IS THERE A BIOLOGY OF MUSIC, AND WHY DOES IT MATTER?

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ABSTRACT

Background. Music is a uniquely human cultural product for which there are good grounds to suspect a biological origin. Chief among these is the cross-cultural universality of the ritualistic use of music in human group settings. In every culture known to ethnography or history, humans have gathered in groups to sing and dance together. So characteristic is this behavior that it belongs among the so-called diagnostic features of our species, along with our upright walk, big brain and language.

Aims. To explore the biology of music, and to trace its implications for our understanding of the origin, nature and structural characteristics of music.

Main contribution. The music featured in group rituals tends to be rhythmic, i.e. to be based upon the even subdivision of time through the musical beat or 'tactus.' This simplest of all structural elements of music turns out to provide surprising leverage for unlocking the biological secret of human music. The capacity to entrain to an isochronous pulse is unique to humans among the higher animals, but occurs in lower animals in a pattern that permits a reconstruction of why and how humans evolved their capacity to "keep time together." Given this reconstruction, a number of structural features of music such as its ubiquitous use of orthogonal discretization of spectro-temporal space can be given a natural interpretation, with far-reaching consequences for our understanding of the role of music in our subsequent evolutionary and cultural history.

Implications. The implications of the biology of human music will be explored, including a potentially crucial role of human music in overcoming the barrier posed to the evolution of music by the sophisticated communicative system of animal calls. In effect, neither human nature, nor the nature of music, can be properly understood without placing human music in biological perspective.

1. INTRODUCTION

Let us be clear about one thing from the very outset: Human music in the form that we know it today - from folk music to the art music of the worlds' major cultures - has no direct parallel or analog in the behavior of any other species in any part of the animal kingdom. Music is, like human language, uniquely human. Indeed, next to human language and its derivatives like mathematics, it is the cognitively most complex activity in which humans engage. As such it is obviously embedded in cultural tradition, and hardly conceivable apart from the intricate webs of historical transmission and cultural elaboration which sustain so much of human activity. Music, then, is a quintessential product of human culture. Nothing that I am about to say should be taken to throw doubt upon or question this basic view of the nature of music. In fact, it is the very premise from which and on the basis of which I will proceed.

Yet to say that music is a uniquely human product of human culture by no means implies that music therefore lacks biological foundations, or that biology is incapable of telling us anything important about its nature, origin and even structures. It is to the exploration of this possibility, and its consequences for our understanding of human music, that my remarks today will be directed.

2. CROSS-CULTURAL UNIVERSALITY AND SPECIES-SPECIFICITY

There is no culture known to ethnography or history in which humans have not gathered under ritual circumstances to sing and dance together (Brown, 1991). There is no known form of such singing and dancing in a group setting that does not qualify as music. This means that music is a human cross-cultural universal. Obviously the form and content of such behavior is determined by the particular culture in which it takes place, but the fact of it is not. If it were, we would expect at least some culture somewhere to do something other than singing and dancing in situations where we would do precisely that. Let us say that they gathered to paint pictures together on just those occasions when we would sing and dance. The very thought shows us that we are imagining creatures quite unlike ourselves. Apparently singing and dancing is somehow connected with what makes us human, with our human nature.

From a biological point of view this fact itself would be less remarkable if our close relatives among the apes did the same thing, but they do not. They have no group behavior resembling the structured and rhythmically synchronized rituals of human song and dance. It seems they cannot even be taught to coordinate their actions to a simple beat (Williams, 1967), something we do with ease and without special training. Rhythmic song and dance in a group setting accordingly is not only a human universal, but is unique to the human species, it is species-specific. Music, accordingly, appears to be a "diagnostic feature" of our species, that is, a trait - in this case a behavioral trait - which helps define our species no less than our upright walk, our big brain and our language.

This interpretation is in fact supported rather than undermined by a circumstance which has been used by some (e.g. Pinker, 1997) to dismiss the possibility that music represents a biological adaptation of our species, namely the fact that music has no obvious utility in the sense of providing resources needed for

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survival. Rather it consumes resources that might be spent on more useful things than to juggle notes and jiggle hips, to put it crudely. Now, if music were useful in the way in which the use of fire for cooking is useful, then the universality of music might simply follow from this utility. It would be retained by whatever group stumbled upon it, and eventually would be universal. Such universality would require no special biological adaptation, any more than the use of fire does. Since music has no such tangible utility its cross-cultural universality must be explained in some other way, presumably along the lines of a behavioral adaptation founded on the evolved nature of our species. But am I not contradicting myself here, in proposing that a lack of tangible survival utility on the part of music supports its status as a biological adaptation? What else but survival utility drives natural selection, and thereby the process of evolution through which a species acquires its adaptations? Obviously I have a good answer to this embarrassing questions, or I would not raise it so blithely. The question will in fact lead us the very heart of the issue of the biology of music.

