

Chapter 22 in "The Origins of Music"

edited by N Wallin, B. Merkur, and S. Brown.

pp. 411-424. Cambridge MA: MIT Press, 2000
Proceedings of a Conference in Florence, Italy, 31 May 1997

A neurobiological role of music in social bonding

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20 May 1998

Key Words: aesthetics, altered states, dance, music, neurodynamics, neurohormones, socialization, solipsism, trance induction

Abstract

Music is regarded in biological terms as originating in the brain, so that most explanations concentrate on the ways in which brains process information. Recent studies of the nonlinear dynamics of the primary sensory cortices have shown that the patterns that are constructed by chaotic nonlinear dynamics in cortical neuropil replace stimulus driven activity. This finding supports the concept that knowledge in brains is entirely constructed within them without direct transfer of information from outside. As knowledge increases by learning, brains of individuals grow progressively apart. The separation results from the uniqueness of the knowledge that is constructed within each brain. The resulting condition of isolation is known among philosophers as epistemological solipsism. This view is reinforced by the tenets of aesthetics, which emphasize the deeply personal experiences of individuals, not as active listeners but as passive recipients of beauty in music and other arts. Neither conventional neuroscience nor aesthetics can explain the deep emotional power of music to move humans to action.

An alternative view is presented, in which human brains are seen to have evolved primarily in response to environmental pressures to bridge the solipsistic gulf between individuals, and to form integrated societies. An evolutionary origin is found in the neurohumoral mechanisms of parental bonding to altricial infants. A case is made that music together with dance have co-evolved biologically and culturally to serve as a technology of social bonding. Findings of anthropologists and psychiatrists are reviewed to show how the rhythmic behavioral activities that are induced by drum beats and music can lead to altered states of consciousness, through which mutual trust among members of societies is engendered.

"All arts, we must remember, are phases of the social mind. We are so much in the habit of thinking of them in terms of art products that we forget that the arts themselves are groups of ideas and acquisitions of skill that exist only in the minds, muscles, and nerves of living men." Giddings (1932):

Introduction

In seeing or writing the phrase "the biology of music", one is struck by the seeming intractability of the problem of understanding emotions in the contrasting contexts of aesthetics and neuroscience. On the one hand, the scientific study of brains must emphasize the features that are regular, reproducible, and common to all participants in making and listening to music. The description is commonly made in terms of information processing by the sensory pathways up to the auditory cortex, with only cursory reference to the meaning and emotion attached to perceptions of music. The emergence of skills in performing and listening to music are described and explained in terms of Darwinian determinism: how and in response to what environmental circumstances have these capabilities evolved? On the other hand, the appreciation of music is a deeply personal activity accompanied by individual feelings that are notoriously difficult to express in words or in nonverbal ways. The creativity that is required for active listening as well as singing or using an instrument to play for one's self and others seems antithetical to scientific determinism. The difficulty of devising a biological connection is compounded by the fact that no other species of animals displays either the capacity for shared rhythms, or the semantics of music, as it appears in humans. Birds, whales and cicadas "sing" and "signal", but they do not manifest the richness of compassion and understanding that we experience in speaking and singing with one another. Humans in all societies have these capabilities in varying individual degree, but we cannot make a tree of evolution to describe their origin from neurohumoral mechanisms of mammalian behavioral controls.

The aim of this essay is to go past the cognitive and aesthetic aspects of music to seek an understanding of the biology of music. The neural mechanisms of sensory and motor processing are necessary for complex patterns to be produced and apprehended. The contribution of aesthetics is required to enlarge the scope of inquiry to include emotional textures. But the role of music as an instrument of communication beyond words strikes to the heart of the ways in which we humans come to trust one another. Trust is the basis of all human social endeavors, and a case is made that it is created through the practice of music. How and why in biological terms can music and dance serve to bring humans together with a depth of bonding that cannot be achieved with words alone?

The biological dynamics of perception

The mechanisms of the ear that transform sounds to neural messages and the pathways that carry the messages to the auditory cortex are well understood (Clynes 1982; Pribram 1982; Wallin 1991). The inner ear has been likened to a harp, the strings of which resonate to a range of frequencies and excite sensory neurons selectively in accordance with their tuning. The process expresses complex sounds as spatiotemporal patterns of neural activity that are shaped by filters, when they pass through relays to the primary auditory cortex. What happens thereafter is a matter for conjecture, as the information is processed through neighboring cortical areas concerned with speech and song. This is revealed by older observations on the deficits produced by brain trauma, and by newer techniques of brain imaging to study patterns of augmented cortical blood flow during speaking, listening and singing. It is thought that the exchanges between association cortices in the newer brain and the older parts of the forebrain, which comprise the deep-lying limbic lobe, generate memories evoked by listening to music, and arouse the emotional states that have become associated with now familiar songs through previous experiences.

