *mean*; they can both function in the conceptual–intentional domain as acts of meaning. Nevertheless, language can express more semantically decomposable propositions; it can refer unambiguously to complex states of affairs in the world. Music embodies and exploits an essential ambiguity, and in this respect, language and music may be at complementary poles of a communicative continuum, meeting somewhere near poetry (Cross 2003c). This inherent ambiguity—together with the quality of the actions and interactions that were noted earlier as integral to music—suffices to differentiate music from language, enabling it to be efficacious for individuals and for groups in contexts where language would be unproductive or impotent, precisely because of the need for language to be interpreted unambiguously (Brandt, Chapter 3, this volume).

Hence, music might be defined broadly and operationally as embodying, entraining, and transposably intentionalizing time in sound and action (Cross 2003a), typically expressed by voices and instruments that articulate patterns in pitch, rhythm and timbre, and involving correlated gestural patterns of movement that may or may not be oriented towards sound production. This definition is not intended as an alternative to conventional dictionary definitions; such definitions effectively delimit those aspects of music that appear significant within recent Western culture. The broad definition is intended to delineate those attributes that, in every community, appear to distinguish music from other spheres of human activity in a way that might enable its relationships to cultural and biological processes to be evaluated. It is not intended to be either constitutive or essentialist.

5.4 **The communal functions of musical actions**

Music, as broadly defined above, is capable of engaging and rewarding communities, groups and individuals. In collective musical behaviour, individuals act and experience what they do

in shared, purposeful time. The experience of the coordinated nature of the collective activity is likely to engender a strong sense of group identity with the communication of pleasure. Music both entrains movement and experience, and allows each participant to interpret its significances for him or her self, independently, without the integrity of the collective musical behaviour being undermined. Music's ambiguity—its 'floating intentionality'—in the self and for or with others, may thus be highly advantageous for groups, serving as a medium for participation and contributing to the maintenance of social flexibility.

A clue to music's efficacy for the individual might be found in Meyer's (1956) suggestion that music does not merely embody metaphors, but is a 'metaphorizing medium' through which seemingly disparate concepts may be experienced as related and become part of a transforming experience of the self. Music appears to constitute a medium that facilitates access to, and the formation of, conceptual–intentional complexes and metaphorical representations that may apply to many individual and social circumstances. As Meyer puts it:

> Music does not [for example] present the concept or image of death itself. Rather it connotes that rich realm of experience in which death and darkness, night and cold, winter and sleep and silence are all combined and consolidated into a single connotative complex… What music presents is not any one of these metaphorical events but rather that which is common to all of them, that which enables them to become metaphors for one another. Music presents a generic event, a 'connotative complex', which then becomes particularized in the experience of the individual listener.
>
> (1956, p. 265)

Thus, music can be interpreted as facilitating the formation of conceptual–intentional complexes across multiple domains of experience, providing a synthetic medium that can bind together the experiences of disparate situations and concepts in whole forms that cannot be decomposed into sets of discrete propositions. This may be of particular significance where two or more domains of experience with fundamentally irreconcilable characteristics appear to coexist, as may be encountered in ritual or religious contexts (Cross 2003c; Merker, Chapter 4, this volume).

5.4.1 **The developmental value of music**

While music can function as a concept-linking medium for mature members of a culture, we suggest that it is also powerfully effective in infancy and in childhood, for the individual and for pairs or groups. 'Protomusical behaviours' (M Papousek 1996) have been identified as the foundation of the ability infants have to interact with others predictively, to exercise the capacity for Trevarthen's 'primary intersubjectivity' (1979, 1980, 1999; Dissanayake, Chapter 2, this volume). For older children and adults, musical behaviours can be interpreted as providing ways of interacting that—by virtue of their ambiguity, or flexible significance—are likely to minimize social conflict. As a group of children play together musically, for each child the significance of their own and others' musical behaviour can be quite different and individual; yet the integrity of the overall musical interaction, and the pleasure gained, need not be compromised. Music's ambiguity allows for the exploration and rehearsal of skills in interacting with others, minimizing the risks of engaging in conflict or misunderstanding, risks that would be more likely were the medium linguistic with unambiguous reference. Musical play can be a way to exercise and acquire social competence and confidence in cost-free and mutually rewarding interaction.

In early childhood, protomusical and protolinguistic abilities are intimately interlinked, sharing many features and relying on common systems in children's cognitions and behaviours. As children develop the capacity for ostensive/inferential communication, the extent to which vocal and gestural behaviours can substitute for one another in linguistic contexts is increasingly constrained;

utterances become more fixed and unambiguous in their significance and meaning. In contrast, protomusical and musical behaviours retain a degree of ambiguity or transposability in their 'aboutness', particularly in the babbling stage (Elowson *et al.* 1998). This ambiguity is evident in the capacity of prelinguistic utterances to reflect or engage with the temporal dynamics of the joint actions, physical events, experienced affective states and changes of affective state that can be shared in social exchanges. The elements of protomusical behaviour can be associated, for infants and children, with any or all of a wide range of types of event in their experience of the world.

