The Music Instinct

The Evolutionary Basis of Musicality

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Why does music pervade our lives and those of all known human beings living today and in the recent past? Why do we feel compelled to engage in musical activity, or at least simply enjoy listening to music even if we choose not to actively participate? I argue that this is because musicality—communication using variations in pitch, rhythm, dynamics and timbre, by a combination of the voice, body (as in dance), and material culture—was essential to the lives of our pre-linguistic hominin ancestors. As a consequence we have inherited a desire to engage with music, even if this has no adaptive benefit for us today as a species whose communication system is dominated by spoken language. In this article I provide a summary of the arguments to support this view.

Key words: **music; evolution; adaptation; hominins; sociality**

The Mystery of Music

Music defies easy definition and, in fact, some would argue any definition at all. Music is about sound; some would also say it is also about vibration and movement. Variations in pitch, rhythm, and timbre are important. But all these factors are not essential; at least they haven't been since John Cage composed his 1952 piece *4,33* (taking 4 minutes, 33 seconds and effectively the sound of silence).

The best definition we can attain is the phrase "I know it when I hear it." This allows for variations with regard to both cultural and individual taste and, indeed, acceptance of what does and does not constitute music—but it is hardly very satisfactory. It is perhaps astonishing that we live surrounded by music, we invest so much time, effort, and resource in listening to and, for some, performing music, and yet we can't really say what it is.

That is just one of the many mysteries of music. Another is why we have such a compulsion to engage with music: why do we find so much music so beautiful to listen to, why does it stir our emotions, why do we have choirs, bands, and orchestras whose reason for existence is nothing more than to make music? Why do we sing in the proverbial bath? And this is not just us in the 21st century Western world, but throughout the world and existing throughout time: engaging with music is a human universal. There are no known societies, and as far as historians and archaeologists can tell, there never have been any societies that did not have cultural practices that we would categorize as music. Very few individuals will express a complete un-interest in music; even fewer will express a formal dislike.

This is very strange. There are not many other activities to which people are so compulsively drawn; those which do exist have clear survival value, either in the present or the past. We all eat; we enjoy good food and have food cultures, just as we have musical cultures: well, this isn't surprising as evolving an enjoyment of eating is a pretty good trick by natural selection to help us survive (although today, in view of the abundance of food in western countries, such as the United States and the United Kingdom, the

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activity of eating is now backfiring, as witnessed by the prevalence of obesity, heart disease, and the like). Sex is another example: something that we enjoy, something that is universal, and something for which, like music, we might have our own individual taste. Again, we can readily understand why we have evolved to be sexy and to enjoy sex: it is another good trick of evolution to keep us reproducing, even if today we often ensure that the reproduction bit is avoided.

The Infuriating Silence of the Past

So what is the point of music? I will argue that the answer is the same as that used to explain our enjoyment of food and sex: music was essential to the survival of our Stone Age ancestors.[1] We have inherited from them a compulsion to engage with music; indeed we have evolved as a musical species. This has had a profound nature on the structure and working of the human brain. We don't normally think of our Stone Age ancestors as being musical; indeed we don't think of them doing anything beyond the basic needs for survival. But I am confident that musicality pervaded their lives.

By this I mean that the use of variations in pitch, rhythm, timbre, and so forth were essential to their means of communication. These still are important today, but we now have language—a combination of words and grammatical rules—that takes precedence. One of the challenges we face is to discover and imagine how humans might have communicated with each other before language had evolved.

This is a question that I find especially pertinent because of my profession: archaeology. I excavate early prehistoric settlements in western Scotland and southern Jordan, seeking to reconstruct the lives of our ancestors. One of the most striking and infuriating facts about the material I excavate—the stone artifacts, the skeletal remains, the dwelling structures, and symbolic objects—is that they are absolutely silent. To interpret the meaning of such artifacts with regard to the music that would have once pervaded ancient settlements is outrageously ambitious and a task that some would say can only ever remain at the level of speculation.

They may be right. So should archaeologists bother to try? Why don't we just leave the study of music to those other disciplines who can actually *hear* their subjects—those who study the music of traditional peoples, those who examine the musicality found within the cries of babies, those who study the song of birds and cetaceans, and those who study Bach?