Music involves not just the auditory system but the somatosensory and motor systems as well, reflecting strong associations between music and dance, the rhythmic tapping,

stepping, clapping and chanting that accompany and indeed produce music. It is inevitable that musical experience involves the motor cortex, basal ganglia and cerebellum in the production of song and dance, based in the genesis and maintenance of rhythmic spatiotemporal patterns of neural activity in widely distributed areas of the brain. How these patterns arise and where the pacemakers may be located is unknown. At best the neurophysiological information can explain some of the physical constraints on the production and apprehension of music, such as the range of auditory frequencies found in instruments and in the human voice, the rates at which repetitive movements can be made and sustained in playing and dancing, and their limitations owing to the inertia of the parts of the body.

My own view of the functions of the auditory and somatosensory pathways has been shaped by my experimental observations of their electrical activity patterns during learned behavior elicited by simple conditioned stimuli. These patterns do not have the periodic oscillations that are characteristic of music and dance. They are remarkably aperiodic waves that reflect the shared oscillations of millions of neurons in cortical areas that are about the size of one's fingernail. The oscillations form patterns that last only a tenth of a second, but they form and collapse at unpredictable time intervals several times each second. The content related to the auditory, somatic, visual or olfactory stimuli is found in the spatial pattern of amplitude modulation (AM) of the common chaotic wave form, that serves as a carrier (Freeman and Barrie, 1994; Barrie, Freeman and Lenhart, 1996). An analogy is the sequence of spatial patterns in the frames of a black and white movie, in which the carrier is white light. The AM patterns are elicited by stimuli in each of the primary sensory cortices, and they all converge and are combined in the limbic system, deep within the forebrain (Freeman, 1998). The particulars of the patterns that relate to the structures of the eye, ear, nose and skin are deleted in the formation of multisensory percepts known as Gestalts. These integrated patterns are the basis for awareness of musical sounds, and the somatosensory (both exteroceptive and proprioceptive) and visual contexts in which they are perceived.

In tracing the path in brains of rabbits taken by neural activity that accompanied and followed the transformation of an odor stimulus by the sensory receptors and its transmission into the cerebral cortex, I found that the stimulus-dependent activity vanished. What appeared in place of the stimulus-evoked activity was a new pattern of cortical activity that was created by the rabbit brain. My students and I first noticed this anomaly in the olfactory system (Freeman and Schneider 1982), and in looking elsewhere we found it in the visual, auditory, and somatic cortices, too (Freeman and Barrie 1994; Barrie, Freeman and Lenhart 1996). In all the systems the traces of stimuli were replaced by novel patterns of neural activity, which were created by the chaotic dynamics of the cortices. These individualized patterns lacked invariance with respect to the stimuli that triggered them (Freeman 1992). They were not eidetic or derived images. Instead, they reflected the experiences, contexts and significances of stimuli, in a word, the *meanings* of the stimuli for the individuals. Our evidence from the other sensory cortices indicated that this principle holds for all senses in all animals, including humans. The conclusion is that the only knowledge that animals and humans can have of the world outside themselves is what which they have constructed within their own brains.

This finding could not have been obtained by introspection, because the process of observation contains within it some well-known operations that compensate for accidental changes in appearances of objects owing to variations in perspective, context, and so forth (Smythies 1994). We are drenched in perceptual constancies, as a necessary condition for daily living. No one can tell from one's own experience or from the constant response R of someone else to a repeated stimulus S that an apparently invariant S-R relation is mediated by inconstant patterns of brain activity. I explain the lack of invariance as owing

to the unity of individual experience (Freeman, 1995), because every perception is influenced by all past experience. Each exposure to a stimulus changes the brain's synaptic structure, so that it cannot respond identically over time, though it may appear subjectively to be so. As Heraclitus remarked, one cannot step twice in the same river.

