Is Music an Evolutionary Adaptation?

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ABSTRACT: In contemplating the function and origin of music, a number of scholars have considered whether music might be an evolutionary adaptation. This article reviews the basic arguments related to evolutionary claims for music. Although evolutionary theories about music remain wholly speculative, musical behaviors satisfy a number of basic conditions, which suggests that there is indeed merit in pursuing possible evolutionary accounts.

KEYWORDS: Evolutionary theories of music; Music industry; Evolutionary origin of language; Music and social bonding; Oxytocin; Mood regulation

Addressing the question of music's origins has a long history and is patently speculative. Although several cultures have provided colorful stories describing how people acquired the capacity for music, most contemporary scholars have focused on possible psychological, social, and cultural beginnings. In this article, I propose to offer a social account of music's origins that is explicitly linked to one of the most successful theories yet devised: the theory of evolution by natural selection.

Evolution is often thought of in purely physiological rather than psychological terms.[1–5] It is not simply that evolution has shaped immune systems, digestive tracts, and knee caps. Evolution has also shaped our attitudes, dispositions, emotions, perceptions, and cognitive functions. Some of our deepest convictions can be traced to plausible evolutionary origins: we love life, we fear death, and we nurture our children because these dispositions better ensure the propagation of our genes.

The theory of evolution by natural selection is a distal theory. It is not a theory that explains specific behaviors, such as why you chose to cook ravioli for dinner last night, or why you parked in a particular parking spot this morning. Similarly, if music is an evolutionary adaptation, this will not allow us to account for particular musical acts, such as Mendelssohn's writing of the *Scottish Symphony.* Evolution proceeds by selecting traits that are adaptive to an organism's environment. For example, evolution did not "originate" or "create" the phenomenon of altruism. Instead, given a certain environment, natural selection favored individuals who exhibited certain altruistic traits. Evolution does not dictate our behavior: it selects which behaviors are likely to be passed on to subsequent generations—and it selects only those behaviors that have a genetic component. So in discussing possible evolutionary origins for musical behaviors, the question is not, What caused people to make music? but rather, How might music-making behaviors have escaped the hatchet of natural selection? or more precisely, What advantage is conferred on those individuals who exhibit musical behaviors over those who do not?

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DOES MUSIC HAVE SURVIVAL VALUE?

Many knowledgeable people have concluded that music has no survival value. Indeed, a number of esthetic philosophers have argued that an essential, defining characteristic of the arts is that they serve no practical function.[6] Accordingly, any music that is created for biological (or even economic) reasons cannot be considered art. Even among evolutionary psychologists such as Steven Pinker, it has been common to suppose that music is not adaptive.[7]

Many linguists—Pinker included—believe that language is likely an evolutionary adaptation.[8] However, the evidence in support of language as an adaptation is not notably stronger than comparable evidence for music. Where pertinent evidence is available, music exhibits the essential properties of all adaptations. My goal in this article is not to attempt to prove that music is adaptive. (Like others, I am not at all convinced that music has evolutionary origins.) Rather, my goal here is to convince you that the question of music's origins remains open and warrants further investigation (see also several articles in Wallin, Merker, and Brown[9]).[10]

Of course there are a number of dangers attending evolutionary speculation.[11,12] Popper (1935/1959) pointed out that no scientist has yet formulated the theory of evolution by natural selection in such a way that a set of observations could, in principle, be used to falsify it.[13] Gould and Lewontin[14] have noted that evolutionary reasoning is plagued by *post hoc* reasoning. Evolutionary theory has been used to defend all sorts of nefarious ideologies, from racism to sexism. Philosophers note that evolutionary arguments often lead to the naturalist fallacy where what is is confused with what ought to be. In the case of music, there is an undistinguished history of polemical writing where certain kinds of music have been condemned for being "unnatural." Finally, by focusing on biological issues, one can leave the false impression that the effects of culture on music are minimal.

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 premusical or protomusical. Moreover, the nebulous rubric *music* may represent several adaptations, and these adaptations may involve complex coevolutionary patterns with culture (see Ref. 15). In biological matters, things are rarely straightforward.

Given these possible dangers, why bother attempting to formulate an evolutionary theory of music? Isn't it premature? First, as noted above, my goal here is not to convince you that music is adaptive; my goal is only to convince you that this is a worthwhile question. Understanding the possible origins of music might help inform us about some of the reasons we tend to respond in certain ways. Second, in the spirit of Popper, I will aim to tell an evolutionary story that is able to generate testable hypotheses. Like other evolutionary accounts, my own theory will draw on existing knowledge, and so be *post hoc* in character. As long as this account remains *post hoc*, Gould and Lewontin's criticisms raise justified and paramount difficulties. However, it is my hope that the theory can be developed to the point where testable hypotheses might be derived.

Before entertaining some possible evolutionary views of music's origins, let us first consider two pertinent complicating points of views. One view is that music is a form of nonadaptive pleasure seeking. A second view is that music is an evolutionary vestige.