The answer is quite simple: music is too important to be left to those disciplines alone. Unless we examine the evidence from human evolution itself, from those silent stone artifacts and fossil crania, we will simply never be able to unravel the mysteries of music. This is because the study of human evolution is not simply about the evolution of how we began to walk upright on two legs, how new types of tools were invented, and how we dispersed around the globe, for example. It is about how we came to be human in the broadest meaning of the term, and a key part of being human is being musical.

By that last statement—that to be human is to be musical—I mean that the capacity for music is deeply embedded in the human genome: it is part of our biology rather than merely our culture and could only have gotten there via an evolutionary process. The best starting point to appreciate this is the one at which we all start—as babies. Colin Trevarthen, the distinguished developmental psychologist, once described how "we are born with a musical wisdom and appetite" (p. 173).[2] That is indeed true: from the moment of birth, and some would argue before, babies are attracted to music—it is their natural, instinctive language.[3] Babies would prefer to hear their mothers sing to them than speak to them; we instinctively know this because when we do speak to babies we do so in a sing-song manner, hyperarticulating our vowels, heightening our pitch, and exaggerating our pitch contours.

The Biological Basis of Music

The biological basis of music is also becoming evident from studies of the brain. The remarkable advances in brain scanning during the last decade are allowing us to identify which parts of the brain are used for which type of mental activity and which are shared between activities and which have specialized functions. The extent to which there are dedicated areas for musical processing, the relationship between language and music in the brain, and the complex interplay between inheritance and development makes the neuroscience of music one of the most fascinating and challenging of fields,[4,5] one that has made enormous progress during the last decade, but still has a long, long way to go.

I find the interplay between inheritance and development of particular interest, partly for personal reasons. My research has argued that we have evolved as a musical species, and yet I am someone lacking in musical ability. My theories would predict that even my own adult and supposedly mature brain could still be manipulated to enhance its level of musical processing. So I undertook a pilot project to test this by working with the neuroscientist Professor Larry Parsons from Sheffield University and Pam Chilvers, a professional singing teacher. Not having participated in any music making for at least 35 years, I underwent a whole year of singing lessons and explored their impact on my own brain.[6] Although the experiment was only a pilot study and lacked various control conditions, I did appear to be able to change my brain, increasing activity in Brodmann's areas 22, 38 and 45, and decreasing activity in other areas. In effect, I began to release a potential musicality that had been placed there by millions of years of evolution, but was neglected and so remained dormant during my own life. It is indeed a key argument of this contribution that an evolutionary perspective on the brain is essential to the further development of the neuroscience of music; without an evolutionary perspective, we can have no robust theory and even less understanding.

Much of our evolutionary history has been shared with other primates; we share a common ancestor with the chimpanzee about 6 million years ago, the gorilla about 10 million years ago, and then progressively earlier with other primates, such as the orangutan, gibbon, and monkey.[7] It is important to recognize, therefore, that these primates exhibit degrees of musicality within their vocalizations whether it is the so-called duets sung by mated pairs of gibbons in the forests of Southeast Asia,[8] the pant-hoots of chimpanzees,[9] or the chattering of geladas.[10] Variations in pitch, rhythm, and timbre play a key role in the vocalizations of such primates. They would have also been critical to those of the common ancestors that we share. The common human-chimpanzee ancestor of c. 6 million years ago is likely to have had vocalizations not too different from those of the chimpanzee today. It was that type of vocalization, I suggest, that gave rise to our capacities for not only music, but also language.[11]

The evolutionary relationship between music and language has long been debated, although in recent years almost all attention has been given to language alone. Some believe that one had precedence over the other, but my view harks back to those writing in the 18th and 19th centuries, such as Jean Jacques Rousseau[12] and Otto Jespersen.[13] They argued that music and language derived from a common root, a single ancient form of communication. This view was particularly well expressed by the ethnomusicologist John Blacking, who referred to a pre-linguistic musical mode of thought and action.[14]

While few academics would disagree that our more distant human ancestors communicated with what some call a "proto-musical language" or a "musilanguage" (p. 271)[15]—this being sufficiently ill-defined to encompass a diverse range of views—a more controversial view is that this type of communication continued up until a very recent time in human evolution. An extreme view is that it

was only with the emergence of our species, *Homo sapiens*, sometime after 200,000 years ago that this single form of communication diverged into the two separate communications systems, those that we now call language and music.[16]

