CON MOLTO SENTIMENTO:

On the evolutionary neuropsychology of music.

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Music is an art without an apparent object - there are no scenes to look at, no sculptured marbles to touch, no stories to follow - and yet it can cause some of the most passionate and intense feelings possible. How does this happen - how can sounds from resonant bodies produce emotion (1) in man?

> Music is experienced as if it had the power to reach man's emotions directly...Music communicates emotions, which one grasps, but does not actually feel; what one feels is a suggestion, a kind of distant, dissociated, depersonalized emotion -- until and unless it unites with one's own sense of life. But since the music's emotional content is not communicated conceptually or evoked existentially, one does feel it in some peculiar, subterranean way...How can sounds reach man's emotions directly, in a manner that seems to by-pass his intellect? What does a certain combination of sounds do to man's consciousness to make him identify it as gay or sad?...The nature of musical perception has not been discovered because the key to the secret of music is physiological -- it lies in the nature of the process by which man perceives sounds --and the answer would require the joint effort of a physiologist, a psychologist and a philosopher (an esthetician). (Rand 1971, 52-56)

Further, what is the possible biological function and evolutionary origin of this process by which sound elicits feeling? As Ray Jackendorff says "there is no obvious ecological pressure for the species to have a musical faculty, as there is for vision and language" (1987, 211). In other words, there is no immediate and obvious biological function for music, as there is for vision or language. One researcher in the psychology of music aptly summarized the problem as follows:

> Musical messages seem to convey no biologically relevant information, as do speech, animal utterances and environmental sounds - yet people from all cultures do react to musical messages. What in human evolution could have led to this? Is there, or has there been, a survival value for the human race in music? (Roederer 1984, 351).

One might object to this characterization with the question "But you are comparing apples and oranges when you compare music to vision and language. Instead, you should be comparing hearing to vision, and music to painting; you should be asking: What is the biological function of art?"

I first wondered about the biological function and evolutionary origin of music over twenty years ago, while I was reading Ayn Rand's article on esthetics, "Art and Cognition." In that article, Rand gives an answer to the question "What is the biological function of art?" in general, but is only able to suggest an hypothesis about music's biological function. The problem lies, as I mentioned at the start of this article, with the fact that music does not, apparently, involve the perception of entities. In the following, I shall attempt a fuller answer and thereby shed some light on the question of how sounds from resonant bodies produce emotions in man. My attempt is made possible by recent scientific research into the nature of the brain.

Unlike many twentieth century theorists, Rand's esthetics is integrated with her complex and persuasive philosophy of reason, reality and man's nature and I think her esthetics deserves special attention as part of my examination of the nature of music. I will examine some of the historical theories of musical meaning, then the more recent scientific investigations into the nature of music, including some of the current theories of music's biological function. I shall review some theories of the nature of emotion and the relation of music to emotion. I shall then offer my theory of the biological origin of music. Subsequently, I shall consider Rand's hypothesis about the nature of music, in light of the research evidence. Lastly, I shall suggest some possible research which might confirm or disconfirm my theory.

I have gathered evidence from several areas of the research literature in search of an answer to the question of music's evolutionary origin and biological function. I believe this evidence indicates that music evolved out of the sonority and prosody (2) of vocal communication and that musical elaboration of those elements has a special biological communication function. Prosody evidently facilitates linguistic syntax - that is, the sound of language helps us understand the meaning of what's said (Shapiro and Nagel 1995).
Furthermore, some aspects of one's pitch (3) perceptions in

music are evidently influenced by one's native language and dialect (Deutsch 1992).

More neuropsychological knowledge is needed to prove my thesis - but I leave the reader to turning over the evidence I have assembled, along with his own knowledge of music, in considering the question: Why does man make music?

Brief History on the Theories of Music's Nature

From the ancient world to the nineteenth century, men theorized about music based on their experience of it, and only a little scientific knowledge about the physics of music which was first examined by the Pythagoreans. Two key ideas have been repeated down through the ages:

1. Music is a form of communication, a kind of language; in particular, the language of feeling.
2. Music can form or inform one's feeling or disposition.

The Ancient Greek "idea of music as essentially one with the spoken word has reappeared in diverse forms throughout the history of music" (Grout 1973,7). The Greeks "were familiar with the idea that music can alter the disposition of those who hear it. They acknowledge its power to soothe, to console, to distract, to cheer, to excite, to inflame, to madden" (West 1992, 31). Aristotle believed that "music has a power of forming the character, and should therefore be introduced into the education of the young" (Politics 1340b, 10-15). In one way or another, music touched everyone in Greek civilization (West 1992).