The biological isolation of brains from each other

These findings can be summarized by saying that a form of *solipsism* isolates each brain from all others. The word as it is commonly used is applied to an individual who is so self-centered that he or she believes that all others are mere projections of their own imaginations. That is *metaphysical solipsism*, by which everything that exists is the projection of a brain. That would lead to the absurd conclusion that all of us are the fantasy of a dreaming rabbit. I am proposing a less common use of the word to mean *epistemological solipsism*, which holds that all knowledge is created within the brains of individuals. Each mind constructs its world view, under the realization that other minds must exist. Knowledge is not "instilled" by indoctrination, as held by programmers who feed information into their computers. It is encouraged to grow by exhortation and example, as held by educators and insightful parents.

Solipsistic views have been held in some degree by many philosophers since Descartes, but they pose difficulties. It is impossible for minds by logic alone to disprove metaphysical solipsism, so how can a mind really be sure that any other mind exists, or, for that matter, the world? How can knowledge be based on the experience of each individual separately, through the sensory systems that form the windows of minds onto the world? How can knowledge of natural laws and mathematics emerge? If knowledge is expressed in a private language within each mind, how can it be shared and verified as being the same in different minds?

These formidable difficulties are not found in the views that knowledge is universal and is there to be taken in like water, or that it is built into minds as categorical structures in order for minds to exist at all. The neural mechanisms by which solipsistic knowledge can be created, made public, and then validated between individuals become clear only in the context of intentional action. Repeated attempts to answer these questions by logic and computation have not succeeded. Hence, the biological data that have emerged from animal brain studies, and that support the solipsistic view, offer new and interesting questions. Why do brains work this way, seeming to throw away the great bulk of their sensory input? What part do they keep? Where and how do they keep it? How do they express what they know in themselves? How do they acquire it? How do they mobilize the past to embed it in the future? Above all, how do they communicate with other brains? This problem is not translating or mapping knowledge from one brain onto another. It is the prior establishment of mutual understanding and trust through shared actions, during which brains create the channels, codes, agreements and protocols that precede that reciprocal mappings of information in dialogues. It takes more than a phone line and a dictionary to make a call to a foreign country.

Therefore, to say that a brain is *solipsistic* is to say that it grows like a neuron within itself, and that it has a boundary around itself in much the way that a neuron has a bounding membrane entirely around itself, preserving its unity and integrity. The barrier is not merely the skin and bone around each brain. It is the private language in each brain, in some respects like the labeling of the self by the immune system. Yet brains arise and are shaped in evolution, not as isolated entities, but as units in societies ranging upwards from pairs to empires. Rainer Maria Rilke described the way in which individuals resonate together in his poem "Liebeslied" (Love Song), first published in *Neue Gedichte* (1907):

Doch alles, was uns anrührt, dich und mich,
 nimmt uns zusammen wie ein Bogenstrich,
 der aus zwei Saiten eine Stimme zieht.
 Auf welches Instrument sind wir gespannt?
 Und welcher Geiger hat uns in der Hand?
 O süßes Lied. [pp. 239-240]

Yet all that touches us, you and me,
 takes us together like a violin bow,
 that draws one voice from two strings.
 On what instrument are we strung?
 And which violinist has us in hand?
 O sweet song. [My translation]

For biologists, the instrument is brain chemistry, and the player is evolution. The growth from within each individual is necessary in order that each brain cope with the infinite complexity of the world, but cooperation with other brains is also a social imperative, because the gulf must be bridged. Rilke saw the isolation as having beneficial aspects by providing ultimate privacy for everyone.

Aesthetics supports the solipsistic view

Something of the solipsistic aspect of music appreciation is conveyed in the term "Aesthetics", which is commonly considered to be a branch of philosophy that analyzes beauty in the fine arts, as distinct from that which is pleasant, moral, or useful. The essential character of beauty and the tests by which it may be recognized are deeply individual. The ability to appreciate it is attributed to those individuals who have engaged in years of study of the arts, so as to refine their capacities for appreciation and judgement. In this view, the psychology of the sensations and emotions, that have the fine arts for their stimulus, are based the impact of a stimulus coming from a work of art or a piece of music, to which the observer or listener responds in an educated but still passive manner, as by sitting in a concert hall and letting the sound waves pour through.

The word aesthetic, from the Greek *aisqetikos* and the Latin form *aesthetica*, was first used about 1750 by Alexander Gottlieb Baumgarten (1961) to designate a cognitive science of sensuous knowledge, whose goal is beauty, in contrast to logic, whose goal is truth. Kant used transcendental aesthetic to denote the a priori principles of sensory experience, couched in the categories of time and space. Hegel (1830) broke from a cognitive, rational science to a phenomenology of the fine arts appealing to the senses, which he called *Aesthetik*. This was so in accord with 19th Century Romanticism, that since then the word is widely used in his sense.