The Musicality of the Earliest Hominins

There were several, perhaps numerous, different species of hominins living in the Plio-Pleistocene landscapes of east and South Africa, each adapted to its own niche.[17] They had brain sizes similar to that of the chimpanzee today, but spent a greater time on two legs and some species, at least, used a wider range of tools, notably those made from stone. The best known is *Australopithecus afarensis*, living 3.5 million years ago and first discovered by Don Johansen in 1976 with a specimen popularly known as "Lucy." The larger-brained of these hominins are traditionally placed into the genus *Homo*, but are more appropriately contained within the australopithecines.[18] We can learn about the existence and lifestyles of these hominins not only from fossilized skeletons, but also from stone artifacts and scattered debris from their living sites, sometimes consisting of many fragments of butchered bones from animals that were either hunted or scavenged.[19]

Archaeologists have made enormous strides toward reconstructing the anatomy and lifestyles of these early hominins. We can use their conclusions to consider how the ape-like call repertoire of the 6-million-year-old common ancestor might have evolved by 2 million years ago. Perhaps the first thing to note is simply that these hominins have smaller teeth than would have been the case of their own ancestors, assumed to have the large canines and molars found in chimpanzees today. By reducing tooth size, the oral cavity became larger and more flexible, enabling a more diverse range of sounds to be generated.

The lifestyles of these hominins would have created selective pressures for the use of a wider diversity of sounds. We know that monkeys give various alarm calls when they see predators, such as eagles and snakes[20,21]; those hominins living in open landscapes and competing with lions and hyenas for game and carcasses would have had a far greater need to warn each other about approaching predators. Similarly they would have needed to call for help and support, surely needing to modulate their calls so as not to attract the wrong type of attention.

The Plio-Pleistocene hominins are likely to have lived within relatively large social groups, having to do so to protect themselves against predators in the relatively open savannah environments.[22] Group living causes its own tensions; within living primates, these are primarily relieved by grooming, which is a means of both building social relationships as well as removing pests and parasites. The anthropologist Robin Dunbar has suggested that such grooming would no longer have been sufficient within these early hominins because of the time demands required when living in relatively large groups.[23] He argues that they began grooming each other by another means, by what he calls vocal grooming.[24]

Precisely what Dunbar means by vocal grooming remains unclear. But what would unquestionably have been essential within these groups would have been letting others know how one is feeling—happy, sad, angry, stressed—and attempting to manipulate the emotions of others. Being emotional is essential to being intelligent,[25,26] making effective decisions,[27] and being a successful member of a social group. As social life became more complex, so too would have been the need for emotional expression and manipulation. Living primates achieve this by facial expressions, body gestures, and calls. I suspect that the latter would have become far more important among the earliest hominins and that they would have become expert at expressing their emotions and reading those of others via their vocal utterances. To do

so, they would have used variations in the pitch, rhythm, and timbre of their calls: they would have used musicality. It is from this context, I suggest, that our emotional sensitivity to music arose.[28]

My argument here is quite simple: our ancestors had to be highly emotional beings to have survived; in the absence of language, musicality would have been the principal manner in which emotions would have been expressed and a response induced in others as a means to manipulate their behavior. So our minds and our bodies evolved to be emotionally sensitive to musical sounds.

The Impact of Bipedalism

The key evolutionary development after 2 million years ago was the emergence of full bipedalism—walking upright on two legs. The key specimen for the next grade of hominin is the "Nariokotome boy," dating to 1.5 million years ago, and classified as *Homo ergaster*.[29] This individual, between 11 and 15 years old, had already gained fully modern stature and we can tell from the shape of his pelvis and knee and ankle joints that he walked in a fully bipedal manner. His brain size would still have remained small, no more than 1000 cc when full grown and thus about the size of a modern 2-year-old child's brain. So this would have been a quite different type of human from you and me.

The evolution of bipedalism had, I suggest, a massive impact on musicality: indeed I have previously claimed that it caused a musical revolution.[30] Just like the reduced dentition in the earliest hominins, the anatomic changes associated with bipedalism enhanced the musical instrument that is the human body. The spine now entered from directly underneath the skull; one knock-on effect was the descent of the larynx to effectively increase the length of the vocal tract and, as a consequence, the diversity of possible sounds.[31] Another key development of bipedalism was enhanced breathing control, something with substantial spin-off benefits for singing.