The Greeks seemed to implicitly acknowledge music's connection to language in their refusal to create or accept purely instrumental music. The early Middle-Age Europeans did likewise, but eventually divorced music from voice, so that by Hegel's time, instrumental, wordless music was considered a superior form (Bowie 1990, 183)

A connection of music to language was mentioned frequently in late nineteenth century examinations of music's meaning. There are many, including Schopenhauer, Hegel, and Tolstoy, who subscribed to the idea that music is "another language," the language of feeling.

> Hegel relates music to "primitive" expressions, such as bird-song or wordless cries. Schleiermacher suggests the ambiguous status of music in relation to natural sound and to speech: "For neither the expression of a momentary sensation by a...speechless natural sound, nor speaking which approaches song are music, but only the

transition to it" (Bowie 1990, 183).

Langer (1957) points out that music fails to qualify as a language because it does not have fixed denotation. And Nietzsche, in an 1871 fragment, took issue with the view that music represents feeling:

> What we call *feelings* are...already penetrated and saturated with conscious and unconscious representations and thus not directly the object of music, let alone able to produce music out of themselves (1980, 364, quoted in Bowie 1990, 230-31).
>
> Feelings, Nietzsche claims, are actually only symbols of *music*, which has a prior ontological status. This opposes the commonplace in some Romantic thinking that music is the language, in the sense of the "representation", the substitute, for feeling...Nietzsche's view makes some sense if one ponders the fact that music can lead to the genesis of feelings which one had never had before hearing the music. (Bowie 1990, 231).

The modern scientific investigation of music began with Hermann von Helmholtz's study of the physics and psychological effects of the tones and keys of music (1954 [1885]). Helmholtz argues that music does not use *all* types of sound, only those "due to a rapid *periodic* motion of the sonorous body; the sensation of a noise to non-periodic motions." (Helmholtz 1863, 9). Most researchers do not *question* what sounds make music, but write with the assumption that they are referring to sounds caused by periodic vibrations (Aiello, Molfese, Sloboda, Stiller, Lange, Schopenhauer, Trehub, Zatorre, etc.). "Tonal stimulation is a constant factor of all musical stimulus" (Meyer 1994, 13). The neurophysiological musical research often revolves around contrasting responses of subjects to periodic (tonal) versus nonperiodic (noise) sounds. Warren, Obusek, and Farmer (1969) found the interesting fact that subjects could not accurately perceive the temporal order of four nonspeech, nonmusical sounds.

John Sloboda (1985) has examined various contemporary scientific theories of musical meaning, among them the idea that music mimics environmental sounds. The mimickry theory is intriguing, but it seems to have a problem sufficiently explaining the depth and range of meaning in music. Indeed, music can aptly imitate some natural sounds, as did Saint-Saens, in his "Carnival of the Animals." But, even in music considered to be as programmatic as Berlioz' "Symphonie Fantastique," we cannot find environmental sounds of which the music would be an imitation. To this point, Helmholtz noted that

> "In music one does not aim at representation of nature; rather, tones and tone sensations exist just for their own purpose and function independently of their relationship to any environmental object" (1863, 370).

Other theorists suggest that music has its effects by expressing tension and its resolution (Schenker 1935; Bernstein 1976). Tension and resolution are certainly a large part of the musical experience, but they name only very general qualities of it and do not seem to address the vast, varied, and subtle ways music can make us feel.

Manfred Clynes sees music as the embodiment of the *forms* of emotion, "emotionally expressive dynamic forms which we have called essentic forms" (1986, 169). Clynes (1974, 1986) theory of music seems to parallel, for sound, what Ekman proposed for facial expression. Ekman (1977) found that there is a systematic relation between emotion and facial expression, and suggested that this is a result of inborn "affect programmes" (automatically triggered sequences of emotion), an idea also accepted by by Tomkins (1962) and Izard (1971). Clynes thinks the essentic forms are biologically determined expressions of emotion, experienced the same way across cultures, which idea seems similar to "inborn affect programmes".

> Essentic forms are specific spatio-temporal forms biologically programmed into the central nervous system for the expressive communication and generation of emotional qualities (1986, 169).

Clynes seems to be using the word “form” metaphorically. It usually refers to the three-dimensional, spatial aspects of things. He seems to be saying that the physiological nature, intensity, and timing of music-evoked emotions have great similarity among individuals. Just as, typically, one's pulse raises, one's muscles tighten and one's breath seems to become more ragged when one is angry, so there are typical bodily changes due to the feelings which music evokes. This typicality is illustrated and represented by the shape of the graph produced by subjects' fingers during experiments with Clynes' sentograph. The graph's shape thereby represents the "form" of the emotion. He has interesting data showing that the same music will evoke similar motor responses in people of vastly different cultures. His sentograph, which measures motor response, attaches to the subject's finger and records, on a graph, subtle movements of the digit upon exposure to music. Clynes found remarkable similarity among individual's responses to a given composer and *between* the responses of different individuals to the same composer's music, as represented by the forms on the recording graphs. De Vries' research confirms Clynes' hypothesis that emotional responses are similar among subjects and showed that responses to music were "not affected by a subject's familiarity with or evaluation of a piece" (De Vries 1991, 46).