In what is still the only large-scale study of children's music and musicality in a non-Western context, Blacking (1967) notes that music subserves primarily social functions for the children of the Venda society in southern Africa: 'Most Venda children are competent musicians … and yet they have no formal musical training. They learn music by imitating the performances of adults and other children' (p. 29). In a society where music is chiefly manifested as interactive behaviour that plays an especially significant role in structuring social relations in both ritual and everyday contexts (Blacking 1976), the musicality that emerges from enculturative processes has profound effects on children's socialization. Blacking's findings relate directly to research on how children learn all manner of knowledge and skills in different cultures, and specifically to the prevalence of 'intent participation learning' in the majority of societies (Rogoff *et al.* 2003), particularly where there is little or no institutionalized schooling. While the Venda culture that Blacking studied might be regarded as exceptional in the importance that it accords to music in structuring social relations, music seems equally socially significant in many other non-Western societies, such as those of the rural Andes (Stobart 1996), or the partially urbanized and heteroglot cultures of north-west China (in the form of *hua'er* songs—Yang 1994). Music and activities exhibiting musicality in infancy and childhood can be conceived of as providing a medium through which social flexibility may be acquired and sustained.

Music may also aid development of the individual's cognitive flexibility. Over the past 20 years, cognitive psychologists have found that infants do not come into the world as blank slates (Spelke 1999); neonates are predisposed to pick up and to process experience in quite specific ways. Capacities for consciousness of events and objects emerge too rapidly to be explained by the operation of a general-purpose learning mechanism, and their adaptive purpose is now abundantly evident. Moreover, it has been shown that infants assimilate information pertaining to the use of physical objects and events quite differently from how they acquire and manage their intentions toward people and social events. For example, very young children may show a highly developed capacity to reason about the social world at a level that may not be manifested in their reasoning about physical objects (Donaldson 1992; Cummins 1998). It could be said that infants come primed for 'physics' and primed for 'psychology', each in domain-specific ways. Yet infants and children ultimately acquire what can be thought of as a domain-general competence that is useful for grasping meanings in any kind of cultural context. We suggest that music, or rather protomusical behaviour, is efficacious in the emergence of this domain-general cultural competence by virtue of its ambiguity—its transposability or floating intentionality. Infants not only emerge into the world primed for investigation of what a psychological scientist might identify as physics and psychology, but predisposed to engage in music-like activities in their interactions with caregivers, which are neither or both of these. Thus, the foci and significances of these protomusical activities—inherent musicality—can lie equally in either domain (Cross 1999): it seems probable that they operate at a more fundamental motivating level, enhancing the likelihood of integration of information across physical and social experience, and facilitating the formation of a general competence not tied to any cognitively specialized domain (Cross 2005).

There is tentative evidence for this suggestion in the positive correlations between IQ and the engagement in musical activities found in studies reviewed by Schellenberg (2003). His own more rigorously conducted study (Schellenberg 2004) shows that engaging in music lessons leads to a small but statistically significant enhancement of IQ. While this evidence suggests that music has limited effect on the intellectual capacities of some individuals, it is also possible that, for Schellenberg's participants, the formal Western music lesson (which tends to take a form very similar to a school lesson) provides a highly culture-specific learning context that minimizes the extent to which the apparent social efficacy of music can be explored and exercised (for an exception to this learning context, see Fröhlich, Chapter 22, this volume).

We conclude that music and language, while different parts of the human communicative toolkit, both provide purposeful syntactic frameworks that serve human needs of joint action and interaction. Similar capacities underlie their use, including the capacity to produce complex and hierarchically structured sequences of events (sounds and actions) and to abstract structure from such patterns produced by others. However, where language and music diverge is in the ways in which the structures of those patterns are endowed with significance. In language, considerations of reference and of relevance with regard to states of affairs in the world (Sperber and Wilson 1986) are paramount. In music, unambiguous reference and relevance are much less significant; the primary determinant of musical experience might well be how the perceived sounds fit with the temporal structures experienced in a moving human body.

5.4.2 Is musicality a universal human talent, and if so, what kind of talent?

Our account of the functions of music presumes that music is not only culturally but humanly universal, i.e., that not only do all known cultures engage in practices that are recognizable as musical, but that all individuals of those cultures have the capacity for musicality. This assumption would be seriously undermined were evidence to be found that a significant proportion of normally developing individuals in any human population were incapable of displaying musical behaviours. On the basis of current evidence, we believe that this is not the case.

In many traditional societies, a capacity to engage in musical activities appears to be expected of all its members (Blacking 1995; Arom 1991). While it is accepted that some people will be more adept or creative than others, a capacity for music is expected of all, like a capacity for speech. In contemporary Western societies, a similar situation prevails: even individuals who feel that they have no capacity to engage in overt musical behaviours are generally expected to have the capacity to listen to music with a degree of appreciation.