With bipedalism would have come a new capability for maintaining an internal rhythm, essential for fluid walking[32] and even more so for endurance running, as is likely to have been undertaken by *Homo ergaster* in the pursuit of prey.[33] I suspect this would have also been the time when the capability, indeed the compulsion, for entertainment occurred—the fact that we cannot help tapping our feet or our fingers to join in with an ongoing rhythm. This new capability for maintaining rhythmic locomotion would have spread over into a capability for maintaining rhythmic sound. To all of these developments we must add the freeing of the arms, the hands, and the upper torso, along with an overall enhanced muscular control. So with *Homo ergaster* a new capability for dance evolved: a capacity for jumping, twirling, skipping, whirling, and even pirouetting under the African sun.

Life History, Social Relations, Colonization, and Cooperation

Archaeologists have been able to track further changes in human lifestyles and life history after the evolution of bipedalism that made additional contributions to the musical capability that we have inherited today. These are especially evident in the next grade of hominins, primarily those referred to as *Homo heidelbergensis* living between 1.5 and 0.5 million years ago. Four critical developments contributed to this enhanced musicality.

First is a change in human life history, leading to what anthropologists call the big helpless baby problem.[34] One of the anatomic requirements for effective bipedalism is a narrow pelvis; this is not, however, conducive to giving birth to large-brained offspring. Human evolution found a compromise to this by enabling humans to give birth to highly immature babies before their brains had grown to a size that would have created even more difficulties at

birth than is currently the case. So once born, human infants continue growing at a fetal rate for another year, quite unlike any other primate: they should really remain safe inside their mothers' bodies for at least an 18-month gestation period.

Such helpless babies need a great deal of care to survive and to become effective members of a social group. Various anthropologists, such as Ellen Dissanayke[35] and Dean Falk,[36] have argued that this would have provided selective pressures for vocal communication, especially as a surrogate for physical contact when babies had to be placed down on the ground to let the mother get on with tasks, such as digging roots or collecting berries. So here might be the start of the universal sing-song type of "motherese" used to provide emotional support and to communicate with babies long before they have the capability for language. Such motherese functions as a surrogate for the physical contact that babies desire. I am sure that adults have been singing to babies ever since the time of *Homo ergaster*, and that this may have itself enhanced our overall musical capabilities.

A second important development would have been changing social relations between males and females, especially with regard to mating patterns.[37] There was a high degree of sexual dimorphism within the australopithecines, males being significantly larger than females, as is found among gorillas today.[38] It is likely that males had harems and effectively chose which females to mate with, using brute force or at least intimidation if necessary. There was a substantial reduction in sexual dimporphism in later hominins: females had increased in body size by 70%, whereas males had increased by only 50%, and thus the females became far closer to males in size. When combined with the greater investment required for child care, this is likely to have led to a major change in mating patterns, perhaps with pair-bonding, with the male provisioning females and infants.[39] A much higher degree of female choice would have arisen: females now had the ability and the need to be selective as to which males they would chose as mating partners and hence which genes would be passed on to their offspring.

The males of many species have to advertise their fitness to females, epitomized in the tale of a peacock and in bird song. Charles Darwin thought that this would have also been essential for our human ancestors, writing in 1871 that:

> It is probable that the progenitors of man, either the males or females or both sexes, before acquiring the power of expressing mutual love in articulate language, endeavoured to charm each other with musical notes and rhythm (p. 880).[40]

Darwin did not have the fossil record that we have today and was working on an analogy with the function of bird song. The evidence that we now have provides substantial support to his argument.[41] It is not just the evidence from the fossil record that suggests a relationship between music and sexual display: the use of music by both males and females to advertise their attractiveness to the opposite sex has always been a pervasive aspect of recorded musical experience. It is one that on some occasions becomes remarkably explicit.

