MANYWORLDS®

RESEARCH REPORT

APPLICATIONS IN SCIENCE

REPORT: MW-AS101
RE-PUB DATE: 03-28-06

Evolution of Human Musicality: The Memory Modulation Theory

Steven D. Flinn (s.flinn@manyworlds.com)
ManyWorlds, Inc. 510 Bering Drive, Suite 470 Houston, TX 77057

ABSTRACT

The evolutionary basis for the development of music in humans has been an enduring mystery. The theory presented here posits that musicality evolved in humans by conferring direct fitness benefits by enabling hominid communicators to influence the persistence of memories of information communicated to other hominids via a musical "coding" process. This ability provided increasing adaptive advantages as the plasticity of hominid behaviors increased. Seen from this general communications-theoretic perspective, musicality can actually be *defined* as just that set of acoustical-based coding protocols that hominids developed to more effectively modulate memories. This theory also has important implications beyond the specifics of hominid evolution to more generalized animal, as well as artificial, communications environments.

INTRODUCTION

The evolutionary basis for the development of advanced musical capabilities (including, more generally, prosody) in humans has remained a mystery. Whereas the other major mode of human acoustical-based communication, language, confers obvious fitness advantages, music has resisted such an easy explanation. Current explanations tend to fall into the categories of either 1) assuming music is a by-product of the evolution of other mental facilities that do directly confer fitness benefits, or 2) positing that musicality evolved as a sexual selection fitness indicator [1].

Neither of these classes of explanations, nor any of the other currently proposed explanations are particularly compelling when weighed against all available data. As an alternative, it is suggested here that advanced musical capabilities evolved in humans because they *do* directly confer specific fitness advantages. In particular, it is argued that human musical capabilities are precisely those set of specialized mental capabilities that co-evolved with language to enable the sophisticated memory modulation of the receiver of information by the communicator of a message.

In other words, music enables individuals and/or groups that are sending and receiving messages to have a degree of control over how the messages will be retained in the memory of the receiver(s). Particularly in the pre-literate human world, such abilities have obvious, direct evolutionary advantages.

Furthermore, this line of reasoning suggests that the evolutionary role of musicality serving as a memory modulating communications capability in humans can be thought of as just a specific example of a more general theory of the evolution of memory modulating communications coding processes. This general theory essentially synthesizes the specifics of hominid evolution with more generalized communications theoretic approaches. The resulting theory is potentially applicable to any environment in which relevant fundamental characteristics of evolution, intelligence and communications are present.

COMMUNICATIONS AND MEMORY MODULATION

The consolidation theory of memory proposed a century ago continues to provide the best model for understanding memory formation and persistence. The theory suggests that it takes time for long-term memories to consolidate. "Considerable evidence suggests that the slow consolidation of memories serves an adaptive function by enabling endogenous processes activated by an experience to modulate memory strength" [2]. In other words, it appears to be an optimized, adaptive trait for the processing of longer-term memory to be highly selective. This is not surprising given that the amount of raw information continuously presenting itself from the environment would overwhelm any highly indiscriminate memory formation process.

Key facilitators of memory modulation are emotional arousal, repetition, and structure[3]. And these are exactly the essential attributes of music – enabling music to be singularly well suited to serve as a vehicle for fine-tuned memory modulation. Recent research suggests that music can, in fact, modulate memory in humans[4]. In particular, music can enhance the probability of long-term memory of coincident events and communications. It appears that music facilitates longer-term memory formation primarily through the evocation of emotion, and perhaps with contributions from repetition and other additional structural elements.

Claude Shannon's seminal work on communications theory[5] generalized and refined thinking on communications in noisy environments. In particular, Shannon demonstrated how messages could be coded to achieve an arbitrarily high degree of fidelity when transmitted across a communications channel subject to noisy conditions. Shannon's original approach, while revolutionizing basic communications engineering, has some important limitations. A key assumption of the model is that the message sender and recipient are modeled as simple "black boxes" -- that is, there is no explicit representation or accounting for internal states of the sender or receiver. Another simplifying assumption is that the communications occurs between just one sender and receiver.

A more generalized application of communications theory can be achieved by explicitly modeling the situation in which the sender and receiver have internal states that correspond to multiple message memory modes. Particular memory modes can be assumed to be differentiated on the basis of the duration of the persistence of the memory, and by the associated reinforcement required to influence the formation of a memory with a given level of fidelity and persistence. In addition, the more general communications model encompasses the degree to which message fidelity is maintained in a noisy environment over a series of individual transmissions and receipts of the message.