There are, nevertheless, persons who are classified as amusical—who app ear, when tested, to lack the capacity to engage with or comprehend the sounds produced by musical behaviours. This deficit may be consequent on a brain trauma, but some individuals with no identifiable neurological damage also appear to lack musical capacities, as defined by particular tests (Peretz 2003). These individuals typically show a dissociation between their capacities to deal with information in the pitch and time domains, frequently exhibiting more profound deficits in the processing of melody than of rhythm. Peretz suggests that an inability to process fine-grained pitch differences inhibits the development of a capacity to engage in musical activities, a condition that she defines as 'amusia'. While earlier studies (e.g., Kalmus and Fry 1980) suggested that some five per cent of the normal population are amusical, evidence from the application of a more sophisticated test instrument—the Montréal Battery of Evaluation of Amusia (MBEA)—suggests that amusia is extremely rare: only 2 per cent of those tested had scores of less than two standard deviations below the mean, but even here, performance was around 70 per cent correct (Peretz *et al.* 2003).

It appears that there is no strong evidence that musicality is not a universal human attribute. However, very little scientific research into the possession of musical capacities has been conducted outside the confines of contemporary Western society, and for a wider picture one must rely on the ethnographic record. From the evidence presented in the ethnographic and scientific literature taken together, we conclude that, as with language, all humans (with a very few rare exceptions) have the capacity to engage in musical behaviours.

In view of the extent to which music appears entwined with other domains of human behaviour, it seems feasible to suggest that this human capacity for music may comprise a number of components, which may have come about under the influence of a range of different evolutionary pressures. The integrated suite of behavioural capacities that constitutes modern human musicality might have a variety of sources in prehistoric adaptive changes.

Pinker's (1997) description of music as a technology with no evolutionarily adaptive value, a view apparently predicated on the notion that music consists simply of sonic patterns, is unacceptable to us. As we have seen, music cannot be reduced to patterns of sound, and its effects appear more far-reaching than simple and immediate hedonic response in individuals. Miller's (2000) sexual selection theory, which focuses on music as display, may well describe some of the ways in which musicality was adaptive in human evolution. However, as evident from the foregoing, music is more than display: it typically involves coordinated *interaction* in individual performance. It seems highly likely that music plays a significant role in forming and maintaining group cohesion among humans, as Brown (2000b) suggests, by virtue of its capacity to entrain activity, and its floating intentionality. Despite differences, there appear to be close functional correspondences between music and language, which support Brown's (2000a) suggestion that they share a common and deeply rooted evolutionary origin.

5.4.3 **Altriciality and play**

Considered as a universal human behaviour, music does appear to have significant proximate effects; however, these effects are not necessarily equitable with ultimate causes. To evaluate music's status in processes of human evolution, it is also necessary to consider how musical behaviours might have become part of the human behavioural repertoire. We propose that processes of progressive juvenalization evident in the later hominid lineage may have spurred the emergence of behaviours that are central to the modern human faculty for music. In the hominid lineage, each successive species appears to have been more altricial than its predecessors, with a progressively longer proportion of the total lifespan spent in increasingly differentiated juvenile states (Bogin 1999).

Joffe (1997) has shown that primate species with complex social organizations are more likely to be altricial; she proposes that a complex social organization is enabled by an extension of the learning period in which members of a species manage their social interaction in more flexible ways. A significant feature of the behaviour of juvenile animals, particularly of predatory or social species, is play, which can be identified as action and interaction that appears to be purposeless (Bekoff 1998) carried out within a world largely constructed by the participants.

Play usually involves the employment of functional behaviours in modified forms, and when used among individuals it requires the negotiation of cooperative agreement (Bekoff 1998). Play enables juveniles to learn to deal with their environment by testing features of it through action, and to acquire the skills necessary to engage with conspecifics when rehearsing and elaborating skills of social interaction. It is also self-stimulating fun in its own right (Panksepp and Burgdorf 2003). Play thus has many musical features and comparable individual and social efficacy. Hanus Papousek (1996, pp. 46–47) describes infant and early childhood musical behaviours as forms of play involving higher-level integrative processes that act to nurture 'exploratory competence'.

Vocal play, in the form of babbling, does not appear to be unique to humans; Elowson *et al.* (1998) note that this behaviour occurs in juvenile pygmy marmosets, and that response from a caregiving adult is more likely when the juvenile is vocalizing, and suggest that pygmy marmoset babbling has relevance to understanding the evolutionary processes of human vocal development. It may be that an association between vocal play and a positive caregiving response privilege the social function of these types of play.

We suggest that in an increasingly altricial lineage, the need to accommodate to population structures with an increasing proportion of members with access to juvenile modes of cognition, motivation and behaviour (other factors being equal) may have favoured the emergence of something like musicality as a means of assimilating the value of those juvenile modes of exploratory cognition into the adult behavioural repertoire, while regulating its modes of expression. Given that play is a particular feature of the behaviour of juveniles in social mammals, and that it is likely to have positive survival value for members of those species who engage in it, it is probable that group behaviours that both enable and regulate it to co-opt its utility into the adult repertoire are likely to have some adaptive or exaptive value. Music can be interpreted as one of these mechanisms, emerging under the selection pressures of the progressive extension and stage-differentiation of the juvenile period in the later hominid lineage.