The colonization of lands outside of Africa is a third development that may have had an impact on musical capabilities. Soon after 2 million years ago, hominins dispersed out of Africa into forested environments of Southeast Asia and what may have been tundra-like landscapes of Europe.[42] This would have brought them into contact with new types of natural sounds, especially new bird calls. There would have been selective pressures to mimic such calls and movement as a means of communication; we know that this is a very widespread feature of many traditional languages today. The cognitive scientist Merlin Donald once referred to this as mimetic culture.[43] Another important argument comes from the anthropologist Brent Berlin. He has explained in certain traditional communities today the size and movement of birds and animals are important for how they are verbally referred to, something he describes as sound synesthesia.[44] I suspect that may have also been the case of pre-modern, and

pre-linguistic humans. In general, it seems likely that the musicality of the natural world would have had an impact on the evolving musicality of the human species.

The fourth key development in this period of human evolution is an ever greater need for cooperation and group bonding. We know, for instance, that by 500,000 years ago, big game hunting had begun.[45] This is an extraordinarily dangerous activity, especially with nothing more than wooden spears, and requires not only cooperation, but also high degrees of trust between members of the hunting party. Group hunting is just one example of how cooperation and trust would have been essential in the lifestyles of our hunter-gatherer ancestors. Plant gathering, food sharing, and child support provide further examples.

How would that have been achieved? One of the key means we achieve cooperation today is by singing and dancing together. Through this, we forge social bonds, develop a group identity, and learn to trust other members of a group. Football crowds, church congregations, children in playgrounds: group music making are all paths to group identity. So too would it have been, I contend, for our ancestors. I am confident that *Homo ergaster*, *Homo heidlebegensis,* and the rest would have engaged in group music making, although the direct evidence to substantiate this is elusive. All that can be offered are the enigmatic 300,000 year old circular "structures" from Bilzingsleben in Germany, as excavated by Mania and later described by Gamble.[46] These are more accurately described as circular spaces demarcated by large fragments of bone; in the absence of postholes, signs of hearths, and domestic debris, they are as likely to have been performance areas rather than the remnants of dwelling structures.

Singing and Dancing Neanderthals

The Neanderthals, *Homo neanderthalensis*, had evolved in Europe by 350,000 years ago, having shared a common ancestor with our species, *Homo sapiens,* around 500,000 years ago in Africa.[47] There has been a long debate in archaeology whether or not the Neanderthals had spoken language—a lexicon of words that could be combined using grammatical rules to create an infinite number of expressions.

Some lines of evidence have led archaeologists to argue that this is likely: the Neanderthals had large brains, modern-like vocal tracts, and could make sophisticated stone tools. They engaged in big game hunting and survived through a variety of challenging environments for more than 300,000 years. How could they possibly have done so without the use of spoken language?

Two other lines of evidence are to the contrary and, to my mind, more persuasive. First, although we have a detailed and extensive knowledge of the Neanderthal archaeological record, there are no traces of any unambiguous symbolic objects.[48,49] There are no paintings, carvings, or signs. Words are symbols and so if the Neanderthals were using audible symbols, I find it inconceivable that they were not also using visual symbols. The converse must also be the case: no visual symbols, no spoken symbols. Second, although the Neanderthals could make sophisticated stone tools, they kept on making essentially the same type of tools year in and year out for not only hundreds of years, but for thousands and tens of thousands of years, in spite of high degrees of environmental change and adaptive stress.[50,51] To my mind, spoken language is a motor for cultural change—it is a means for creativity and technological innovation. By talking about the tools we make and use, we simply cannot avoid changing and improving their design. So I find the cultural and technological stasis of the Neanderthals strong evidence that they did not communicate by language.

Instead, I believe that they had evolved a particularly advanced form of proto-musical language that I refer to as **Hmmmmm**,[52] which stands for a form of communication that was:

- holistic—because it relied on whole phrases rather than words, rather like music;
- manipulative—because it was focused on manipulating behavior of others rather than the transmission of information;
- multi-modal—because it used the body as well as the voice;
- musical—because it used the variations in pitch, rhythm, and timbre for emotion expression, care of infants, sexual display, and group bonding; and
- mimetic—because it involved high degree of mime and mimicry of the natural world.

Neanderthals would have been singing and dancing Neanderthals, their musicality being critical to their social lives and adaptation to their Ice Age landscapes.

The Evolution of Compositional Language in the *Homo sapiens* Lineage

This form of Hmmmm communication system would have also been used by the immediate ancestor of *Homo sapiens* in Africa. But within that lineage, it ultimately diverged into two systems, those which we now call language and music.