Shannon termed the approaches to preserving the fidelity of messages over noisy communications channels "coding". What is clear is that if we apply the more general model of communications to an environment in which senders and receivers have multiple memory modes, coding can in principle be developed to modulate how messages will be stored in the receiver's memory. In other words, judicious selection of the right coding enables senders to ensure signal is encoded in the appropriate memory regime of the receiver under noisy conditions. And this coding approach can enable an arbitrarily high fidelity of the cascading of the message throughout a network of communicating nodes – that is, an environment in which the message is transmitted from a sending node to a specific receiving node, that in turn re-sends the message to another receiving node, and so on, all within a noisy environment. This more general model of effective communications is the framework that most effectively models and promotes understanding of the evolution of communications coding in animals, including humans, and can likely even be extended to the more general cases of the evolution of communities of sufficiently intelligent agents as well.

EVOLUTION OF HUMAN MUSICALITY

The evolution of humans can therefore be thought of abstractly as the evolution of increasingly intelligent agents that co-evolved enhanced communications capabilities to enable the effective communications of increasingly complex messages among senders and receivers. If the architecture of the human brain had been such that there existed only one mode of memory, then a communications capability relying simply on syntactical structures would have been sufficient. However, the degree of persistence of memories in the human brain (as well, of course, as the brains of other animals) can, as a first approximation, be divided into two basic categories: short-term and long-term memory. And again, this seemingly universal organization of memory modes appears to be an adaptation to amplify signal, in the broadest sense of the word, in a very noisy world.

Syntactical structures alone do not seem generally to enable the sender of a message to influence in a fine-grained manner the strength of memory of the receiver, except perhaps to a degree through the techniques of redundancy and metaphor. However, clearly the ability to directly influence the strength of a receiver's memory of a message would have been of exceedingly high value as the intelligence of the senders and receivers, and the sophistication of associated messages, increased. Indeed, the encoding of a message in long-term memory significantly increases the probability that the message will be re-transmitted with high fidelity by the original receiver to others. This cascading of the original message vastly amplifies the evolutionary value of preferential memory selection by the message sender.

It is therefore argued that music is just the (expected) mode of communication that co-evolved with language and overall intelligence that enabled finer and finer control of the memory modulation of receivers by message sender(s). Music has all the right characteristics to fit this critical and expected role, and no other known communications mode fills such a role as effectively. Nor is there any other explanation for the evolution of human musicality that so well fits the relevant facts as they are currently understood.

In today's world of human communications, which is dominated by writing and other durable communications coding approaches, we often take for granted the ability to store important information over time, and from generation to generation. There can certainly no doubt, however, that these modern forms of information storage provide powerful adaptive benefits, as demonstrated by their rapid spread and growth. Throughout most of hominid evolution, however, the hominid brain itself was the only viable longer-term information storage vehicle available, and sophisticated transmission of information was apparently predominantly oral. In this world, for example, the ability for an individual or group to "remember" the precise route to a far away food source that was discovered long ago, or to accurately recall any of a myriad of other beneficial behavioral rules, could have meant the difference between life or premature death. And the benefit of the value of the memory could well be amplified even more if it spanned multiple generations.

So, in a sense, it is submitted that musicality filled in the pre-literate world the role that writing would later fill in an even more effective way. For example, we see the power of musically modulated memories clearly in the way that ancient narratives were passed from generation to generation with high fidelity. These narratives were sung. In fact, if Homer's works had not been sung, but had been just prose, we likely would have lost the Iliad and Odyssey to the mists of time.

Even in today's world, we see what seem to be vestigial examples of musical-based memory modulation. For example, children typically learn their "ABC's" by singing their way through the alphabet. And advertisers (annoyingly!) effectively ensure their messages are preserved in the long-term memory of recipients by encoding their message in a "wrapper" of musicality and verse.

The extreme durability of the memories of musically modulated messages can be readily observed in patients suffering from diseases such as Alzheimer's in which memory is progressively lost. Typically the last memories to be lost are childhood songs and rhymes. That the most persistent memories would be modulated by musicality early in life are consistent with the predictions of the general theory of memory modulation outlined below.