5.5 **The archaeological record**

Archaeological evidence is clear: musical behaviours have been a part of human life for many millennia. Modern humans in Europe were manufacturing musical pipes from the bones of birds at least 36,000 years ago, and the sophistication of these instruments exceeds that of many medieval and contemporary examples of such pipes (Scothern 1992). It seems likely that when modern humans arrived in Europe around 40,000 years ago, they had already developed instrumental musical behaviours; it is likely that instruments were in use far earlier, and that musical behaviours that made use of the voice and body movements had a long history prior to the development of musical artefacts.

From 30,000 years ago, however, there is a marked increase in the evidence for musical activities, including rasps, percussion instruments, many more bone pipes, and in the evidence that rocks and caves were exploited for their acoustic properties (Cross and Watson 2006; Morley 2003). These musical activities seem to have been widespread, often occurring in what appear to be loci of intense human activity, which includes the making of graphical art. The evidence—fragmentary as it is—suggests that musical performance was a group activity, rather than one involving a select few individuals. The differential preservation of bone over other organic materials is likely to bias the record, and with the focus of archaeological research on Europe, the rest of the old world that was occupied by anatomically modern humans has been neglected. There is the possibility that objects used for sound production have yet to be identified. Increasingly sophisticated analysis (e.g., d'Errico *et al.* 2003) and methods of excavation, and experimental work on the potential sound-producing properties of archaeological materials (cf. Cross *et al.* 2002) should help to fill out the record of musical activities in prehistory. However, we do know enough to assert that musical behaviours are extremely ancient, probably dating at least to the emergence of behavioural complexity in anatomically modern *Homo sapiens*.

While a fully integrated capacity for musicality is evident in early modern humans, musicality appears to be made up of a number of psychological capacities, including those for the production and perception of complex sequences of sounds and actions, for social entrainment, and for creatively engaging with patterns of sounds and actions—all manifestations of multiple intentionalities. The palaeo–anatomical and archaeological records suggest that these different

capacities arose at different times in the hominid lineage that leads to modern humans (Morley 2002; 2003).

The evidence suggests that our nearest primate relatives have few capacities that could be interpreted as musical. Chimpanzees and bonobos lack the phonational capacity for the production of complex vocal signals, partly because of their very different physiques (Morley 2002), and there is no evidence that either species can entrain to regular patterns of visual or sonic stimuli (however, see Fitch 2006). A recent survey of systems of animal communication (Seyfarth and Cheney 2003) concludes that even among primates, the interpretability of vocal signals by conspecifics is generally bound so tightly to the awareness of present circumstances that they cannot be regarded as referential. Calls that might be conceived of as conveying disembedded information to conspecifics are better thought of as expressing an individual's affective state, without reference or intention to inform others. As the authors note, 'In sum, a variety of results argue that, in marked contrast to humans, nonhuman primates do not produce vocalizations in response to their perception of another individual's ignorance or need for information' (p. 159). It appears that although some non-human primates, notably gibbons, can produce complex and long sequences of sound and action, a key element of musicality—the engagement with the intentionalities of such sequences—is absent (Merker, Chapter 4, this volume).

The likelihood of significant continuities between the lifeways of other primates and of australopithecines (currently the oldest known ancestor genus leading to modern humans) suggests that no significant components of a human faculty for music emerged with this latter group of species, although it might be hypothesized that the move to bipedalism laid some of the foundations for a capacity for entrainment in rhythmic stepping and gesturing. Recent evolutionary thinking (see Wood and Collard 1999) interprets the very early humans *Homo habilis* (and possibly *Homo rudolfensis*) (from 2 million years before the present) as manifesting a high degree of continuity with australopithecine lifeways and capacities; however, the archaeology associated with the species shows significant changes in the evidence for toolmaking and the transmission of traditions of tool manufacture. While *H. habilis* and *rudolfensis* remains are fragmentary and their interpretation is debated, the manufacture and use of tools suggests that the species had more muscularly developed hands, perhaps with a longer thumb, than did their predecessor species, and a greater degree of refinement in the control of manual movement (Wilson 1998). These capacities are likely to have allowed for the beginnings of finely controlled expressive manual gesture, an intrinsic component of all modern human communicative systems.

With *Homo ergaster* and *Homo erectus* (from about 1.8 million years before the present), major changes occurred; brain size reached around 1000 cc, and body size and configuration approximated those of modern humans. *H. ergaster* and *H. erectus* had more complex lifeways and toolkits than their precursors, and a vast increase in geographical range. The capacity for the much-enhanced control of phonation—conferred by a barrel-shaped chest, the enhanced articulatory capacities of the vocal system, and the presence of an ear canal of modern proportions—suggests that vocal sounds were increasingly significant for this species. This may indicate significant changes in social life, perhaps marking the emergence of a rich vocal repertoire to replace other forms of interpersonal interaction (in conformance with Dunbar's [1992] 'grooming-to-gossip' model). The evidence also suggests that some foundational components of musicality were in place, most likely expressed in the use of vocal sounds to articulate complex emotion states in the regulation of social relations, and possibly to convey referential information.