We know that *Homo sapiens* first appeared in Africa between 200,000 and 100,000 years ago; there is an increasing convergence of the evidence from the fossil,[53] genetic,[54] and archaeological records to verify this.[55] At around 70,000 years ago we start to see some dramatic changes in the archaeological record, although the origins of these can certainly be traced back considerably earlier in time.[56]

The most important site is Blombos cave on the coast of South Africa. Within this cave there are stratified deposits dating to 70,000 years ago which contain the earliest unambiguous symbolic artifacts, pieces of incised stone.[57] The deposits have high quantities of red ochre, which had probably been used for body painting. This cave has also produced one of the earliest examples of body decoration in the form of a necklace made from shell beads,[58] along with some very fine stone artifacts and bone tools.[59]

This date of 70,000 years ago seems important because it was very soon after that date that *Homo sapiens* dispersed from Africa, beginning a remarkably rapid phase of global colonization.[60] This took our species into South Asia, the Middle East, East Asia, Australia, Europe and eventually across the Baring straits into the Americas. Within a few thousand years of *Homo sapiens'* arrival in Europe and Asia, all other members of our genus had become extinct, including the singing and dancing Neanderthals.

What was it that enabled *Homo sapiens* to start using symbols, painting their bodies, and making beads? What gave them the inspiration and ability to colonize the globe? How were they so effective at out-competing all other types of human? The power of language is the only feasible explanation currently on the table for consideration. It was in Africa between 200,000 and 70,000 years ago that the ancient form of communication, Hmmmmm, diverged into its two modern-day components: compositional language and music. Quite why and how are questions that go beyond the scope of this article; suffice to say that I suspect that some chance genetic mutations were important.[61]

Why is language so powerful? Why did it lead to such enhanced adaptive success for *Homo sapiens*? The answer is simply that language is far better at transmitting information than is a musical-type of communication. This gave *Homo sapiens* an adaptive edge over other forms of humans, not only by being able to pass on factual information, but also by the ability to tell stories. This meant that musicality no longer played such a key role in the communication system of *Homo sapiens*; being freed from its relatively ineffective role of transmitting information, musicality was now able to be specialized in the things that music does particularly well: expressing emotion and creating a sense of group identity. It is perhaps not surprising, therefore, that we begin to find complex musical

instruments in the archaeological record.[62] The earliest known is an ivory flute, dating to 36,000 years ago found within Geissenklösterle cave in Germany. Soon after this date, we find numerous bird-bone flutes within the archaeological record of Ice Age Europe. While we are able to spin various adaptive stories about the role of such flutes and group music making during the Ice Age, I do not think that we should minimize the sheer enjoyment that music making provides today and would surely have done so during those long, dark winter nights of the Ice Age.

The Joy of Being a Musical Species

To conclude: we are a musical species because of a long evolutionary past when communication by variations in pitch and rhythm, by the use of harmony, and by group singing and dancing was essential to survival and reproduction. Because of the evolution of compositional language with *Homo sapiens*, the adaptive significance of music making is of less significance today. But just as with our enjoyment of food and sex, our evolutionary history has left us with an instinct, a thirst, need, nothing less than a burning desire for music. We neglect our musical instinct at our peril. We are the very lucky beneficiaries of a pre-linguistic but musical Stone Age past.

Conflicts of Interest

The author declares no conflicts of interest.