The social dimension of aesthetics is largely reduced to the relations between artists and critics. According to Giddings (1932): "All arts, we must remember, are phases of the social mind. We are so much in the habit of thinking of them in terms of art products that we forget that the arts themselves are groups of ideas and acquisitions of skill that exist only in the minds, muscles, and nerves of living men." Whereas art and aesthetics are both creative processes, they differ in their directions of change in complexity. The artist begins with a high degree of complexity steeped in chaos, but is constrained by the physical medium in which the work is done and by the discipline of the Academy. The critic begins in a rigid academic milieu and has his or her mind opened by a work of art into a higher degree of complexity, over the edge of order into chaos, which is not otherwise accessible. Artist and critic interact reciprocally to construct the dynamics through which art and aesthetics come into being. For both workers the experience of beauty is achieved

through a sense of closure within their fields of intentionality, which are developed, maintained, and evolved by the neurodynamics within their brains.

These fields of intentional neural activity reveal the neurodynamic operations that construct the psychological space-time arena in which logic is performed. They may provide the raw materials from which a new biological science of beauty in music might be constructed, which might explain the forms of brain activity that underlie our attainment of harmony, balance, congruity, proportion, and symmetry, and the neural operations that support critical judgement, taste, discernment, and critical responsiveness. However, these aspects contribute little to understanding raw emotions induced by music in circumstances where beauty is not at issue, but power is.

Selected neuropeptides dissolve the solipsistic barrier

Even though the neural mechanisms are unclear, there is no doubt that music has the power to induce and modulate different emotional states, and that these states are accompanied by the release of neurohormones in the affected brains. Under the neurochemical theory of emotion founded by Walter Cannon (1939) each state of emotion is mediated by a neurohormone acting on the hypothalamus as well as other parts of the brain. It supplanted the James-Lange theory of emotion, according to which the emotional states are felt and identified by the sensory systems, including those of the viscera. Neither of these is wrong, nor entirely satisfactory, and in interesting respects they were both anticipated in practice by the ancient Greeks, who formulated three main classes of music relating to emotional states. Phrygian music was martial, and it served with trumpets to incite action in battle. The emotions of fear and rage are associated with the intracerebral release of norepinephrine. Similar forms of aggressive or terrified behavior in modern times are induced by cocaine and amphetamine, which mimic some of the central effects of norepinephrine. Lydian music was solemn, slow, plaintive, and religious, with reliance on flutes instead of trumpets. The contemplative and relaxed moods induced by this Muzak-like music are those associated with the release of serotonin in the brain. Similar effects were induced by ingestion of mushroom hallucinogens, which preceded LSD, and are now gained by use of Prozac, which blocks endogenous serotonin re-uptake and prolongs its action. Ionian music was convivial, joyful, and according to Plato "effeminate", relying heavily on drums to induce dancing. Pleasurable states are now associated with the intracranial release of dopamine and the endorphins. Then as now they were induced by alcohol and tetrahydrocannabinol, which serve as adjuvants to facilitate the passive onset of such states at modern rock concerts and rave dances.

These partial explanations still fall short of explaining the deep roots of the appeal of music in human affairs, particularly in respect to the call for communal action and understanding. The use of language is an evolutionary triumph that has made civilization possible, but its use for communication by representations, both oral and written, requires the prior preparation and shaping of brains to create trust. Trust is an implicit expectation and faith in the predictability of the behavior of those to whom one has committed one's self by a transformation of the self. It transcends the solipsistic barrier.

Such a commitment is seen at the most primitive level in mammals in the transformation that takes place in a mother at the time of giving birth and committing herself to the care of her newborn infant. In many species, including humans, the transformation occurs in the father as well, by which a child's behavior is transformed into that of a parent. Recent studies in brain function during copulation to orgasm in both males and females and in females during lactation have shown that the neuropeptide, oxytocin, is released into the basal forebrain (Pedersen et al. 1992). It appears to act by dissolving pre-existing learning by loosening the synaptic connections in which prior knowledge is held. This opens an

opportunity for learning new knowledge. The melt-down does not instill the knowledge. It clears the path for the acquisition of new understanding through behavioral actions that are shared with others, including cooperative caring for the infant and the other parent.