3. THE ESTHETICS OF NATURE AND SELECTION IN RELATION TO SEX

Music as we know it is a phenomenon squarely in the domain of esthetics, and it is time to remind ourselves that we are far from the only species on earth engaging in esthetic extravaganzas. Let me do so by way of a few examples: the peacock's tail, the parrot's colors, and the tail of the lyrebird, all in the visual domain and built into the animal's structure, so to speak (overhead transparencies). But the esthetic effect need not thus be built into the animals body: the same can be done by behavior, as in the collection of useless but gaudy objects decorating the bower of the bowerbird (overhead). And in the vocal domain there is the repertoire of roughly 1,800 distinct melodies sung by the male brown thrasher (Catchpole & Slater, 1995), and there are the cultural song traditions of the humpback whales featuring true innovation and repertoire turnover. Then there is the vocal artistry the of the Pied Butcherbird of Australia, and the dramatically modulated great call of the female kloss gibbon, a singing ape inhabiting tiny islands in the high seas west of Sumatra (last two on CD).

None of these esthetic displays feed any mouths or fend off any predators in the struggle for survival. On the contrary: mouths must be fed to support these costly displays and many of them increase susceptibility to predators, yet natural selection insists on equipping species after species with frivolous antics and ornaments which make no sense at all from the point of view of survival. The point is that Darwinian selection has nothing to do with the puritan work ethic. As long as the energy and survival bill is paid, evolution is open to any device that might help get genes into the next generation, and one way of doing so is to make an impression on the opposite sex by an extravagant and costly esthetic display. That is why almost invariably these animal displays are connected to reproduction rather than survival, and have as their setting and mechanism the special form of natural selection called sexual selection. And that is why a lack of prosaic utility is no argument against the evolutionary origin of music. In fact, quite the opposite is true: if music is to have any evolutionary background at all, its lack of mundane utility places human music squarely into the most appropriate natural context conceivable, namely the spirals of sexual selection that equip animal species with ornamental colors, with singing voices and with bizarre behavioral displays, that is, into the world of natural esthetics. Let me illustrate this by a concrete example with an intimate connection to the origins of human music.

4. AN EVOLUTIONARY SCENARIO FOR THE ORIGIN OF THE HUMAN ABILITY TO KEEP TIME.

The simplest of all the structural characteristics of music is the device upon which all rhythmic music is built: the even subdivision of time by the musical pulse, the beat or "tactus." This device must not be confused with rhythmic patterns, because it is the presupposition of all rhythmic patterns in music (Arom 1991, p. 179), namely the isochronous subdivision of time into equal intervals: one, one, one, one, one.... (demonstrate). It is the only means by which several individuals can synchronize their behavior with high temporal precision. It allows them to do so by making the next beat in the sequence perfectly predictable. Only thus can we to tap along ***on*** the beat, rather than after it, as happens in all other behavior because of the inevitable lag of a reaction time between stimulus and response. That lag is eliminated by the predictability of the isochronous beat, and so individuals can act simultaneously rather than sequentially, and with high precision, by each entraining to the musical pulse. In this simple circumstance lies a biological mystery whose solution is also the answer to the origins of music, as I hope to show you presently.

First of all, across the wide range of human activities, the phenomenon of entrainment to an isochronous pulse is virtually unique to human music, i.e. it does not figure prominently in any other human behavioral domain which might have served as its primary arena of development and from which it might have been secondarily borrowed by music. Quite the contrary, its other occurrences, like in dance, are directly related to music, or, like in drill and poetry, are likely to be borrowed from or derived from music, rather than the other way around. Moreover, we have already noted that the musical pulse and the time-keeping behavior in which it features is cross-culturally universal among humans, but conspicuously absent among our close evolutionary relatives the apes. But it is even worse than that: it is absent among higher animals generally! Humans are the only mammals who are capable of keeping time together. Other animals move rhythmically, but only humans move rhythmically together in time, that is, keep time. And here comes the biological mystery: Though synchronization or entrainment to an isochronous pulse is unique to humans among higher animals, it occurs here and there among lower animals such as a few species of cicadas, crickets, fireflies, frogs, and crabs. Not commonly - far from it - but a species here and there among these lower forms of life does employ this timing device to synchronize group behavior, exactly like we do, by latching on to an isochronous subdivision of time into one, one, one... (CD sample of cicadas recorded on Java).