In a view which seems consonant with Clynes', Jackendorff points out that dance is closely related to music, and that

> going beyond crude rhythmic correspondences, we have undeniable and detailed intuitions concerning whether the character of dance movements suit or fail to suit the music. Such intuitions are patently not the result of deliberate training...This suggests that...a cognitive structure can be placed into close correspondence with musical structure...[which] might encode dance movements...[which can be] provisionally called *body representation* -essentially a body-specific encoding of the internal sense of the states of the muscles, limbs, and joints. Such a structure, in addition to representing the position of the body, would represent the dynamic forces present within the body, such as whether a position is being held in a state of relaxation or in a state of balanced tension....There is every reason to believe that such a representation is independently necessary for everyday tasks. ...It would likely be involved as well in correspondences between emotional and muscular states -for instance, one carries oneself differently in states of joy, anger, depression, elation, or fear. (1987, 238-9)

Consonant with this view, Hevner (1936) found that individuals show general agreement about the emotional content of pieces of music and that there is broad agreement among members of a culture about the musical mood of a piece, even among children as young as three years of age (Kastner and Crowder 1990). And Stiller notes that

> a number of important musical universals have been identified: Melodies worldwide are made mostly of major seconds; all musics employ dynamic accents, and notes of varying lengths; and all display extensive use of variation and repetition...the universality of music suggests that there may be a biological basis for its existence. (1987, 13)

Research confirms the everyday experience that music causes emotional states which can seriously affect our actions. Konecni (1982) found that subjects who had been insulted by confederates working for the experimenter were quite aggressive about shocking those confederates. But subjects who had merely been exposed to loud, complex music were almost as aggressive about shocking confederates as the insulted subjects had been! In another experiment subjects were able to shape their moods by their musical choices, and thereby optimize their moods. Depending on the way they felt when they came to the experimental session (anxious or angry or happy), and how they wanted to feel afterwards, they could pick music that changed the way they felt entirely - once again supporting the idea that the sounds of music have a direct effect on emotions.

In many respects, mood is a better concept than emotion to describe the results of music. Giomo says "This affective meaning, labelled 'mood', is of an individual and nameless nature, not truly describable using emotion labels" (Giomo 1993, 143). Sloboda points out that "the ability to judge mood is logically and empirically separable from the ability to feel emotion in response to music. It is quite possible to judge a piece of music to represent extreme grief, yet be totally unmoved by it" (1991, 111). DeVries

(1991) suggested that there are two steps in reacting to music: one in which music directly activates "programmes" which trigger emotions and a second in which a person allows themselves to experience the emotion or suppresses it, depending on the congruity of the emotion with, among other things, their personality and cultural background.

In searching for an evolutionary origin to music, Konecni, as does Roederer (1984), posits that music helps to synchronize the emotional states necessary for collective action, such as the excitement needed for the hunt or battle. Many primitive tribes seem to use music in this way (as do college bands during football games). And, indeed, a few other species, such as birds and cetaceans, have music-like behaviors (4), wherein they produce sounds of periodic vibrations and which are intimately tied to intra-species communication and collective action. Stiller claims that "Music helps to insure...cooperation -- indeed, must play an important role in that regard, or there would have been no need to evolve such a unique form of emotional communication" (1987, 14). He quotes Alan Lomax to the effect that music organizes the mood, the feelings, the general attitude of a group of people. This seems to echo the Ancient Greek view that music teaches men how to feel like warriors or like lovers.

Granted,

> ...there may be a certain cultural advantage in having some rudimentary form of music to help synchronize collective rhythmic activity or to serve some ceremonial aspect of social life, no particular reason is evident for the efflorescence of musical complexity that appears in so many cultures (Jackendorff 1987, 214).

The socio-biological theory of musical meaning may explain some of the psychological roots of music's evolutionary origins but what determines the kinds of sounds which can cause the experience of emotion, i.e. the neurological roots? And why do we have so many kinds of music which we listen to for its own sake?

The Neuropsychological Data on Language and Music

Why should certain kinds of sounds be able to directly evoke feeling? By what means, what neuropsychological processes?

As have so many in the history of music theory, Roederer (1984) wonders whether the answer lies in the unique human capacity for language. Human infants have high motivation to acquire language, as evidenced by the assiduous way they attend to, imitate, and practice language. Language activities are very pleasurable; if they were not, human infants would not be motivated to perform language-related activities as much as they do. On this evidence, I venture to say that humans have built-in developmental pleasure/pain processes for producing and listening to language. Language acquisition is a cognitive activity that is highly motivated and important to survival. Are the emotions aroused for language acquisition the evolutionary link between sound and emotion? That is, are humans moved by sound as a result of a biological need to be interested in acquiring language?