NAPS THEORY OF MUSIC

Most pleasurable activities, such as eating and sex, have clear links to survival. Such activities ultimately stimulate brain mechanisms that are specifically evolved to reward and encourage adaptive behaviors. Note that once brain mechanisms are in place that permit the experience of pleasure, it may be possible to stimulate those mechanisms in ways that do not confer a survival advantage. We can call these behaviors nonadaptive pleasure seeking (NAPS). An example of NAPS behavior is found in the human taste for sugars and fats. In premodern times, sugars and fats were rare in human diets, but highly nutritious in the amounts available. There are good reasons why human tastes would evolve to reward the ingestion of foods with high fat or sugar content. However, centuries of human ingenuity have succeeded in generating a modern diet that contains unnaturally high levels of fats and sugars—levels so high as to cause health problems such as diabetes and heart disease. Although such tastes originally conferred an increased chance of survival, in the modern environment, these behaviors have become less adaptive.

Another example of NAPS behavior is found in drug use, such as heroin or cocaine. These drugs can directly activate the brain's pleasure centers, simply by injecting or imbibing a substance. Although the channel for pleasure exists for good evolutionary reasons, it may be possible to exploit the channel without any concomitant survival-enhancing result.

As in the case of drugs, it is possible that musical behaviors are forms of nonadaptive pleasure seeking. That is, music itself may not enhance human survival; music may merely exploit one or more existing pleasure channels that evolved to reinforce some other adaptive behavior(s). We might call this view the "NAPS theory of music."

One way to determine whether some pleasure-seeking behavior is adaptive or nonadaptive is to consider how long the behavior has been around. In the long span of evolutionary history, nonadaptive pleasure-seeking behaviors tend to be short-lived. For example, heroin users tend to neglect their health and are known to have high mortality rates. Furthermore, heroin users make poor parents; they tend to neglect their offspring. Poor health and neglect of offspring are infallible ways of reducing the probability that one's genes will be present in a future gene pool. After many generations, natural selection will tend to militate against heroin use. Those individuals who are not disposed (for whatever reason) to use heroin, are much more likely to procreate and so pass along their aversion to the use of such drugs, provided that the aversive behavior is somehow linked to a gene or genes.

The use of alcohol already suggests how NAPS behaviors can transform a gene pool. Although no gene has been identified, either for alcohol susceptibility or for alcohol tolerance, the responses of different human populations to alcohol show a suggestive pattern. Large quantities of alcohol became possible only with the advent of agriculture. Modern European and Asian descendents of early agrarian cultures (such as originated in Mesopotamia) manage to deal with alcohol better than descendents of traditional hunter-gatherer societies, such as indigenous peoples in the Americas and in the arctic regions of Europe. Of course there are certain to be nongenetic factors influencing alcohol tolerance and abuse. However, alcohol researchers suspect that genetic factors are at work. Those people who have descended from traditional agricultural societies have a clear statistical advantage in dealing with the

nonadaptive consequences of alcohol, and this would be expected if alcohol had been prevalent in these societies for thousands of years.

If music itself has no survival value (and merely exploits an existing pleasure channel), then any disposition towards musical behaviors would tend to worsen one's survival. Spending inordinate amounts of resources (such as time and money) on music would be expected to place music lovers at an evolutionary disadvantage. In other words, if the NAPS theory of music is true, then we would expect music appreciation to be correlated with marginal existence: as in the case of alcohol, music lovers would be disproportionally more likely to end up on "skid row."

In addition, if music is nonadaptive, then it must be the case that music is historically recent; otherwise music lovers would have become extinct some time ago. As we will see, the archaeological evidence indicates that music is very old—much older than agriculture—and this great antiquity is inconsistent with music originating as a nonadaptive pleasure-seeking behavior. In short, there is little evidence that musical behaviors have been selected against. All of this suggests that there is little support for the NAPS theory of music.

MUSIC AS AN EVOLUTIONARY VESTIGE

Another possibility is that, although music at one time did indeed confer some survival value, it is now merely vestigial. Like the human appendix, at one time this "organ" may have contributed directly to human survival, but now it is largely irrelevant —a piece of evolutionary litter. If this view is true, then we would have to ask What advantage did music once confer? and How have things changed so that music is no longer adaptive?

MEASURING THE ADAPTIVE VALUE OF MUSIC

The adaptive value of some function is often evident in the individual survival costs arising from that function. For example, the larynx of newborn infants is anatomically arranged so that breathing and swallowing can happen at the same time. When the larynx enlarges, our physiological capacity for speech is purchased at the price of the danger of choking. In effect, one measure of the evolutionary advantage of speech is the mortality rate due to choking.

Similarly, an estimate of the evolutionary advantage conferred by music is to measure the amount of time people spend in musical behaviors. In the Atlas mountains of Morocco, full-time Jujuka mountain musicians are supported by the local villagers. That is, there is an entire caste of people whose principal productive activity is music making. A ready index of the importance of music in such a society may be the ratio of the number of musicians to the number of farmers and herders.

SOME EVOLUTIONARY THEORIES OF MUSIC

Of the various proposals concerning a possible evolutionary origin for music, eight broad theories can be identified:

Mate selection. In the same way that some animals find colorful or ostentatious mates attractive, music making may have arisen as a courtship behavior. For example, the ability to sing well might imply that the individual is in good health.

Social cohesion. Music might create or maintain social cohesion. It may contribute to group solidarity, promote altruism, and so increase the effectiveness of collective actions such as defending against a predator or attacking a rival clan.

Group effort. More narrowly, music might contribute to the coordination of group work, such as pulling a heavy object.

Perceptual development. Listening to music might provide a sort of "exercise" for hearing. Music might somehow teach people to be more perceptive.