GENERAL CASE AND HYPOTHESES

The evolution of music in humans can be viewed as just a special case of the evolution of memory modulation communications modes. It follows from this that the theory should provide a number of testable predictions that extend beyond the realm of human evolution. For example, in extending the theory to a general animal model, we would predict some of the following points.

First, it should be expected that memory modulating communications modes would be most important for species whose behavior is not predominantly instinctual. In other words, unless there is sufficient plasticity of behavior, memory modulation would be ineffective in providing adaptive advantages. For example, this seems to rule out application of the theory posited here to the musicality of songbirds. In their case, the instinctual-driven behavior and the typical sexual asymmetry of musical capabilities would tend to support a sexual selection explanation of the musical capabilities.

Second, it should be expected that, for species with sufficient behavioral plasticity, such communications modes would be most likely to be found in long-lived species, as persistent memories over a longer life span would have more time to confer adaptive advantages.

Third, the capability for the modulation of memory in message receivers should be particularly acute in the young of a species, as the younger individuals would have the most time to benefit from advantageous long-term memories.

These predictions remain to be rigorously tested. However, it is intriguing that possible memory modulating communications modes may have been developed independently in several mammalian species that fit the general criteria -- for example, humans, whales and perhaps elephants[6].

It should be emphasized that in the general theory, musicality is only one possible communications coding approach to memory modulation. There may well be other modes (e.g., rhythmic movements and patterns, etc.), and these modes may be complementary with acoustical modes.

More broadly, the theory can be applied to any environment in which evolving intelligent agents with multiple memory modes have an opportunity to influence overall fitness through the means of communications. Simulations of such general environments should provide another avenue of testing of the generality of the theory.

RELATION TO OTHER THEORIES

With regard to other proposed explanations of the evolution of musicality in humans, the theory proposed here does not necessarily invalidate all of them. For example, there may indeed be elements of sexual selection at work

with regard to human musicality -- the proposed theory would simply view that as a specific adaptation of the more general memory modulation mechanism. Similarly, theories that propose that musicality provides fitness advantages that accrue from social cohesiveness[1] may well have merit -- however, it is argued here that the benefits of social cohesiveness are, again, just one manifestation of the more general role of music as a memory modulation communications code. And it should be pointed out that the memory modulation theory of music does not need to resort to group-based fitness arguments -- its adaptive benefits are abundantly clear at the level of individual fitness.

The proposed theory, does, of course, stand opposed to theories that posit that human musicality is just a by-product of the evolution of other mental capabilities that did confer direct adaptive advantages. Such by-product theories are, as a practical matter, simply those default evolutionary explanations that are employed in the absence of compelling, direct explanations of the fitness advantages of advanced musical capabilities exhibited by humans. However, with the theory proposed here there *is* a strong explanation of the direct fitness advantages of musicality. In addition, recent studies have strongly indicated that the musicality in humans is quite neurologically modularized[7,8], which is much less supportive of a by-product theory, and more supportive of music having direct adaptive benefits.

REFERENCES

1. McGaugh, J. L. (2000). Memory -- a Century of Consolidation. *Science, 287,* 248-251.

2. Peretz, I. (2001). Brain Specialization for Music: New Evidence from Congenital Amusia. *Annals of the New York Academy of Sciences, 930*, 153-165.

3. Tramo, M (2001) Music of the Hemispheres. *Science, 291,* 54-56

4. Cahill, L. & McGaugh, J. L. (1998). Mechanisms of Emotional Arousal and Lasting Declarative Memory. *TINS, 21,* 7, 294-299.

5. Gray, P et al. (2001). The Music of Nature and the Nature of Music. *Science, 291,* 52-54.

6. Schulkind, M. D., Hennis, L. K., & Rubin, D. C. (1999). Music, Emotion, and Autobiographical Memory: They're Playing Your Song. *Memory and Cognition, 27,* 6, 948-955.

7. Shannon, C. E. & Weaver, W. (1949). *The Mathematical Theory of Communication*. Chicago, IL: University of Illinois Press.

8. Wallin, N., Merker, B., & Brown, S. (Eds.) (2000). *The Origins of Music*. Cambridge, MA: MIT.

Reprinted courtesy ManyWorlds Inc.

For further information, contact the Publisher
ManyWorlds Publishing - Science
510 Bering Drive, Suite 470
Houston TX 77057

ISBN: 1-4243-0208-0
from January 2007: **978-1-4243-0208-6**