A well documented example of this process of transformation in adults comes from the biology of brain washing. Well known techniques of sensory isolation, overload, stress, and chemical manipulation can lead to a crisis in brain function called by Pavlov 'transmarginal inhibition', that is followed by a remarkable state of malleability and an opportunity for re-education. This condition has also been characterized as an "altered state" and as a trance. The transformation goes beyond acceptance of what cannot be changed, and it is not a loss of recollection of the past. It constitutes a wholesale change in beliefs and attitudes by which a new person emerges with new social commitments. Sargant (1957) documented the striking similarities between these techniques and those used to arouse the fervor of dancers in preliterate tribes and the parishioners of evangelistic churches in congregations from the 17th century to the present, in which the avowed goal was religious conversion to save souls. The features characterizing the process were the presence of strong emotional arousal, such as by fear of devils or of pain, severe physical exercise, such as by prolonged dancing, sensory overload as by continual loud singing, chanting, and stomping in time to loud drums and horns, and lack of sleep by all-night revelry.

Music and dance as the biotechnology of group formation

Anthropologists and ethnopsychiatrists have documented the prevalence in preliterate tribes of singing and dancing to the point of physical and psychological collapse during religious and social ceremonies. Typically the members of a community gather at a central place surrounded by the musicians and their instruments, the priests and shamans as masters of ceremony (Price 1982), a central altar, and icons that symbolize the tribal totems and deities. Rhythmic drumming, chanting, clapping, marching in step, and pirouetting around bonfires last for hours, through the night into the dawn, as one by one the participants drop from exhaustion. They are then succored by other, older members of the tribe, then brought into rituals to symbolize the admission to new, adult status. This is the moment of change. Emile Durckheim (1915) described the socializing process as the use of "...totemic emblems by clans to express and communicate collective representations", which begins where the individual feels he *is* the totem and evolves to beliefs that he will become the totem or that his ancestors are in the totem. The religious rites and ceremonies lead to "collective mental states of extreme emotional intensity, in which representation is still undifferentiated from the movements and actions which make the communion towards which it tends a reality to the group. Their participation in it is *so effectively lived* that it is not yet properly imagined." [Durckheim, pp. 465-472]

Verger (1954) recorded in photographs the ceremony of ritual death and rebirth, in which participants who have collapsed into the deep unawareness of transmarginal inhibition are sewn into shrouds, are carried by tribesmen to the local cemetery, and are returned thereafter to the tribeswomen for re-birth by unsewing, revival and succor as new persons. The choice of fertility symbols and the behaviors of the participants indicate the powerful basis in sexuality of the ceremonies, commonly becoming orgiastic.

There is no reason to doubt that these activities give great pleasure and catharsis to those caught up in the communal spirit of the events, and that immersion in the dance is followed by a refreshed sense of belonging to the tribe. What is at issue is the extent to which feelings of bonding and the formation of a neural basis for social cooperation might be engendered by the same neurochemical mechanisms that evolved to support sexual reproduction in altricial species like ourselves, and that might mediate religious, political,

and social conversions, involving commitment of the self to a person as in transference, fraternity, military group, sports team, corporation, nation, or new deity. The common feature is the formation of allegiance and trust.

Music as sound appeals to the ear, but the making and appreciation of music involve the entire body through the somatosensory and motor systems of the performer and the active audience (Clynes 1982). Dance on a stage appeals to the eye, but its real charm is found by the participants who shape their movements into a living and evolving unity. The strongest basis for the cooperation lies in rhythmically repeated motions, because they are predictable by others, and others can thereby anticipate and move in accord with their expectations. Music gives the background beat.

Biocultural evolution of music in socialization

Here in its purest form is a human technology for crossing the solipsistic gulf. It is wordless, illogical, deeply emotional, and selfless in its actualization of transient and then lasting harmony between individuals (Wilson 1992), and perhaps even among higher apes despite their lack of a sense of rhythm (Williams, 1967). It constructs the sense of trust and predictability in each member of the community on which social interactions are based. The dance alone does not suffice, but it is exemplary of the nature of wordless give-and-take cooperation by which are constructed the channels for verbal communication. A significant discovery by our remote ancestors may have been the use of music and dance for bonding in groups larger than nuclear families. According to Roederer (1984), who also proposed the utility of music for training in language skills, for understanding the musical aspects of speech, and for signalling emotional states: "... 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 would 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" [p. 356]. That accomplishment may have accompanied or even preceded the invention of fire, tools and shelter, because the maintenance, development, and transmission across generations of information about the techniques for working matter into useful forms must have required the prior existence of channels to support the social interactions. These channels form through emotional attachments, not logical debate.