Motor skill development. Singing and other music-making activities might provide (or have provided) opportunities for refining motor skills. For example, singing might have been a necessary precursor to the development of speech.

Conflict reduction. In comparison with speech, music might reduce interpersonal conflict. Campfire talk may well lead to arguments and possible fights. Campfire singing might provide a safer social activity.

Safe time passing. In the same way that sleep can keep an animal out of harm's way, music might provide a benign form of time passing. Evolutionary biologists have noted, for example, that the amount of sleep an animal requires is proportional to the effectiveness of food gathering. Efficient hunters (such as lions) spend a great deal of time sleeping, whereas inefficient feeders (such as grazing animals) sleep relatively little. Sleep is thought to help keep an animal out of trouble. A lion is more apt to injure itself if it is engaged in unnecessary activities. As early humans became more effective at gathering food, music might have arisen as a harmless pastime. (Note, for example, that humans sleep more than other primates.)

Transgenerational communication. Given the ubiquity of folk ballads and epics, music might have originated as a useful mnemonic conveyance for useful information. Music might have provided a comparatively good channel of communication over long periods of time.

Sexual Selection

Before continuing, we should take a moment to discuss a variant of the mate selection theory. Charles Darwin identified a form of natural selection known as sexual selection. The classic example of sexual selection is the peacock's tail. The function of the tail is not to promote the survival of the peacock; rather, the function is to promote the survival of the peacock's genes. Sexual selection arises once a particular genetic preference is established by the opposite sex—in this case, the preference of the peahen for flashy tails. Even if one peahen is not particularly impressed by Las Vegas–style tails, it remains to the female's benefit to mate with the most colorful male if her offspring are more likely to be desired by other females who are fond of colorful tails.

Darwin himself suggested that music might have arisen due to sexual selection in mating calls.[16] Like the peacock's tail, the preferences of hominid women could create an escalating competition for ever more elaborate and beautiful melodies. Miller[17] has suggested that sexual selection accounts for why musical interests appear to peak in adolescence. However, the members of the all-male Vienna Philharmonic notwithstanding, there is nothing to indicate that one sex is more musical than

the other, and so there is no evidence of the dimorphism commonly symptomatic of sexual selection. Women may be impressed by men who serenade them outside their balcony windows, but unlike female songbirds, female humans are perfectly capable of serenading men. Currently, there is no other known example of sexual selection that does not exhibit high sexual dimorphism—although one should note that biology is full of surprises.

TYPES OF EVIDENCE

In presenting a case for the evolutionary origins of music, we can consider four types of evidence:

Genetic evidence. The best evidence of an evolutionary origin would be the identification of genes whose expression leads to the behavior in question. Unfortunately, it is rare for scientists to be able to link particular behaviors to specific genes. Although behavior-linked genes have been discovered in other animals (such as fruit flies), no behavior-linked gene has yet been conclusively established in humans. As in so many other areas, music has attracted a kind of folklore related to heritability. In some cultures, it is common for people to assume or believe that musical talent is partly inherited. More recently, work at the University of California, San Francisco by Baharloo *et al.*[18] appears to suggest a genetic component for absolute pitch.

Neurological evidence. The existence of specialized brain structures is neither a sufficient nor a necessary condition for music to be an evolutionary adaptation. Nevertheless, if stable anatomical brain structures exist for music, then this is consistent with music arising from innate development rather than being due solely to a generalized learning.

Ethological evidence. Are musical behaviors consistent with survival and the propagation of genes? In order for music to be an evolutionary adaptation, music-related behaviors must somehow increase the likelihood that the musical person's genes will be propagated.

Archaeological evidence. Since complex evolutionary adaptations arise over many thousands of generations, we must ask how widespread music is in biological history? If music originated in the past few thousand years, then it is highly unlikely to be an evolutionary adaptation. Evolution does not work that fast.

As noted, there is currently no evidence that links music to any gene. Let's consider the other areas of evidence in more detail.

ARCHAEOLOGICAL EVIDENCE

Let's begin by considering some of the archaeological facts. The archaeological record shows a continuous record of music making in human settlements. Wherever you find evidence of human settlement, you find evidence of musical activities.

In 1995, paleontologist Ivan Turk discovered a bone flute while excavating an ancient burial mound in Divje Babe, Slovenia.[19,20] This flute has been determined to be between 43,000 and 82,000 years old, using electron spin dating. The instrument was fashioned from the femur of the now-extinct European bear.

Of course, finding this flute does not mean we have found the earliest musical instrument; this is just the earliest found instrument. As musical instruments go, flutes are rather complicated devices. If we look at contemporary hunter-gatherer societies, the most common instruments are rattles, shakers, and drums. For example, prior to the arrival of Europeans, by far the most common instruments in native American cultures were rattles and drums. The same pattern of preferred instruments is evident in African and Polynesian cultures. If we assume that rattles and drums typically predated the use of flutes, then the ancient music makers of Slovenia might well have been creating instrumental music somewhat earlier than 100,000 years ago.

What sort of music making, however, might have existed prior to the fashioning of musical instruments? It is not unreasonable to assume that singing preceded the making of musical instruments by some length of time. If we suppose that singing predated instrument making by 50% of the intervening time, then music making might have existed 150,000 years ago—roughly twice the age of the older estimate for the Divje Babe flute. Even this figure might be a conservative estimate, and the actual origin of music might be twice as old, say around 250,000 years ago.