It was not until the appearance of *Homo heidelbergensis* (*c.*700 to 500 kyr BP), however, that we find the fully modern vocal tract, together with an auditory system that is maximally sensitive to speech frequencies (Martinez *et al.* 2004). This coadaptation suggests that vocal sounds were crucially significant for this species, more so than other environmental sounds. This can be

construed as a refinement of earlier *H. ergaster* capacities, which is supported by evidence for the production and use of an expanded range of artefacts. This advance in creativity is likely to have been manifested in the capacity to produce and perceive increasingly complex vocal sounds and sequences, including behaviours that we might identify as singing.

Following the emergence of anatomically modern *Homo sapiens,* which dates back some 150 kyr BP, we ultimately find evidence for symbolic intelligence or 'fully modern *sapiens* behaviour' (Henshilwood and Marean 2003), and unambiguous evidence of musical behaviours. These behaviours are built on cognitive, physiological and behavioural foundations that emerged in the preceding hominid species, as outlined above. At what point these behaviours can be considered symbolic, in the sense of having the capacity to indicate meaning through an arbitrary coupling of sign and referent, is open to debate, but the capabilities probably emergent in *H. ergaster*, and then developed in *H. heidelbergensis*, would have featured strong associations between emotional content and vocal and physical gesture. Symbolic culture, in which signs enter into a web of interrelationships that come to constitute a significant feature of the ecology of the human mind (Chase 1999), emerged with modern *Homo sapiens*.

Thus, we suggest that the emergence and development of complex manual and vocal gesture, under the conditions of greater social complexity associated with *H. ergaster* and *H. erectus*, constituted the foundations of what would come to be melodic vocalization, i.e., singing. It seems likely that the production and perception of complex sequences of sounds with the voice was very important by the time of *H. heidelbergensis*, and that the social roles of such vocalizations, including the potential to rehearse and refine social interactions, were built on subsequently, to become a part of music and language in the fully symbolic culture that emerged in modern humans.

5.6 **Conclusions**

The evolutionary story can be read as indicating that a version of Brown's (2000a) musilanguage may have emerged with *H. ergaster*, perhaps restricted to the exchange of social information, with a further development of a capacity for more general reference with *H. heidelbergensis*. It seems likely that the divergence between music and language arose first in modern humans, with language emerging to fulfil communicative, ostensive and propositional functions with immediate efficacy. Music, operating over longer timescales, emerged to sustain (and perhaps also to foster) the capacity to manage social interactions, while providing a matrix for the integration of information across domains of human experience. We propose that music and language enabled the emergence of modern human social and individual cognitive flexibility (Cross 1999). We regard both music and language as subcomponents of the human communicative toolkit—as two complementary mechanisms for the achievement of productivity in human interaction though working over different timescales and in different ways.

While the selection pressures for the emergence of language are widely regarded as self-evident (Pinker 1994), those for music appear less well understood, perhaps because the effects of music appear less immediate and direct, or obvious, than do those of language (Mithen 2005). However, we suggest that a degree of adaptation to changes in the rate of individual maturation evident in the later hominid lineage may be a factor that led to the human capacity for musicality, distinct from, and perhaps foundational, in respect of language (Cross 2003b).

Musical capacities are built on fundamentally important social and physiological mechanisms and, at an essential level, are processed as such. Music uses capacities crucial in situations of social complexity; the vocal, facial and interactive foundations of these capabilities are evident in other higher primates, and such capacities would have become increasingly important and

sophisticated as group size and complexity increased. Vocal emotional expression, interaction, and sensitivity to others' emotional state would have been selectively important abilities; individuals in which these capabilities were more developed would have been selectively favoured. Fundamentally integrated into the planning and control of complex sequences of vocalizations, and related to the prosodic rhythm inherent in such sequences, is rhythmic motor coordination. The motor system is primed in the instigation of such vocal behaviours, and corporeal gesture is consequently incorporated into the execution of the vocal behaviour.

In terms of their potential selective advantages, developed musical behaviours could confer an advantage on individuals in terms of sexual selection; this was due to their foundations in the capacities to communicate emotionally and effectively, to empathize, to bond and elicit loyalty. Musical abilities have the potential to be a proxy for an individual's likelihood of having strong social networks and loyalties, and of contributing to a group. Musical behaviour also has the potential to be a mechanism for stimulating and maintaining those networks and loyalties; because of the stimulation of shared emotional experience as a consequence of participation in musical activities, it can engender strong feelings of empathic association and group membership. Musical or protomusical behaviour has the potential to make use of several cognitive capacities at once, relying on the integration and control of biological, psychological, social and physical systems; it gives the opportunity to practise and develop these integrated skills in a context of limited risk.

The emergence of full (specialized, as opposed to proto-) musical behaviours, with foundations in social interaction, emotional expression, and fine control and planning of corporeal and vocal muscular control, lends them extremely well to integrating important cognitive skills. The execution of musical activities could become increasingly important and beneficial on both individual and group levels, with increasing social complexity within and between groups. Because music production and perception is processed by the brain in ways that are complex and related to interpersonal interaction and the formation of social bonds, it stimulates many associated functions. It seems that musical participation, even without lyrics or symbolic associations, can act on the brain in ways that are appealing to humans, because of their vicarious stimulation of fundamentally important human interactive capacities.