> Experiments show that there are strong similarities in the way in which people perceive structure in music and in language...[but] overall, the syntax of music has much more latitude than that of language. Thus, in the syntaxes of music and language, we must remember that music is far more flexible and ambiguous than language (Aiello 1994, 46-9).

Furthermore, neuropsychological evidence seems to be a odds with the proposal that language is the basis of music. The areas of the brain which primarily process speech are, apparently, mostly different from those which process music (5). Investigations into the brain areas which process speech and music have turned up the interesting finding that, in most infants, the left hemisphere responds more to speech sounds and the right to musical tones, as indicated by a type of EEG called auditory evoked potentials, (Molfese 1977).

Measures of how much attention a neonate paid to left or right ear stimuli (as indicated by "high amplitude non-nutritive sucking") indicated that most infants responded more to language sounds presented to their right ears (left hemispheres) and to musical sounds presented to their left ears (right hemispheres) (Entus 1977; Glanville, Best, and Levenson 1977), although Vargha-Khadem and Corbellis (1979) were not able to replicate Entus' findings. Best, Hoffman, and Glanville (1982) found a right ear advantage for speech in infants *older* than two months during tasks in which infants had to remember and discriminate phonetic sounds and musical timbres. Infants younger than two months showed an ear advantage only for musical notes, and that advantage was for the left ear. In older children and adult non-musicians, damage to the left hemisphere usually impairs language functions but tends to spare musical abilities, including singing. Damage to the right hemisphere, particularly the right temporal lobe, tends to leave language functions intact, but impairs musical abilities and the production and comprehension of language tone and of emotion expressed through language or other sounds (Joanette, Goulet, and Hannequin 1990).

Zatorre (1979) found a left ear advantage for the discrimination of melodies versus speech in a dichotic (6) listening task with both musicians and nonmusicians. He found cerebral-blood-flow evidence that right temporal lobe neurons are particularly important in melodic and pitch discriminations (Zatorre, Evans, and Meyer 1994). Tramo and Bharucha (1991), following the work of Gordon (1970), found that the right hemisphere seems to process the perception of harmonics (tested by the detection of complex relationships among simultaneous musical sounds). Damage to the right temporal lobe impairs the ability to recognize timbre (7), and time cues *within* tones that determine the recognition of timbre (Samson and Zatorre 1993). These authors suggest that "the same acoustical cues involved in perception of musical timbre may also serve as linguistic cues under certain circumstances" (Ibid., 239). There are now indications that timbre and phonetic information are processed through some common stage beyond peripheral acoustic processing. Research is underway to determine whether voice identification also proceeds through this same timbre-phoneme nonperipheral stage (Pitt 1995).

In a critical review, Zatorre (1984) notes that right-sided damage can produce deficits in tasks that process patterns of pitch and timbre differences. Adults with partial or complete excisions of the right temporal lobe were found to be significantly impaired in the perception of pitch (Zatorre 1988). Kester et. al (1991) found that musical processing was most affected by right temporal lobectomy. In a review of the literature on the infant's perception of tone sequences, or melodies, Trehub (1990) found that human infants do not use local pitch strategies characteristic of nonhuman species, that is, they do not depend on the recognition of particular, or absolute pitches, to identify tone sequences. Rather, like human adults, they use global and relational means to encode and retain contours of melodies, with little attention to absolute pitch. (Although, interestingly, Kessen, Leving and Wendrich (1979) found that infants paid very close attention to experimenters' singing and could imitate pitch quite well.) In other words, human infants have the ability to recognize exact pitches, but the exact key in which a melody is played makes little difference for human recognition of melody, while animals depend on the particular pitch in which their "song" is sung to recognize it. This seems to imply that even human infants are extracting the abstract pattern of the sounds, rather than using the sounds as signs, specific perceptual markers, of events.

In reviewing the research on infants' perception of music, Trehub (1987) suggests that infants have the skills for analyzing *complex* auditory stimuli. These skills may correspond to musical universals, as indicated by infants' preference for major triadic chord structures.

The evidence indicates that human infants have the ability to recognize and process music in a fairly complex way, at a very early age. Furthermore, music processing in most infants and adults seems to occur primarily in the right hemisphere (8).

And infants, like adults, appear to find music interesting: they tend to pay attention to it, they like to engage in imitations of adult pitches and, they learn to sing as soon as they learn to speak (Cook 1994).

The Neuropsychological Data on Emotions

How does the data on the neuropsychological processes involved in music relate to the data on the neuropsychological processes involved in emotions? It is well-established that for most people, right hemisphere damage causes difficulties with the communication and comprehension of emotion (Bear 1983; Ross 1984). Apparently, the right hemisphere mediates the processing of many types of emotionally-laden information: visual, facial, gestural, bodily, and auditory.