On the other hand, the Divje Babe flute might truly be an early specimen, and singing might have developed about the same time. Using the most recent estimate for the Divje Babe flute would therefore place the origins of music making about 50,000 years ago.

In summary, the archaeological record implies that music making likely originated between 50,000 years ago and a quarter of a million years ago. Although Wurlitzer organs, American Bandstand, and MTV are relatively recent phenomena, music making, in general, is really quite old. The evidence pointing to the great antiquity of music satisfies the most basic requirement for any evolutionary argument. Evolution proceeds at a very slow pace, so nearly all adaptations must be extremely old. Music making satisfies this condition.

Incidentally, the antiquity of music raises problems for those who would wish to use evolutionary arguments in esthetic debates by claiming that one music is "more natural" than another. Whatever the origins of music, the vast majority of people have long ceased to live in Pleistocene conditions. In deciding whether Twisted Sister is better or worse than the Grateful Dead, appealing to the sounds of neolithic caves is unlikely to help.

ANTHROPOLOGICAL EVIDENCE

Turning to contemporary anthropology, we can ask, What does the plethora of existing human cultures tell us about music? Without taking time to review the evidence, there is one overwhelming conclusion from the modern anthropological record. There is no human culture known in modern times that did not, or does not, engage in recognizably musical activities.

Not only is music making very old, it is ubiquitous; it is found wherever humans are found.[21] Moreover, I neglected earlier to mention one important fact about the bone flute at Divje Babe: the flute was found in a Neanderthal burial site. The Divje Babe flute isn't even a human artifact. In short, it may be that music making is not just ubiquitous among *Homo sapiens*; music making may possibly be characteristic of the entire genus *Homo*.

The evidence pointing to the ubiquity of music satisfies another important basic requirement for any evolutionary argument. Relatively few adaptations are not found throughout the entire population of the affected species. For example, if eyelashes confer an evolutionary advantage, then just about everyone should have eyelashes. There are some exceptions to this principle, some of which are very important. For example, humans divide into female and male versions, so there are some genes that are not shared by everyone. Another more subtle example is the gene that codes for sickle-cell—a gene that protects against malaria, but that can also cause anemia. In general, however, adaptive genes are typically ubiquitous throughout a gene pool.

ETHOLOGICAL EVIDENCE

When studying a particular animal, ethologists often begin by making an inventory of observed behaviors. What does the animal do, and how often does it do it? Activities that require a great deal of time and large expenditures of energy are understandably considered important. Ethologists assume that behaviors are likely to be optimized. Even behaviors that seem unimportant (such as infant play or sleeping) often have a serious or critical purpose.

Primates, for example, spend an extraordinary amount of time grooming each other. Ethologists feel obliged to formulate theories that account for the various proportions of resources dedicated by an animal to different activities.

Let's apply the ethological approach to the behaviors we call musical. For the purposes of illustration, we will consider two case descriptions. The first case is that of the Mekranoti Indians of the Brazilian Amazon, and the second case is that of contemporary society in the United States.

The Mekranoti Indians

The Mekranoti Indians are hunter-gatherers who live in the Amazon rain forest of Brazil. In Mekranoti culture, singing plays a prominent role in daily life. For several months of the year, every morning and evening the women lay banana leaves on the ground where they sit and sing for between one and two hours. The men sing early every morning, starting typically around 4:30, but sometimes as early as 1:30 A.M. The men sing for roughly two hours each day, and often they will also sing for a half hour or so before sunset.

When singing, the Mekranoti men hold their arms in a sort of cradling position and swing their arms vigorously. The men endeavor to sing in their deepest bass voices and heavily accent the first beats of a pervasive quadruple meter with glottal stops that make their stomachs convulse in rhythm. Anthropologist Dennis Werner[22] describes their singing as a "masculine roar." When gathering in the middle of the night, the men are obviously sleepy, and some men will linger in their lean-tos well after the singing has started. These malingerers are often taunted with shouted insults.

Werner reports that "Hounding the men still in their lean-tos [is] one of the favorite diversions of the singers. 'Get out of bed! The Kreen Akrore Indians have already attacked and you're still sleeping,' they [shout] as loudly as they [can]…. Sometimes

the harassment [is] personal as the singers [yell] out insults at specific men who rarely [show] up."[23]

What is extraordinary about the Mekranoti singing is the amount of time involved —roughly two hours per day. (Remember, this is a subsistence hunter-gatherer society.) For the evolutionary ethologist, the important question arising from the Mekranoti Indians is why music making would attract so much of the tribe's resources. We will return to this question later.

Modern United States of America

By way of comparison, consider now the prevalence of music in a modern industrialized society like the United States. For the ethologist looking at modern human behaviors, a crude though ready index of the amount of resources we dedicate to a particular activity can be found by measuring economic activity.

There is a widespread misconception that the foremost export sector in the US economy is "high technology." In fact, the preeminent export sector in the US economy is entertainment. Of the various component areas—films, sports, television, toys, and games—it is music that ranks foremost.

How big is the music industry? The music industry is bigger than the pharmaceutical industry. People spend more money on music than on prescription drugs. We purchase recordings, go to concerts, buy sheet music, take our children to music lessons, listen to commercial radio, watch film accompanied by music, and encounter Muzak in the local shopping mall. The most active concert venues in the world are freeways: a major preoccupation for millions of drivers is listening to music.