The formation of a social group, such as a tribe, has its dark sides, one of which is the formation of a boundary, with the exclusion of nonself from the self that constitutes the unity. Those individuals who do not "belong" become enemies, who are to be walled off, expelled, and possibly destroyed, if they are perceived as menacing the welfare of the group. The process is similar to sexual jealousy, which manifests the exclusionary nature of the pair bond. Internecine tribal warfare that is fueled by the unknown chemistry of hatred is just as illogical and selfless as the bonding within a community. Outsiders are seen as objects or animals that are treated as tools or slaves. Biologists refer to the phenomenon in terms of *nearest neighbor competitive inhibition*, *winner-take-all* networks, and *survival of the fittest*. It may well be that wholesale extermination was the necessary price for the exceedingly rapid pace of human evolution over the past half million years. Fortunately our more recent ancestors discovered civilized alternatives to death-dealing, unrestricted warfare. Music and dance have close relatives in team sports, which are forms of ritualized combat, actions and reactions that are carefully choreographed toward symbolic goals, and which instill powerful feelings of identity not only in the players as "team spirit" but in the spectators who root for the teams.

Another dark side is the use of drugs (Fort 1969) such as wine, opium, and hallucinogenic mushrooms to induce the pleasurable subjective correlates of neurochemical bonding. Repeated dissolutive trances can result in derelicts like hermits, alcoholics, addicts, dropouts, zombies, and other marginalia of society. The prehistorical records compiled by Frazer (1890) in "The Golden Bough" and Graves (1948) in "The White Goddess" show how the religious rites of the ancient world were imbued with neuroactive substances, which may have facilitated destructive practices such as self-castration and suicide, particularly *quintessence* that was embodied in alcohol. (The four essences of which the earth was made were air, earth, water, and fire. The heavens were made of ether, the fifth essence. Agents that altered the states of consciousness were interpreted as touching the participants with the spiritual liquor.) The persistence of savage and asocial behavior, appears to have led to the development of larger social structures, governments, academies and universities, by means of which to channel and control the destructive side effects of orgiastic bonding. Shamans, priests and church bureaucracies regulated the time, place and manner of ceremonies with respect to stars and seasons. Chiefs, kings and armies imposed constraints on tribes for the sake of peace and the general welfare.

With emergence of city states run by bureaucrats and academic intelligentsia, the Greeks (James 1993) relegated the Dionysian orgies to the lower classes. Plato banned all music except the Lydian from his Academy in recognition of its power to degrade rational minds and subvert social order. The Catholic Church in the Middle Ages labeled the Dionysian rituals as "pagan" and suppressed them to maintain political control, opening the way for Apollonian music (Nietzsche 1872), such as Gregorian chants. Close harmony provided for bonding of a different kind among intellectuals, stripped of its sexual overtones. Syncopation was forbidden. The "Devil's Interval" was allegedly called that because God and the world could not exist between the beats. Physicians also used the medical term *syncope* to signify cessation of function in a transient loss of consciousness. The dialectic between Apollo and Dionysus re-emerged in the Baroque, and it continues to infuse fresh energy into music through syncopation and atonality in jazz, blues, and rock-and-roll, which through radio and MTV are bonding young people in nations everywhere. They stand opposed to older generations; intentional bonding is always exclusionary.

Conclusion

I conclude that music and dance originated through biological evolution of brain chemistry, which interacted with the cultural evolution of behavior. This led to the development of the chemical and behavioral technology for inducing altered states of consciousness. The role of trance states was particularly important for breaking down pre-existing habits and beliefs. That melt-down appears to be necessary for personality changes leading to formation of social groups by cooperative action leading to trust. The bonding is not simply a release of a neurochemical in an altered state. It is the social action of dancing and singing together, which induces new forms of behavior, owing to the malleability that can come through the altered state. It is reasonable to suppose that musical skills played a major role early in the evolution of human intellect, because they made possible the formation of human societies as a prerequisite for the transmission of acquired knowledge across generations.

Acknowledgement

Parts of this essay were adapted from my 1995 book "Societies of Brains" with permission of the publisher. The research support of the National Institute of Mental health is gratefully acknowledged.

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