Are there then any connections or parallels between the ecological, social and evolutionary setting for such rhythmic coordination among lower animals - where the behavior is

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called synchronous chorusing - and what we know about our own origins, and the social system and behavior of the common ancestor we share with chimpanzees? As I have detailed in two publications (Merker 2000; Merker 1999/2000), there is.

Here I can only give you the gist of the story. In all cases of synchronous chorusing among lower animals it is the males who synchronize their signalling behavior to a common, isochronous pulse to attract mobile females during the mating season. In most species the synchrony is not genuinely cooperative, but represents a concealed form of signal competion or, in a few cases, a defense against predators. We will leave these aside to focus on the few cases of genuine cooperative synchrony, because that is obviously what music involves. In these cases males invariably live in small scattered clumps or groups, one here, one there. The females are the mobile ones, and during the breeding season males try to attract mobile females by their chirping. A lone male can do no more than chirp as well as he can, and hope that his signal is loud enough to reach the ear of a migrating female. But when males live in groups, there is a new possibility, and it involves synchrony, because there is one thing you can accomplish by behavioral synchrony which cannot be achieved in any other way: you can get the sounds of several voices to add, and the summed loudness will increase the geographic reach of the mating signal and will therefore reach more female ears. The more exact the synchrony - the more perfect the entrainment to the isochronous pulse - the more effective the amplitude summation. Thus, well synchronized groups of males will attract females to themselves ***at the expense of*** less well synchronized groups, and through this reproductive advantage a time-keeping synchronously chorusing species evolves.

Let me now suggest that the very circumstances that led to synchronous chorusing in some lower animals have a striking parallel in the social behavior of the common ancestor of humans and chimpanzees. Chimpanzee and humans are rare exceptions among higher animals in that they practice female exogamy, that is, females migrate from their place of birth to their adult habitat. Among chimpanzees this is combined with male territoriality. That is, a male is born, lives and dies on the territory he helps defend against neighboring groups, while a female - at sexual maturity - leaves her birth territory to settle on a new territory to mate and rear her young (Pusey 1979). The net effect is that stable groups of territorial males must attract females from other territorial groups, and are thus in competion with other male groups for migrating females. Female exogamy is also present in humans, characterizing a majority of hunter-gatherer societies (Ember 1978). This is the well-kept secret of chimpanzee and human females: they are the adventurers, while males are the home-bodies. Thus, we can assume that the combination of male territoriality and female exogamy characterized the common ancestor of chimpanzees and humans. This amounts to a social situation exactly like the one we have seen promoting the evolution of synchronous chorusing in insects: clusters of males competing for migrating females. How then can we get the voice into the human-chimpanzee ancestral equation? It enters on its own, through the peculiar chimpanzee group behavior called the "carnival display."

When a subgroup of foraging chimpanzee males discovers a ripe fruiting tree they tend to launch a noisy display of combined vocal and locomotor excitement which attracts other males and females of their territory to the site. The new arrivals join the noisy and often lengthy group display - it can last a whole night. Eventually everybody settles down to feed on the newly discovered resource. The display is genuinely cooperative in that it attracts additional mouths to share the resource, and it is an honest signal of resource discovery, since false alarm are likely to provoke retaliation.

A carnival display as practiced by today's chimpanzees - and presumably by the common acnestor - is utterly chaotic, and does not contain a hint of synchronization among the hooting, screeching voices. That is a pity, because a single chimpanzee voice normally does not carry beyond the borders of the territory upon which its bearer lives, and therefore cannot be heard by a migrating female trying to make a decision regarding which new territory she is to settle on to mate and rear her young. If she could hear the carnival displays of different territories, over time she would know something about the presence of cooperative males and the abundance of fruit trees on different territories, information that would be highly relevant to her decision regarding where to settle. Now simply assume that at the time of the common ancestor there was a subpopulation whose males synchronized their voices to a common beat, and thereby were able to sum the loudness of their voices just like synchronously chorusing insects do. This would allow them to broadcast the witness of their voices regarding their own cooperativity and the resource-richness of their territory to the tuned ears of migrating females, and thus to attract these to themselves ***at the expense of*** those groups of males who did not synchronize and whose carnival display therefore did not reach the ears of females. My suggestion is simply that we are the direct descendants of that synchronizing subpopulation of common ancestors, and that our ability to keep time cooperatively in music with the help of the musical pulse is a trait conserved from that breakthrough adaptation. It informs the cross-cultural ubiquity of rhythmic music as well as other uses of the human capacity to entrain to an isochronous pulse. Our non-synchronizing friends the chimpanzees, by the same token, are descendants of those who were left behind in the rain forest, persisting in a chaotic carnival display.