Of course financial measures are crude indicators of behavioral significance. The ethological point is simple. In both a hunter-gatherer society and a modern industrial society, we find humans dedicating a notable proportion of the available resources to music making and listening. Music may not be more important than sex; but it is arguably more expensive, and it is certainly more time consuming.

In order to put these behaviors in perspective, suppose you were a Martian anthropologist visiting Earth. There are many aspects of human behavior that would have recognizable value. You would see people engaged in growing and preparing food, in raising and educating children, people involved in transportation, health, and governance; but even if Martian anthropologists had ears, I suspect they would be stumped by music.

If you are still not convinced that music attracts a peculiarly excessive proportion of human resources, consider another comparison. Think of how important food is to human well-being, of how tasty and enjoyable food is and can be. Now how many universities have departments of cuisine or nutrition, or departments of food sciences, or even departments of home economics? Now consider how many universities have departments of music. Why would music figure more prominently than food? To a visiting tourist from Mars, music sticks out; it is a remarkable and bizarre activity that earthlings do.

Of course, we must be careful in drawing any conclusions about adaptations based on observations of modern behaviors. If music making is an adaptive behavior, then it must have arisen long ago in the environment of evolutionary adaptedness—namely, the Pleistocene period, when the vast majority of human evolution occurred.

ETHOLOGY AND EVOLUTION

Just because an animal spends a lot of time on certain activities does not mean that the activity represents an evolutionary adaptation. Ethologists must connect the behavior to an explicit evolutionary account. That is, there must exist a plausible explanation of how the behavior would be adaptive.

Before considering such a theory for music, let us examine a nonmusical example —an example that has a richer theoretical literature about its origins. Specifically, we will consider some of the evolutionary arguments that have been advanced to account for the origins of language.

ON THE EVOLUTIONARY ORIGIN OF LANGUAGE

As in the case of music, views concerning the origins of language are necessarily speculative. Nevertheless, we can learn a great deal by considering some of the theories that have been advanced concerning its origin. Until recently, the principal view of language was that it facilitated complex collaborative activities such as coordinating actions during hunting. This account seems unlikely, first, because talking is a bad idea when tracking prey, and second, because men as a group display inferior language skills compared with women.

A number of anthropological psychologists have suggested that language (and even music) evolved as surrogates for social bonding.

The Grooming and Gossip Theory of Language Origins

The most empirically grounded of the recent theories of language origins is what might be called the "grooming and gossip hypothesis." Its principal advocate is Robin Dunbar.[24] The theory proposes the following logic.

Animals often live in groups for mutual protection against predators. In general, larger groups are more effective in detecting and warding off predators than smaller groups, but there are costs associated with maintaining a large group. One cost is that feeding must be much more intensive in a given area and so a larger group must travel greater distances in search of food. A second cost is that as group size increases, threats are more likely to arise from internal conflict within the group rather than from external predators. That is, there is a point where group size effectively minimizes predation, but at the cost of threats from members of the group itself. Nowhere is this more evident than in primates. As a consequence of internal threats, animals within the group begin to form alliances with one another. These alliances reduce the likelihood of conflict due to the threat of group retaliation.

In primates, the principal means by which alliances are formed and bonds maintained is through grooming. Grooming accounts for between 10% and 20% of an individual's daytime activities.

There is good evidence to suggest that the principal purpose of grooming is to form alliances between individuals. First, grooming partners are much more likely to come to the defense of one another when threatened by another member of the group. Even more important evidence comes from relating the amount of time spent grooming to the size of the group. Different primate species have different typical

group sizes. Gorillas, macaques, chimpanzees, and bonobos, among other groups, tend to form groups that have different average sizes. Primatologists have measured the different amounts of time each species engages in grooming.[25]

A major discovery has been that there is a consistent relationship between group size and the amount of time spent grooming. As the group size increases, the average grooming time also increases. This is an unusual finding: there is no reason to suppose that animals in larger groups tend to get dirtier than animals in smaller groups, so the increase in grooming is unlikely to be related to cleanliness. Primatologists widely agree that the increase in grooming time for larger groups arises from the need to form more extensive networks of alliances. In a large group, an individual fares better by having a wider circle of friends, and the way to build primate friendships is through mutual grooming.

In the case of humans, the common "group size" has been estimated at roughly 150 people. This is approximately the size of most rural villages in the world. This means that human groups are especially large when compared with other primates. As Dunbar has pointed out, "If modern humans tried to use grooming as the sole means of reinforcing their social bonds, as other primates do, then the equation for monkeys and apes suggests we would have to devote around 40% of our day in mutual mauling."[26]

Dunbar has suggested that language evolved as an alternative to physical grooming. In effect, physical grooming was replaced by "vocal grooming," whose purpose remains the formation and maintenance of friendships or alliances. Such vocal grooming has a distinct advantage over physical grooming: we can talk to several people simultaneously. This increases the number of people we can bond with at the same time.

Note, however, that even language has significant limitations for multiple concurrent social interaction. Dunbar[27] has noted that "there appears to be a decisive upper limit of about four on the number of individuals who can be involved in a conversation." When a fifth or sixth person joins a conversation there is a marked tendency for the group to subdivide into two or more concurrent conversations. It is only in hierarchical situations (such as in a formal lecture) where a single conversation can be maintained in a larger group.