The evidence suggests that the right hemisphere has a special relationship with the emotional functions of the human mind, specifically in being able to process and project emotional meaning through perceptual information (Kolb and Whishaw 1990). For most people, the right hemisphere performs integrative visual functions, such as grasping visual gestalts and comprehending visual and architectural wholes; the inability to recognize faces is sometimes the consequence of right temporal lobe damage. (Kolb and Whishaw, 1990) Right hemisphere damage can often lead to the inability to be aware of whole areas of space in relation to oneself, called perceptual neglect. (See A. Luria's *The Man With A Shattered World* for an agonizing description of what the world seems like when one's brain cannot perform these visual and kinesthetic integrations.) Neglect of half of perceived space, called hemi-neglect, is a frequent result of extensive right parietal damage. The right hemisphere is fundamentally involved in comprehending the *connotative* meanings of language, metaphors and nonliteral implications of stories; and the right hemisphere seems to be involved in the comprehension of meaning commmunicated through sound, especially voice. Oliver Sacks discusses patients with "tonal agnosia,"

> For such patients, typically, the expressive qualities of voices disappear - their tone, their timbre, their feeling, their entire character - while words (and grammatical constructions) are perfectly understood. Such tonal agnosias (or 'aprosodias') are associated with disorders of the right temporal lobe, whereas aphasias go with disorders of the left temporal lobe (1987, 83).

He also describes aphasics (9) who are not able to grasp the denotative meaning of words and yet are able to follow many conversations by the emotional tone of the speakers.

> With the most sensitive patients, it was only with [grossly artificial mechanical speech from a computerised voice synthesizer] that one could be wholly sure of their aphasia (Ibid., 80-1).

The patients would use all kinds of extraverbal clues to understand what another was saying to them. He claimed that a roomful of them laughed uproariously over a speech given by Ronald Reagan because of the patent insincerity of it.

Rate, amplitude, pitch, inflection, timbre, melody, and stress contours of the voice are means by which emotion is communicated (in nonhuman as well as human species), and the right hemisphere is superior in the interpretation of these features of voice (Joseph 1988). Samson and Zatorre (1993) found similar cortical areas responding to pitch and timbre in humans and animals. In dichotic listening tasks, Zurif and Mendelsohn (1972) found a right ear advantage for correctly matching meaningless, syntactically organized sentences with meaningful ones by the way the sentence was emotionally intoned. The subjects could apparently match such nonsense sentences as: "Dey ovya ta ransch?" with "How do you do?" by the intonation the speaker gave the sentence. Heilman, Scholes, and Watson (1975) found that subjects with right temporal-parietal lesions tended to be impaired at judging the mood of a speaker. Heilman et. al (1984) also compared subjects with right temporal lobe-damage to both normals and aphasics (4) in discriminating the emotional content of speech. He presented all three types of subjects with sentences wherein the verbal content of the speakers was filtered out and only the emotional tone was left, and found those with temporal lobe damage to be impaired in their emotional discriminations. In a similar study, Tompkins and Flowers (1985) found that the tonal memory scores (how well the subjects could remember specific tones) for right braindamaged subjects were lower than those of other subjects, implying that right braindamage leads to a problem with the perceptual encoding of sound, put not necessarily with the comprehension of emotional meaning per se.

The human voice conveys varied, complex, and subtle meaning through timbre, pitch, stress contour, tempo, and so forth and thereby communicates emotion.

> What is clear is that the rhythmic and the musical are not contingent additions to language....The "musical" aspect of language emphasizes the way that all communication has an irreducibly particular aspect which cannot be substracted (Bowie 1990, 174).

Best, Hoffman, and Glanville found that the ability to process timbre appears in neonates and very young infants, apparently before the ability to process phonetic stimuli 1982).

Through the "music" in voice, we comprehend the feelings of others and we communicate ours to them. This is an important ability for the well-being of the human infant, who has not yet developed other human tools for communicating its needs and comprehending the world around it - a world in which the actions and feelings of its caretakers are of immense importance to its survival. Emotion is conveyed through language in at least two ways: through the specifically verbal content of what is said, and through the "musical" elements in voice, which are processed by the right hemisphere. One of the characteristic features of traditional poetry is the dense combination of the meaning of words with the way they sound, which, when done well, results in emotionally moving artworks (Enright 1989). Mothers throughout the world use nursery rhymes, a type of poetry, to amuse and soothe infants and young children, that is, to arouse emotions they find desirable in the children. "Music can articulate the 'unsayable', which is not representable by concepts or verbal language" (Bowie, 1990, 184). “Men have not found the words for it nor the deed nor the thought, but they have found the music” (Rand 1943, 544) .