I have had to skip a mass of significant detail - including the role of locomotor rhythms and dance in all of this, as well as the operation of other forms of sexual selection than that represented by female choice of mating territory - but here my point is simply this, that basic Darwinian biology may indeed have important insights to contribute to our understanding of the nature of music and its origins. The very possibility of the scenario I have drawn up tells us that this must be so, quite apart from whether in the end that scenario will turn out to have merit or not.

5. IMPLICATIONS.

I am suggesting, in other words, that the ultimate roots of human music extend back some five million years into the past to the parting of ways between pre-chimpanzees and hominids through a late miocene "breakthrough adaptation" of synchronous chorusing, preserved ever since as the structural basis for all rhythmic music in the isochronous musical pulse, and as the human propensity to entrain to such a pulse. One advantage of this scenario is that it takes us through what might be called the "simplicity bottleneck" needed for the subsequent elaboration of true human music from its rudimentary beginnings in synchronous

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chorusing on the part of our late miocene ancestors. The reason for this is ***not*** that "animal beginnings have to be simple": they often are not, and much evolutionary change proceeds on the basis of preexisting complexity. The reason, rather, is the peculiar simplicity of the elements of human music, both in the pitch and in the time domain. These elements are something as simple as sets of discrete pitches and discrete durations with proportional values. The complexity of human music stems not from the complexity of its elements, but from the combinations these simple elements enter into as part of a non-blending or Humboldt system (Merker, 2002). Compared to the radical simplicity of musical notes and durations, most animal calls and the vocal phrases of which animal song is composed are highly complex affairs. Very few songbirds in fact use the kind of pure, simple notes that make up the song of the pied butcherbird we had occasion to listen to earlier. The radical simplicity likely to be enforced by the need for precise synchronization to a common isochronous pulse thus provided an ideal point of departure for elaboration of the kind of non-blending combinatorics of simple and discrete elements that eventually led to the kind of music humans manifestly employ throughout the highly diverse musical traditions of the world's many cultures.

While the complexity of ordinary animal calls and song phrases constitute an obstacle to the evolution of a combinatorial system of music for which an origin in synchronous chorusing provides a solution, the emotional semantics of animal calls provides a plausible point of departure for another dimension of human music, namely its expressive dynamics. We had no trouble recognizing the drama of the accelerated crescendo sung for us by the Kloss gibbon female, nor was the elegance of the soft landing she performed with the descending glides of her decelerated coda lost on us. In sharp contrast to the discrete pitches and durations that supply the combinatorial elements of human music, its expresse dynamics are best modelled by continuous variables, and here there is a rich background of expressive dynamics and emotional vocal gestures that we share with the animal kingdom by virtue of our biological status as apes, primates, mammals and even vertebrates. With the interest currently being evoked by the emotional and expressive aspects of music, here would seem to be a fertile interface beween biology and music which has so far received far too scant attention. This is all the more so, since the same dynamics also enter the prosody of human language.

The biology of music thus rests on a dual foundation. One is broad, embodying the dynamics of emotional expressiveness which to varying degrees and in varying instances we share with members of the animal kingdom. And the other is exceedingly narrow. It is more like a pivot than a foundation, namely the unique, indeed unlikely, biological circumstances through which a higher primate, an ape, came to reap reproductive benefit from a synchronizing trick which up to that point had been exploited only by scattered species of lower animals in the chorusing rituals of their mating games. That trick, I argue, the simple "one, one, one..." of the musical pulse, not only launched us on a unique evolutionary trajectory which still has not run its full course, but like a passage through the eye of the needle it set our feet on that path of discretization and metrics which eventually would disclose to us that limitless universe of music which orthogonal discretization of spectrotemporal space - in frequency and in time - makes possible through the nonblending combination of discrete elements. That universe was opened up to humans, and only to humans, among all the species inhabiting this planet, and it is my firm belief that the biology of music holds the key not only to our understanding of the natural origins of that process, but to our understanding of the ultimate nature of music as well, and its role as a defining trait of our own nature as a species. And with that I hope that I have given you not only some cogent reasons for thinking that there is a biology of music, but that there are good grounds for thinking that the knowledge it provides matters to us, both as human beings and as students of music.

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