References

1. Mithen, S. 2005. *The Singing Neanderthals: The Origins of Music, Language, Mind and Body*. Orion. London.
2. Trevarthen, C. 1999. Musicality and the intrinsic motive pulse: evidence from human psychobiology and infant communication. *Musicae Scientiae* Special Issue 1999–2000, 155–215.
3. Trehub, S.E. 2003. Musical predispositions in infancy: an update. In *The Cognitive Neuroscience of Music*. I. Peretz & R. Zatorre, Eds.: 3–20. Oxford University Press. Oxford, UK.
4. Peretz, I. & R. Zatorre, Eds. 2003. *The Cognitive Neuroscience of Music*. Oxford University Press. Oxford, UK.
5. Patel, A. 2008. *Music, Language and the Brain*. Oxford University Press. Oxford, UK.
6. Mithen, S.J. & L. Parsons,2008. The brain as a cultural artefact. *Cambridge Archaeolog. J.* **18:** 401–410.
7. Mithen, S.J. 2005. *Op.cit.*
8. Geissmann, T. 2000. Gibbon songs and human music from an evolutionary perspective. In *The Origins of Music*. N.L. Wallin, B. Merker & S. Brown, Eds.: 103–124. Massachusettes Institute of Technology Press. Cambridge, MA.
9. Mitani, J.C. 1996. Comparative studies of African ape vocal behaviour. In *Great Ape Societies*. W.C. McGrew, L.F. Marchant & T. Nishida, Eds.: 241–254. Cambridge University Press. Cambridge, UK.
10. Richman, B. 1987. Rhythm and melody in gelada vocal exchanges. *Primates* **28:** 199–223.
11. Mithen, S. 2005.*Op. cit.*
12. Thomas, D.A. 1995. *Music and the Origins of Language: Theories from the French Enlightenment*. Cambridge University Press. Cambridge, UK.
13. Jespersen, O. 1895/1983. *Progress in Language*. Amsterdam Classics in Linguistics 17. John Benjamins. Amsterdam, the Netherlands.
14. Blacking, J. 1973. *How Musical is Man?* University of Washington Press. Seattle, WA.
15. Brown, S. 2000. The "musilanguage" model of human evolution. In *The Origins of Music*. N.L. Wallin, B. Merker & S. Brown, Eds.: 271–300. Massachusettes Institute of Technology Press. Cambridge, MA.
16. Mithen, S. 2005. *Op. cit.*
17. Johanson, D. & B. Edgar. 1996. *From Lucy to Language*. Weidenfeld & Nicolson. London.
18. Wood, B. & M. Collard. 1999. The human genus. *Science* **284:** 65–71.
19. Isaac, B., Ed. 1989. *The Archaeology of Human Origins: Papers by Glynn Isaac*. Cambridge University Press. Cambridge, UK.
20. Cheney, D.L. & R.S. Seyfarth. 1990. *How Monkeys See the World*. University of Chicago Press. Chicago, IL.
21. Zuberbüler, K. 2003. Referential signalling in nonhuman primates: cognitive precursors and limitations for the evolution of language. *Adv. Study Behav.* **33:** 265–307.
22. Dunbar, R.I.M. 1988. *Primate Societies*. Chapman & Hall. London.
23. Dunbar, R.I.M. 1993. Coevolution of neocortical size on group size in primates. *J. Hum.Evol.* **20:** 469–493.
24. Dunbar, R.I.M. 1996. *Gossip, Grooming and the Evolution of Language*. Faber & Faber. London.