While this model for the emergence of musicality appears to fit well with the evidence available from ethnographic, cognitive, comparative, palaeo–anatomical and archaeological sources, other ecologically observable behaviours suggest further facets to the evolutionary story require consideration. The investigation of the origins, emergence and nature of musical behaviours in humans is in its early stages, and has more to reveal. It concerns an element of human behaviour that, in contrast with Pinker's (1997) opinion, the vast majority of people would miss very much if they were suddenly bereft of it. It would be impossible to do away with music without removing many of the abilities of social cognition that are fundamental to being human.

References

Arom S (1991). *African polyphony and polyrhythm*. Cambridge University Press, Cambridge.

Auer P, Couper-Kuhlen E and Muller K (1999). *Language in time: The rhythm and tempo of spoken language*. Oxford University Press, Oxford.

Baily J (1985). Music structure and human movement. In P Howell, I Cross & R West, eds, *Musical structure and cognition*, pp. 237–258. Academic Press, London.

Bekoff M (1998). Playing with play: What can we learn about cognition, negotiation and evolution? In DD Cummins & C Allen, eds, *The evolution of mind*, pp. 162–182. Oxford University Press, Oxford.

Benzon W (2001). *Beethoven's anvil: Music, mind and culture*. Basic Books, New York.

Blacking J (1961). Patterns of Nsenga *kalimba* music. *African Music*, **2(4)**, 3–20.

Blacking J (1967). *Venda children's songs: A study in ethnomusicological analysis*. Witwatersrand University Press, Johannesburg.

Blacking J (1969). The value of music in human experience. *Yearbook of the International Folk Music Council*, **1,** 33–71.

Blacking J (1976). *How musical is man?* Faber, London.

Blacking J (1995). *Music, culture and experience*. University of Chicago Press, London.

Bogin B (1999). *Patterns of human growth*, 2nd edn. Cambridge University Press, Cambridge.

Bowles S and Gintis H (1998). The moral economy of community: structured populations and the evolution of pro-social norms. *Evolution and Human Behaviour*, **19,** 3–25.

Brown S (2000a). The 'musilanguage' model of music evolution. In N Wallin, B Merker and S Brown, eds, *The origins of music*, pp. 271–300. MIT Press, Cambridge, MA.

Brown S (2000b). Evolutionary models of music: From sexual selection to group selection. In F Tonneau & NS Thompson, eds, *Perspectives in ethology 13: Behavior, evolution and culture*, pp. 231–281. Plenum Publishers, New York.

Chase P (1999). Symbolism as reference and symbolism as culture. In C Knight, R Dunbar and C Power, eds, *The evolution of culture: An interdisciplinary view*, pp. 34–49. Edinburgh University Press, Edinburgh.

Clayton M, Sager R and Will U (2004). In time with the music: The concept of entrainment and its significance for ethnomusicology. *ESEM Counterpoint,* **1,** 1–82.

Cross I (1999). Is music the most important thing we ever did? Music, development and evolution. In S W Yi, ed., *Music, mind and science*, pp. 10–39. Seoul National University Press, Seoul.

Cross I (2003a). Music and biocultural evolution. In M Clayton, T Herbert and R Middleton, eds, *The cultural study of music: A critical introduction*, pp. 19–30. Routledge, London.

Cross I (2003b). Music and evolution: causes and consequences. *Contemporary Music Review,* **22(3)**, 79–89.

Cross I (2003c). Music, cognition, culture and evolution. In I Peretz and R Zatorre, eds, *The cognitive neuroscience of music*, pp. 42–56. Oxford University Press, Oxford.

Cross I (2005). Music and meaning, ambiguity and evolution. In D Miell, R MacDonald and D Hargreaves, eds, *Musical Communication,* pp. 27–43. Oxford University Press, Oxford.

Cross I, Zubrow E and Cowan F (2002). Musical behaviours and the archaeological record: a preliminary study. In J Mathieu, ed., *Experimental archaeology: Replicating past objects, behaviors and processes*, pp. 25–34. British Archaeological Reports International Series 1035. Archaeopress, Oxford.

Cross I and Watson A (2006). Acoustics and the human experience of socially organised sound. In C Scarre and G Lawson, eds, *Acoustics, space and intentionality: Identifying intentionality in the ancient use of acoustic spaces and structures*, pp. 107–116. McDonald Institute for Archaeological Research, Cambridge.

Cummins DD (1998). Social norms and other minds: the evolutionary roots of higher cognition. In DD Cummins and C Allen, eds, *The evolution of mind*, pp. 30–50. Oxford University Press, Oxford.

D'Andrade R (1995). *The development of cognitive anthropology*. Cambridge University Press, Cambridge.

D'Errico F, Henshilwood C, Lawson G, *et al*. (2003). Archaeological evidence for the emergence of language, symbolism, and music – an alternative multidisciplinary perspective. *Journal of World Prehistory*, **17(1)**, 1–70.

Darwin C (1871). *The descent of man and selection in relation to sex*. Murray, London.