Was nature being functionally logical and parsimonious to combine, in the right hemisphere, those functions which communicate emotion with those that comprehend emotion?

As social animals, humans have many ways of communicating and comprehending emotions: facial expression, gesture, body language, and voice tone. I propose that music's biopsychological origins lie in the ability to recognize and respond directly to the feelings of another through tone of voice, an important ability for infant and adult survival. (The tone of voice of an angry and menacing person has a very different implication than that of a sweet and kind person.)

> If inflection and nuance *enhance* the effect of spoken language, in music they *create* the meaning of the notes. Unlike words, notes and rests do not point to ideas beyond themselves; their meaning lies precisely in the quality of the sounds and silences, so that the exact renderings of the notes, the nuances, the inflection, the intensity and energy with which notes are performed *become* their musical meaning.
> (J. M. Lewers, quoted in Aiello 1994, 55)

Furthermore, I propose that the sound literally triggers those physiological processes which cause the corresponding emotion "action programmes," "essentic forms," or whatever one wishes to call these processes. This would explain the uniquely automatic quality in our response to music.

I am proposing that the biopsychological basis of the ability of sound to cause emotions in man originates in man's ability to emotionally respond to the sounds of another's voice. Theoretically, this ability lies in the potential for certain kinds of sounds to set off a series of neurological processes resulting in emotions, which events are similar to those occurring during the usual production of emotions. As so many in the history of musical theory have conjectured, music *does* result from language - but not language's abstract, denotative qualities.

However, I should posit that it is *not* the ontogeny of language *per se* that caused the development of music in humans. Many nonhuman animals communicate emotion and subsequently direct and orchestrate actions of their species through voice tone, and there is considerable evidence that humans do likewise, which argues that this ability arose before the emergence of language.

Returning to my earlier discussion of motivation in the infant acquisition of language, it seems more likely that the pleasures and emotions communicated through voice (which motivate the acquisition of language) are another biological application of the ability of voice tone to emotionally affect us, rather than an initial cause of emotion in voice. Human's were already set to be affected by voice tone when we acquired the ability to speak. Pleasure associated with vocalizing likely developed into pleasure in language acquisition.

However, music, especially modern Western music, has gone far beyond the kinds of auditory perceptions and responses involved in simple tone of voice alone. The ability to emotionally recognize and respond to tone of voice was developed early on in the evolution of *Homo sapiens*, as evidenced by the same ability in our closest animal relatives, the great apes. The history of music seems to show that humans greatly expanded on the use of voice tone through their ability to abstract. It appears that men created instruments, learned how to distill and extract the essence of tones and their relationships, rearranged and expanded the range, timbre, and rhythm of sounds used both by voice and by instruments, and thereby created a new, artistic means of expressing a huge range of emotions.

The evidence found by Clynes and others indicates that there is a special pattern of sound for each emotion or mood, which pattern humans are able to recognize in various voices, both human and instrumental. Helmholtz noted that the major keys are

> well suited for all frames of mind which are completely formed and clearly understood, for strong resolve, and for soft and gentle or even for sorrowing feelings, when the sorrow has passed into the condition of dreamy and yielding regret. But it is quite unsuited for indistinct, obscure, unformed frames of mind, or for the expressing of the dismal, the dreary, the enigmatic, the mysterious, the rude...[and it is] precisely for these ...[that] we require the minor mode (1954 [1885], 302)

The implication of the evidence is that humans have learned how to abstract the sound pattern evoking, for example triumph, and then re-present this pattern in its essential form in a musical composition, giving the listener an experience of the emotion of triumph rarely possible in life. Through abstraction, the emotion-provoking sounds have been rendered essential and rearranged into new patterns and combinations, thereby enabling humans to have an emotion-evoking artistic experience far greater than that possible from the sounds of the spoken voice alone. Many theories of music, to some extent, recognize that music makers take the fundamental qualities of music and rearrange them to invent new ways of feeling - see any number of essays in Philip Alperson's book *What is Music?*

In relation to this theory, it is noteworthy that only the sounds of periodic vibrations can be integrated so as to evoke emotion because the voice produces periodic vibrations in its normal operation. (Despite the best efforts of modern musical theorists, all else is experienced as meaningless noise.) In the history of music theory, thinkers have placed most of their emphasis on the relations and perceptions of harmonies (Grout 1973; Lang 1941). My proposal for the biological basis of music concerns a system generally without harmony - the human voice (there are some harmonic overtones in any voice or instrument). How do these factors relate to one another? Historically, music began as plainsong without accompaniment and as simple melodies.