All of this suggests that language is most useful in close interpersonal interactions, such as grooming, gossiping, courting, and conspiring. Note, however, that there are other activities that are of value to members of a social group that involve the entire group (or at least large segments) rather than groups of twos or threes. Chief among these group activities is defense. When under threat, uniform group action is indeed a mighty force, much more powerful than smaller groups of twos and threes.

MUSIC AND SOCIAL BONDING

At this point, we might speculate how music might fit into this account. Let's assume, for the moment, that the hypothesis that language evolved as a surrogate for physical grooming is true, and that language thereby allowed humans to live in larger groups with their attendant complex social relations. We could certainly conceive of a similar function for music. In some ways, music provides several advantages over

language. Singing is much louder than speaking, so singing may facilitate group interactions involving more than the four individuals posited as the upper limit for conversation.

This view of the possible origins for music was essentially proposed by Juan Roederer in 1984: "... the role of music in superstitious or sexual rites, religion, ideological proselytism, and military arousal clearly demonstrates the value of music as a means of establishing behavioral coherency in masses of people. In the distant past this could indeed have had an important survival value, as an increasingly complex human environment demanded coherent, collective actions on the part of groups of human society."[28]

In light of later work by primatologists such as Dunbar, there appears to be merit in Roederer's hypothesis. Music might have originated as an adaptation for social bonding—more particularly, as a way of synchronizing the mood of many individuals in a larger group. That is, music helps to prepare the group to act in unison.

Perhaps a helpful image is to imagine the cackling of geese prior to their taking off. How is it that individual geese manage to synchronize their actions so that the entire flock takes flight more or less simultaneously? For anyone who has watched geese take off, there is a clear increase in the volume of cackling: more and more geese start honking. The general hubbub of honking geese is apt to raise the arousal levels of all geese in the vicinity. This increased arousal (which includes increased heart rate) would prepare the geese for a significant collective expenditure of energy.

MUSIC AND SOCIAL BONDING—FURTHER EVIDENCE

It is this theory of music and social bonding that I believe holds the greatest promise as a plausible evolutionary origin for music. For the remainder of this article, I would like to review further phenomena that provide support for this hypothesis. The evidence is going to come from the following five sources: various mental disorders imply a strong link between sociability and musicality; child development implies a social role for music; brain structures related to music are linked to social and interpersonal functions; the most popular musical works imply social functioning; music modifies hormone production in groups of people.

Complementary Disorders: Williams Syndrome and Asperger Autism

Consider two mental disorders: Williams syndrome and Asperger-type autism. The principal feature of Williams syndrome is mental retardation. Williams syndrome is unique in that sufferers display three additional characteristics. One characteristic is high verbal abilities. Individuals suffering from Williams syndrome take a great interest in words. Their speech is fluent and peppered with a remarkably sophisticated vocabulary. In fact, when first encountering someone with Williams syndrome, the language fluency tends to mask the mental handicap.

In addition to high verbal abilities, Williams syndrome individuals also exhibit high sociability. They are gregarious and sociable. Coupled with the high verbal abilities, this makes Williams syndrome children a delight to work with. Finally, Williams syndrome children exhibit high musicality.

Daniel Levitin and Ursula Bellugi[29] have described the musical activities of Williams syndrome children at a summer camp in New York State. The children are remarkable. The entire camp is alive with music. Although the children have been shown to have no greater musical aptitude than normals, they clearly relish both the musical activities and the social environment in which their musical enthusiasms can flower.

Now consider the case of Asperger-type autism. Autism is characterized by a strong aversion to social interaction. Although most autism is associated with reduced mental functioning, mental retardation is not always evident. There are autistic individuals with normal and above-average intelligence as well. Autism is related to an emotional deficit—notably the failure to develop the so-called secondary or social emotions, including shame, pride, guilt, love, and empathy. For normal children, these secondary emotions typically appear by the age of about four.

Temple Grandin is a high functioning Asperger-type autistic who has become well known through her writings about her own condition. Concerning love, Grandin talks about her confusion in high school when reading Shakespeare's *Romeo and Juliet*. "I never figured out what it was all about," said Grandin. In a trip through the Rocky Mountains with Oliver Sacks, Grandin remarked, "The mountains are pretty, ... but they don't give me a special feeling, the feeling you seem to enjoy." "You get such joy out of the sunset," she said. "I wish I did, too. I know it's beautiful, but I don't 'get' it."[30] Grandin's experience of music is similar. Although Grandin has perfect pitch and what she describes as a tenacious and accurate auditory memory, she finds music leaves her cold. She finds the sounds "pretty," but in general, she just doesn't get it.[31] All the fuss about music leaves her mystified.

Grandin's own explanation is that not all of the "emotional circuits" are connected. Sacks interprets the phenomenon as follows: "An autistic person can have violent passions, intensely charged fixations and fascinations, or, like Temple [Grandin], an almost overwhelming tenderness and concern in certain areas. In autism, it is not affect in general that is faulty but affect in relation to complex human experiences, social ones predominantly, but perhaps allied ones—esthetic, poetic, symbolic, etc. No one, indeed, brings this out more clearly than Temple herself….She feels that there is something mechanical about her mind, and she often compares it to a computer…. She feels that there are usually genetic determinants in autism; she suspects that her own father, who was remote, pedantic, and socially inept, had Asperger's—or, at least, autistic traits—and that such traits occur with significant frequency in the parents and grandparents of autistic children."[32]

The contrast between Asperger-type autism and Williams syndrome is striking. On the one hand we have a group of people whose symptoms include high sociability linked with high musicality. On the other hand we have a group of people whose symptoms include low sociability linked with low musicality. Together, these mental conditions are consistent with a relationship between sociability and musicality—and this link is the principal assumption of a group-oriented evolutionary account.