Dissanayake E (2000). Antecedents of the temporal arts in early mother–infant interactions. In N Wallin, B Merker and S Brown, eds, *The origins of music*, pp. 389–407. MIT Press, Cambridge, MA.

Donaldson M (1992). *Human minds: An exploration*. Allen Lane/Penguin Books, London

Drake C Jones MR and Baruch C (2000). The development of rhythmic attending in auditory sequences: attunement, referent period, focal attending. *Cognition*, **77,** 251–288.

Dunbar R (1992). Neocortex size as a constraint on group size in primates. *Journal of Human Evolution*, **22,** 469–493.

Elowson AM, Snowdon CT and Lazaro-Perea C (1998). 'Babbling' and social context in infant monkeys: parallels to human infants. *Trends in Cognitive Sciences*, **2,** 31–37.

Fitch W Tecumseh (2006). The biology and evolution of music: a comparative perspective. *Cognition*, **100(1)**, 173–215.

Foley RA (1995). *Humans before humanity*. Blackwell, Oxford.

Freeman WJ (1995). *Societies of brains. A study in the neurobiology of love and hate*. Erlbaum, Mahwah, NJ.

Frege G (1952). On sense and reference. In P Geach and M Black, eds, *Translations from the Philosophical Writings of Gottlob Frege*. Blackwell, Oxford.

Hagen EH and Bryant GA (2003). Music and dance as a coalition signaling system. *Human Nature*, **14(1)**, 21–51.

Henshilwood CS and Marean CW (2003). The origin of modern human behavior: critique of the models and their test implications. *Current Anthropology*, **44(5)**, 627–651.

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

Jacobs A (1972). *New dictionary of music*, 2nd edn. Penguin Books, Harmonsdworth.

Janata P and Grafton ST (2003). Swinging in the brain: Shared neural substrates for behaviors related to sequencing and music. *Nature Neuroscience*, **6(7)**, 682–687.

Joffe TH (1997). Social pressures have selected for an extended juvenile period in primates. *Journal of Human Evolution*, **32(6)**, 593–605.

Jones MR and Yee W (1993). Attending to auditory events: The role of temporal organization. In S McAdams and E Bigand, eds, *Thinking in sound*, pp. 69–112. Oxford University Press, Oxford.

Kalmus A and Fry DB (1980). On tune deafness (dysmelodia): Frequency, development, genetics and musical background. *Annals of Human Genetics*, **43(4)**, 369–382.

Koelsch S, Kasper E, Sammler D, Schultze K, Gunter T and Frederici A (2004). Music, language and meaning: brain signatures of semantic processing. *Nature Neuroscience*, **7(3)**, 302–307.

Langer S (1942). *Philosophy in a new key*. Harvard University Press, Cambridge, MA.

Lavy M (2001). *Emotion and the experience of listening to music: A framework for empirical research*, Ph.D. thesis.University of Cambridge. Available at *http://www.scribblin.gs*

Magrini T (2000). From music-makers to virtual singers: New musics and puzzled scholars. In D Greer, ed. *Musicology & sister disciplines*, pp. 320–330. Oxford University Press, Oxford.

Martinez I, Rosa M, Arsuaga J-L *et al.* (2004). Auditory capacities in Middle Pleistocene humans from the Sierra de Atapuerca in Spain. *Proceedings of the National Academy of Sciences*, **101(27)**, 9976–9981.

Meyer LB (1956). *Emotion and meaning in music*. University of Chicago Press, London.

Miller G (2000). Evolution of human music through sexual selection. In N Wallin, B Merker and S Brown, eds, *The origins of music*, pp. 329–360. MIT Press, Cambridge, MA.

Miller G (2001). *The mating mind: How sexual choice shaped the evolution of human nature*. Vintage/Ebury, London.

Mithen S (2005). *The singing Neanderthals: The origins of music, language, mind and body*. Weidenfeld & Nicolson, London.

Morley I (2002). Evolution of the physiological and neurological capacities for music. *Cambridge Archaeological Journal*, **12(2)**, 195–216.

Morley I (2003). *The evolutionary origins and archaeology of music: An investigation into the prehistory of human musical capacities and behaviours*. Ph.D. thesis. University of Cambridge, Cambridge. Darwin College Research Reports, DCRR-002, available online at www.dar.cam.ac.uk/dcrr/

Nelson S (2002). *Melodic improvisation on a twelve-bar blues model: an investigation of physical and historical aspects, and their contribution to performance*. Ph.D. thesis. City University London, Department of Music, London.

Oatley K and Johnson-Laird PN (1998). The communicative theory of the emotions: Empirical tests, mental models and implications for social interactions. In JM Jenkins, K Oatley and NL Stein, eds, *Human emotions: A reader*, pp. 84–97. Blackwell, Oxford.

Panksepp J and Burgdorf J (2003) ''Laughing" rats and the evolutionary antecedents of human joy? *Physiology and Behavior*, **79,** 533–547.

Papousek H (1996). Musicality in infancy research: Biological and cultural origins of early musicality. In I Deliège and JA Sloboda, eds, *Musical beginnings*, pp. 37–55. Oxford University Press, Oxford.