> The fact that music could achieve simultaneity, that it could have vertical as well as horizontal events, was a revolutionary discovery....Now music had a new kind of interest, the accidental or contrived vertical combination of two or more pitches" (Aiello 1994, 44)

Although polyphony (10) was created some time during the Middle Ages, apparently the conscious use of harmonic chords was developed even later.

Helmholtz mentions that

> A favourite assertion that "*melody is resolved harmony*," on which musicians do not hesitate to form musical systems without staying to inquire how harmonies had either never been heard, or were, after hearing, repudiated. According to our explanation, at least, the same physical peculiarities in the composition of musical tones, which determined consonances for tones struck simultaneously, would also determine melodic relations for tones struck in sucession. The former then would not be the reason for the latter, as the above phrase suggests, but both would have a common cause in the natural formation of musical tones (1954 [1885], 289).

In other words, harmony and melody complement each other, using the same mathematical relationships of tones and their perception. Harmony does this simultaneously, melody does this over time. However, harmony is not an equal partner in the creation of music, because we can make music without harmony and because harmony does not make music on its own: music requires a sequence of sounds and silences through time. Harmony developed as man abstracted musical qualities in sound, rearranged them, and used them simultaneously. It is likely that theoreticians have focused on harmony in their analysis of music because complex harmonies are a major part of modern western music and because melodies are more difficult to analyze due to the the element of time. Given the historical development of music, I believe the emphasis on harmony is an artifact of human analytical ability. Moreover, an harmonic chord on its own is not music - it is always necessary to have a sequence of tones to have music.

Beyond Neuropsychology to Music as Art

I have posited a biological/evolutionary *origin* to music, but I have not, as yet, proposed a survival function for it. Before I do that, I would like to address the wider issue of the biological function of art *per se.* In her article "Art and Cognition," Rand (1971) presented her theory on the cognitive foundations of art. This theory is of particular interest to me, not only because it is founded on and well-integrated with her revolutionary philosophy of Objectivism, but because it is specifically based on man's cognitive and motivational nature, on what she called his "psycho-epistemological needs" (11), and thereby posits gives an answer to the question of art’s biological roots. Her hypothesis in no way addresses or accounts for my original question, What is the evolutionary basis of the ability to respond to sound? With her hypothesis, the question remains unanswered. But her theory is worth addressing because she asked and attempted to answer many of the fundamental questions about music's nature.

Rand argued that art is a means of making conceptual yet concrete the information of the senses, which, thereby, makes that information more meaningful to us.

> The visual arts do not deal with the sensory field of awareness as such, but with *the sensory field as perceived by a conceptual consciousness*.
>
> The sensory-perceptual awareness of an adult does not consist of mere sense data (as it did in his infancy), but of automatized integrations that combine sense data with a vast context of conceptual knowledge. The visual arts refine and direct the sensory elements of these integrations. By means of selectivity, of emphasis and omission, these arts lead man's sight to the conceptual context intended by the artist. They teach man to see more precisely and to find deeper meaning in the field of vision. (Rand 1971, 47)

Painting makes conceptual the sense of sight, sculpture the sense of sight and touch, dance the sense of body motion, or kinesthesia, and music the sense of hearing.

But Rand argued that music does not follow exactly the same psycho-epistemological process as the other arts. According to Rand, the art of music embodies man's sense of life by abstracting how man uses his mind.

> The other arts create a physical object,...and the psycho-epistemological process goes from the perception

> of the object to the conceptual grasp of its meaning, to an appraisal in terms of one's basic values, to a consequent emotion. The pattern is: from perception - to conceptual understanding - to appraisal - to emotion.
>
> The pattern of the process involved in music is: from perception - to emotion - to appraisal - to conceptual understanding.
>
> Music is experienced as if it had the power to reach man's emotions directly (Rand 1971, 50)

In other words, upon listening to music, it can cause us to experience feelings which we subsequently appraise. Whether we like or dislike the feelings caused by the music (or have some complex reaction to it), helps determine what kinds of music we individually favor. An interesting facet of the musical experience is the fact that many unrelated images tend to come to mind when we listen to music, imagery which seems to correspond to the emotions. It is as if our minds find it illogical to have feelings with no existential objects to evoke them, so our minds provide images of an appropriate nature. This process seems reminiscent of others, such as the way in which we "see" faces in myriad visual images, or think we hear voices in the sound of the wind. The common thread between them is the mind's automatic attempt to make sense of the world, both external and internal.

According to Rand, how might sound evoke these emotions?

> If man experiences an emotion without existential object, its only other possible object is the state or

actions of his own consciousness. What is the mental action involved in the perception of music? (I am not referring to the emotional reaction, which is the consequence, but to the process of perception.)...The automatic processes of sensory integration are completed in his infancy and closed to an adult.