MUSIC AND SOCIAL FUNCTION

Consider the following question: What is the most successful piece of music in modern history? Of course the answer to this question depends on how we define

success—and this is far from clear, as esthetic philosophers have shown. Nevertheless, I want to use a straightforward criterion: let us assume that the most successful musical work is the one that is most performed and most heard. Using this criterion, you might be surprised by the answer. The most successful musical work was composed by Mildred and Patti Hill in 1893, and revised in the 1930s.[33] The piece in question is, of course, "Happy Birthday." "Happy Birthday" has been translated into innumerable languages and is performed on the order of a million times a day. It remained under copyright protection until the middle of the twentieth century. For many people, the singing of "Happy Birthday" is the only time they sing in public. For other people, the singing of "Happy Birthday" constitutes the only time they sing.

In some ways, "Happy Birthday" is the quintessential feminist work. Its composers remain unknown and uncelebrated; the work was created by the collaboration of two women rather than as an egotistic expression of one man. It is a thoroughly domestic work: "Happy Birthday" is performed in the kitchen or lunch room rather than in the concert hall. No other musical work has evoked so much spontaneous music making. The work is domestic, amateur, and relationally oriented. Despite its extraordinary success, it remains undervalued as a musical creation.

"Happy Birthday" plays a role in our evolutionary story because I suspect that for the vast majority of human history, music making was of this ilk. In Western culture, it is surely the camp songs sung by Girl Scouts or the songs sung by British soccer fans that come closest to what might be imagined in Pleistocene *Homo sapiens*. In all these cases, the music serves an obvious social role and in helping to define a sense of identity and common purpose.

In light of our evolutionary hypothesis, let us return and reconsider the singing of the Mekranoti Indians. Recall some of the characteristic features—especially the singing done by the men: the men's singing is done late at night and in the early morning, and their singing is associated with a high degree of machismo. Like most native societies, the greatest danger facing the Mekranoti Indians is the possibility of being attacked by another human group. The best strategic time to attack is in the very early morning while people are asleep. Recall the insult shouted at men who continued to sleep in their lean-tos: "Get out of bed! The Kreen Akrore Indians have already attacked and you're still sleeping." The implication is obvious. It appears that the nightly singing by the men constitutes a defensive vigil. The singing maintains arousal levels and keeps the men awake.

Of course music making is also associated with stirring a war party. North American Indians famously sang and danced prior to initiating an attack on another tribe. One might suppose that engaging in an activity that publicly announces a hostile intention would be counterproductive. War dances might possible warn an enemy of an impending attack. However, the music making seems to serve a more important role: that of raising arousal and synchronizing individual moods to serve the larger goal of the group.

SOCIAL BONDING AND HORMONES

Apart from arousing individuals, music can also pacify. Experimental work by Fukui has shown that listening to music can reduce testosterone levels. Fukui himself was quick to point out the possible social and evolutionary significance of this

finding. In human social groups, lower levels of testosterone are likely to result in less aggression, less conflict, less sexual confrontation or sexual competition, and consequently more group cohesiveness.

A problem with Fukui's experiment is that he did not manipulate the type of music heard by his listeners. Listeners simply listened to their favorite music. Depending on his sample of listeners, we might expect whole genres of music were not represented. We might suppose, for example, that heavy metal, hard rock, or thrash music might well have increased rather than decreased testosterone levels. Further research is necessary to document the specific hormonal changes associated with different types of musical experiences. However, Fukui's work at least shows that music can have marked effects on hormone levels—specifically, hormones that relate especially strongly to sociability.

OXYTOCIN AND THE BIOLOGY OF SOCIAL BONDING

An important question to ask is how precisely music might bring about social bonding. Neurophysiologist Walter Freeman[34] has proposed a pertinent theory related to the hormone oxytocin.

Oxytocin is most commonly associated with the "let-down" response in new mothers—that is, the response that enables the flow of breast milk following childbirth. The presence of oxytocin also has dramatic effects on the brain. For example, when a ewe gives birth to a lamb, the olfactory bulb in the ewe's brain is bathed in oxytocin. Following the birth of the new lamb, a ewe will imprint on the smell of the new lamb, but will subsequently fail to recognize the smell of her former offspring. The result is that the ewe will suckle only the newborn lamb.

Neurophysiological research has shown that oxytocin acts as a sort of "eraser" that wipes away previous memories and simultaneously facilitates the storage of new memories. When linked with significant life events, oxytocin is the cement that binds new memories. The amnesic properties of oxytocin are evident in all kinds of learning episodes. However, their strongest effects occur during major limbic activations, such as those resulting from trauma or from ecstasy. Pavlov discovered this phenomenon when serious spring flooding affected his lab and nearly drowned his caged dogs. Following their rescue it was discovered that the dogs had to be retrained from scratch.[35]

In his book, *Societies of Brains*, Freeman chronicles a number of circumstances where oxytocin release occurs and the effects of these releases on neural organization. As we have noted, oxytocin releases are associated with trauma and ecstasy. In addition to childbirth, oxytocin is released in males and females following sexual orgasm. Freeman also suggests that oxytocin is released during trance and while listening to music.