Papousek M (1996). Intuitive parenting: A hidden source of musical stimulation in infancy. In I Deliège and JA Sloboda, eds, *Musical beginnings*, pp. 88–112. Oxford University Press, Oxford.

Peretz I (2003). Brain specialization for music: New evidence from congenital amusia. In I Peretz and R Zatorre, eds, *The cognitive neuroscience of music*, pp. 192–203. Oxford University Press, Oxford.

Peretz I, Champod AS and Hyde K (2003). Varieties of musical disorders: The Montréal Battery of Evaluation of Amusia. *Annals of the New York Academy of Sciences: The Neurosciences and Music*, **999,** 58–75.

Pinker S (1994). *The language instinct*. Allen Lane, London.

Pinker S (1997). *How the mind works.* Allen Lane, London.

Plotkin H (1997). *Evolution in mind*. Allen Lane, London.

Roederer JG (1984). The search for a survival value of music. *Music Perception*, **1,** 350–356.

Rogoff B, Paradise R, Arauz RM, Correa-Chévez M and Angelillo C (2003) First-hand learning through intent participation. *Annual Review of Psychology*, **54,** 175–203.

Schellenberg EG (2003). Does exposure to music have beneficial side effects? In I Peretz and R Zatorre, eds, *The cognitive neuroscience of music*, pp. 430–448. Oxford University Press, Oxford.

Schellenberg EG (2004). Music lessons enhance IQ. *Psychological Science*, **15(8)**, 511–514.

Scherer C and Zentner MR (2001). Emotional effects of music: Production rules. In P Juslin and JA Sloboda, eds, *Music and emotion: theory and research*, pp. 361–392. Oxford University Press, Oxford.

Scherer KR (1991) Emotion expression in speech and music. In J Sundberg, L Nord and R Carlson, eds, *Music, Language, Speech and Brain*, 146–156. MacMillan Press, Basingstoke.

Scothern PMT (1992). *The music-archaeology of the palaeolithic within its cultural setting*. Ph.D. thesis. University of Cambridge, Cambridge.

Seyfarth RM and Cheney DL (2003). Signalers and receivers in animal communication. *Annual Review of Psychology*, **54,** 145–173.

Shennan S (2002) *Genes, memes and human history*. Thames and Hudson, London.

Shore B (1996). *Culture in mind: Cognition, culture, and the problem of meaning*. Oxford University Press, Oxford.

Sloboda JA (1985). *The musical mind*. Oxford University Press, Oxford.

Spelke E (1999). Infant cognition. In RA Wilson and FC Keil, eds, *The MIT encyclopedia of cognitive sciences*, pp. 402–404. MIT Press, Cambridge, MA.

Sperber D and Wilson D (1986). *Relevance: Communication and cognition*. Blackwell, Oxford.

Stephan KM, Thaut MH, Wunderlich G *et al*. (2002). Conscious and subconscious sensorimotor synchronization – prefrontal cortex and the influence of awareness. *NeuroImage*, **15,** 345–352.

Stobart HF (1996). *Tara* and *Q'iwa*: Worlds of sound and meaning. In MP Baumann, ed., *Cosmología y música en los Andes (Music and cosmology in the Andes)*, pp. 67–81. Biblioteca Iberoamericana and Vervuert Verlag, Madrid and Frankfurt.

Stobart HF and Cross I (2000). The Andean anacrusis? Rhythmic structure and perception in Easter songs of Northern Potosí, Bolivia. *British Journal of Ethnomusicology*, **9(2)**, 63–94.

Sykes JB (1983). *Concise Oxford dictionary*, 7th edn. Oxford University Press, Oxford.

Thaut MH (2005). Rhythm, human temporality, and brain function. In D Miell, R MacDonald and D Hargreaves, eds, *Musical Communication*, pp. 171–191. Oxford University Press, Oxford.

Trevarthen C (1979). Communication and cooperation in early infancy. A description of primary intersubjectivity. In M Bullowa, ed., *Before speech: The beginning of human communication*, pp. 321–347. Cambridge University Press, London.

Trevarthen C (1980). The foundations of intersubjectivity: Development of interpersonal and cooperative understanding in infants. In D Olson, ed., *The social foundation of language and thought*, pp. 316–342. Norton, New York.

Trevarthen C (1999). Musicality and the intrinsic motive pulse: Evidence from human psychobiology and infant communication. *Musicae Scientiae (Special Issue 1999–2000)*, 155–215.

Wallaschek R (1893). *Primitive music.* Longmans, Green & Co., London.

Waterman CA (1991). Uneven development of African ethnomusicology. In B Nettl and PV Bohlman, eds, *Comparative musicology and anthropology of music*. University of Chicago Press, London.

Wilson FR (1998). *The hand: How its use shapes the brain, language, and human culture*. Pantheon Books, New York.

Wood B and Collard M (1999). The human genus. *Science,* **282,** 65–71.

Yang M (1994). On the hua'er songs of north-western China. *Yearbook for Traditional Music*, **26,** 100–116.