25. Damasio, A. 1994. *Descartes Error: Emotion, Reason and the Human Brain*. Putnam. New York.
26. Le Doux, J. 1996. *The Emotional Brain*. Simon & Schuster. New York.
27. Oately, K. & J.J. Jenkins. 1996. *Understanding Emotions*. Blackwell. Oxford, UK.
28. Mithen, S. 2005. *Op. cit.*
29. Walker, A. & R. Leakey, Eds. 1993. *The Nariokotome Homo erectus Skeleton*. Springer Verlag. Berlin.
30. Mithen, S. 2005. *Op. cit.*
31. Aiello, L.C. 1996. Terrestriality, bipedalism and the origin of language. In *Evolution of Social Behaviour Patterns in Primates and Man*. W.G. Runciman, J. Maynard-Smith & R.I.M. Dunbar, Eds.: 269–290. Oxford University Press. Oxford, UK.
32. Thaut, M.H., K.W. McIntosh, G.C. McIntosh & V. Hoemberg 2001. Auditory rhythmicity enhances movement and speech motor control in patient's with Parkinson's disease. *Funct. Neurol.* **16:** 163–172.
33. Bramble, D.M. & D.E. Lieberman. 2004. Endurance running and the evolution of Homo. *Nature* **432:** 345–352.
34. Key, C. A. & L.C. Aiello. 1999. The evolution of social organization. In *The Evolution of Culture*. R. Dunbar, C. Knight & C. Power, Eds.: 15–33. Edinburgh University Press. Edinburgh, Scotland, UK.
35. Dissanayke, E. 2000. Antecedants of the temporal arts in early mother-infant interaction. In *The Origins of Music*. N.L. Wallin, B. Merker & S. Brown, Eds.: 389–410. Massachusettes Institute of Technology Press. Cambridge, MA.
36. Falk, D. 2004. Prelinguistic evolution in early hominins: whence motherese? *Behav. Brain Sci.* **27:** 491–503.
37. Key, C.A. & L.C. Aiello. 1999. *Op. cit.*
38. McHenry, H.M. 1996. Sexual dimorphism in fossil hominids and its sociological implications. In *The Archaaeology of Human Ancestry*. J. Steele & S. Shennan, Eds.: 91–109. Routledge. London.
39. Key, C. & L.C. Aiello. 2000. A prisoner's dilemma model for the evolution of paternal care. *Folia Primatol. (Basel)* **71:** 77–92.
40. Darwin, C. 1871. *The Descent of Man, and Selection in Relation to Sex*. Murray. London.
41. Miller, G. 2000. Evolution of human music through sexual selection. In *The Origins of Music*. N.L. Wallin, B. Merker & S. Brown, Eds.: 329–360. Massachusettes Institute of Technology Press. Cambridge, MA.
42. Straus, L.G. & O. Bar-Yosef, Eds. 2001. Out of Africa in the Pleistocene. *Quat. Int.* **75:** 1–3.
43. Donald, M. 1991. *Origins of the Modern Mind*. Harvard University Press. Cambridge, MA.
44. Berlin, B. 2005. "Just another fish story?" Size-symbolic properties of fish names. In *Animal Names*. A. Minelli, G. Ortalli & G. Singa, Eds.: 9–21. Institutio Veneto di Scienze, Lettre et Arti. Venice, Italy.
45. Thieme, H. 1997. Lower Palaeolithic hunting spears from Germany. *Nature* **385:** 807–810.
46. Gamble, C. 1999. *The Palaeolithic Societies of Europe*. Cambridge University Press. Cambridge, MA.
47. Mithen, S. 2005. *Op. cit.*
48. Mithen, S.J. 1996. On Early Palaeolithic "concept-mediated" marks, mental modularity and the origins of art. *Curr. Anthropol.* **37:** 666–670.
49. D'Errico, F. & A. Nowell. 2000. A new look at the Berekhat Ram figurine: implications for the origins of symbolism. *Cambridge Archaeolog. J.* **10:** 123–167.
50. Mellars, P. 1996. *The Neanderthal Legacy*. Princeton University Press. Princeton, NJ.
51. Stringer, C.B. & C. Gamble. 1993. *In Search of the Neanderthals*. Thames & Hudson. London.
52. Mithen, S. 2005. *Op. cit.*
53. McDougall, L., F.H. Brown & J.G. Fleagle. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* **433:** 733–736.
54. Ingman, M., H. Kaessmann, S. Paabo, & U. Gyllensten. 2000. Mitochondrial genome variation and the origin of modern humans. *Nature* **408:** 708–713.
55. McBrearty, S. & A. Brooks. 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *J. Hum. Evol.* **38:** 453–563.
56. Marean, C.W., M. Bar-Matthews, J. Bernatchez, *et al*. 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* **449:** 905–908.
57. Henshilwood, C.S., F. d'Errico, R. Yates, *et al*. 2002. Emergence of modern human behaviour: Middle Stone Age engravings from South Africa. *Science* **295:** 1278–1280.
58. Henshilwood, C.S., F. d'Errico, M. Vanhaeren, *et al*. 2004. Middle Stone Age shell beads from South Africa. *Science* **304:** 404.
59. Henshilwood, C.S. & J. Sealy. 1995. Bone artefacts from the Middle Stone Age at Blombos Cave, Southern Cape, South Africa. *Current Anthropology* **38:** 890–895.
60. Mellars, P. 2006. Going east: new genetic and archaeological perspectives on the modern human colonisation of Eurasia. *Science* **5788:** 796–800.
61. Mithen, S. 2005. *Op. cit.*
62. D'Errico, F., C. Henshilwood, G. Lawson, *et al*. 2003. Archaeological evidence for the emergence of language, symbolism, and music: an alternative interdisciplinary perspective. *J. World Prehist.* **17:** 1–70.