In many cases, the presence of oxytocin is correlated with human and animal bonding circumstances. For example, in the case of sexual orgasm, oxytocin may significantly facilitate pair bonding in the same way that oxytocin following childbirth facilitates mother–child bonding. Freeman's suggestion that music causes oxytocin to be released has important repercussions for instances of peer-group bonding and social identity. If Freeman is correct, there would be good neurophysiological reasons for lovers to enjoy music while courting, for union members to sing

while on the picket line, for religious groups to engage in collective music making, for colleges to promote alma mater songs, and for warriors to sing and dance prior to fighting.

MOOD REGULATION

Thayer and his colleagues have carried out a number of studies concerning how people regulate their moods. One study attempted to determine what people do to try to get out of a bad mood. Of 29 categories of activities, the foremost activity was calling or talking to a friend. The second most frequently reported activity was trying to think positive thoughts—to give oneself a sort of "pep talk." The third most frequently reported activity—ahead of a wide variety of behaviors—was listening to music. Forty-seven percent of respondents reported that they used music to temper or eliminate a bad mood.[36]

Thayer *et al.*[37] carried out a similar study to determine what people do to raise their alertness or energy level. Listening to music was reported by 41% of respondents, following activities such as sleeping, taking a shower, getting some fresh air, and drinking coffee. Finally, in a third study investigating what people do to reduce nervousness, tension, or anxiety, listening to music ranked third at 53%, following after only calling or talking to someone, and trying to calm down by thinking about a situation.

There are two points to highlight from these studies. The first is that the foremost category of behavior for mood regulation is being with or conversing with a friend. That is to say, our first tendency is to seek mood regulation through social interaction. Moods are contagious, and we rely to some extent on each other to modulate, reinforce, or temper our moods. Although we know that moods are highly influenced by the individual's physiological state—notably through food, exercise, or rest—behaviors such as eating, exercise, and rest are less frequently used for mood regulation than music.

The second point to highlight is the obvious point that music appears to figure prominently as a method for mood regulation. Although in contemporary society music tends to be experienced in a personalized or individualized listening context, we already know that this context is historically unprecedented. Most music making in hunter-gatherer societies occurs in a social or group context. Until the invention of the phonograph, the vast majority of music in Western culture was also experienced in social or group contexts. In short, music is not out of place in the list of socialized behaviors used for mood regulation.

CONCLUSION

By way of conclusion, first let me reiterate that I do not think the evidence in support of music as an evolutionary adaptation is strong. The purpose of this article has been to show that there are no obvious or fatal impediments that rule out a possible evolutionary origin.

We might summarize the basic evidence as follows:

- Complex evolutionary adaptations arise only over many millennia. Accordingly, in order for a behavior to be adaptive, it must be very old. As we have seen, music making does indeed conform to the criterion of great antiquity.
- Behavioral specializations are often expected to be associated with specific anatomical or functional brain structures. Lesions and other neurological assaults can leave an individual with impaired musical functioning. There are double-dissociations between various amusias and virtually every other kind of functional mental loss. This does not prove that music is not acquired by general learning, but the neurological evidence is at least consistent with the possibility that there are specialized music-related brain structures.
- In order for a behavior to be adaptive, the behavior itself must enhance the propagation of the individual's genes. As we have seen, musical behaviors are consistent with mood modification and group mood synchronization—and these synchronous states are at times clearly associated with situations where group efforts are adaptive—such as in the case of defense against other human groups. In addition, high musical involvement is not associated with dereliction or poor survival (such as the case for alcohol); this raises problems for the view that music is a form of nonadaptive pleasure seeking.

The evidence we have for mood regulation and synchronization is suggestive:

- We have noted contrasting disorders in Williams syndrome and Asperger-type autism. In one case, we see a group of individuals who are highly sociable and also highly musical. In the other case, we see a group of individuals who display extremely low sociability and also low musical understanding or affinity.
- Although we did not review this literature, the emergence of the secondary or socialized emotions in child development is strongly associated with musical empathy, understanding, and sophistication. The pertinent research on child development implies a social role for music.
- We noted that the most popular musical works often imply some sort of social function. "Happy Birthday" is only one example. Group identity is often expressed through, for example, folk songs, Girl Scouts' camp songs, sports, and war dances.
- Although we did not review the literature, it is also known that the emergence of musical tastes relates to postpubescent socializing and group identity.
- Finally, we discussed how music modifies hormone production in groups of people.

As noted at the beginning of this essay, there is a long history of abuse of genetic claims serving ulterior and often nefarious motives. Even if we assume that musicality has some adaptive function, the repercussions for modern music making and modern musical enjoyment are likely to be minimal. Music is now deeply embedded in a cultural/historical context where human musical memories span centuries, and the fashion cycle is a significant engine of change. Music is now part of a Lamarckian system where acquired characteristics are transmitted in Dawkinsean "meme pool" rather than in Mendelian "gene pool."[38] Like language, the details of musical culture and tastes are largely a product of enculturation.

Nevertheless, it remains worthwhile to attempt to understand where music comes from and why it has achieved such a ubiquitous presence in human lives. Evolutionary theorizing about music may well remain in the realm of *Just-So* stories. There is always the possibility, however, of a testable hypothesis emerging, and if so, we'll all wait with interest to see the results.

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