The single exception is in the field of sounds produced by periodic vibrations, i.e., music...musical tones heard in a certain kind of succession produce a different result -the human ear and brain *integrate* them into a new cognitive experience, into what may be called an auditory entity; a melody. The integration is a physiological process; it is performed unconsciously and automatically. Man is aware of the process only by means of its results.

Helmholtz has demonstrated that the essence of musical perception is mathematical; the consonance or dissonance of harmonies depends on the ratios of the frequencies of their tones...[There is] the possibility that the same principles apply to the process of hearing and integrating a succession of musical tones, i.e., a melody -- and that the psycho-epistemological meaning of a given composition lies in the kind of work it demands of a listener's ear and brain (Rand 1971, 57-8)

Music gives man's consciousness the same experience as the other arts: a concretization of his sense of life. But the abstraction being concretized is primarily epistemological, rather than metaphysical; the abstraction is man's consciousness, i.e., his method of cognitive functioning, which he experiences in the concrete form of hearing a specific piece of music. A man's acceptance or rejection of that music depends on whether it calls upon or clashes with, confirms or contradicts, his mind's way of working. The metaphysical aspect of the experience is the sense of a world which he is able to grasp, to which his mind's working is appropriate....A man who has an active mind...will feel a mixture of boredom and resentment when he hears a series of random bits with which his mind can do nothing. He will feel anger, revulsion and rebellion against the process of hearing jumbled musical

sounds; he will experience it as an attempt to destroy
the integrating capacity of his mind." (Rand 1971, 58)
1971)

In other words, she proposed that the arrangement of sounds in music causes one's brain to perform a sensory/perceptual integration similar to those performed during the solution of an existential problem, and that one emotionally reacts to the kind of cognitive work which the music makes one perform through the integration.

In line with the assumptions of musical research, she notes that only sounds caused by periodic vibrations can be integrated by the human brain. We can analyze the sounds of music as follows: simultaneous sounds into harmonies, successions of sounds into melodies, or what Rand called "auditory entities" and percussions into rhythms.

According to Rand's hypothesis, musical sounds are physiologically integrated by the brain and our emotions are in response to the type of integration performed. She proposed that the musical integration parallels perceptual integration in nonmusical cognitive activities, and that we respond emotionally to the type of integrating work music causes us to perform. Her hypothesis assumes no direct physiological induction of emotion, but proposes that the emotion is a response to the kind of cognitive work caused by the integration of the sounds.

Is this view consonant with the scientific facts? Rand's hypothesis supposes that a perceptual integration results in emotions such as joy, delight, triumph, which are normally generated in humans by a complex *conceptual* cognitive activity. I am not aware of any other purely perceptual integrations in other sense modalities which result in such emotions (although there may be some visual stimuli, such as a beautiful sunset or graceful human proportions, for which we have in-built pleasurable responses). In this respect, sound seems to be unique.

Idiot-savants and some individuals with IQ's in the teens, respond fully to music, as well as

> A man whom childhood meningitis had left mentally retarded as well as behaviorally and emotionally crippled, but who...was so familiar with... *all* the Bach cantatas, as well as a staggering amount of other music)...evincing a full understanding and appreciation of these highly intellectual scores. Clearly, whatever had happened to the rest of his brain, his musical intelligence remained a separate - and unimpaired - function (Stiller 1987, 13).

Under Rand's theory, is this possible? Such cognitively impaired individuals would not normally perform many complex conceptual mental integrations, nor experience the feelings accompanying those integrations. One might infer that these mental cripples, unable to self-generate cognitive activities which would allow them the pleasures of deep feelings, are enabled the life-giving experience of such feelings through music (hence, some of them completely devote themselves to music). That is, their cognitions are not complex enought to produce many profound and pleasurable feelings on their own, but they are able to pleasurably shape their emotional world with music. Presumably, if their perceptual abilities are intact, their brains could still perform the integrations necessary under Rand's hypothesis. But how could their *psycho-epistemological* sense of life respond to the activities, in that they are not capable of much in the way of conceptual activity?

However, consider the following:

> If a given process of musical integration taking place in a man's brain resembles the cognitive processes that produce and/or accompany a certain emotional state, he will recognize it, in effect, physiologically, then intellectually. Whether he will accept that particular emotional state, and experience it fully, depends on his sense-of-life evaluation of its significance." (Rand 1971, 61)

Here, she seemed to say that the processing and integrating of the sounds are very similar to the *physiological* processes involved in the existential evocations of emotions. In other words, her statement seems to imply that she thinks the music physiologically induces the emotion, which is subsequently evaluated and accepted or rejected.

It seems to me that Rand was not perfectly clear as to the exact nature of music's production of emotions. On the one hand, she seemed to say that the emotions are a reaction to the kind of cognitive work the music causes us to perform. On the other hand, she seemed to say that the music physiologically induces the emotion.

Parsimony inclines me to take this analysis one step further and propose that musical sounds induce the neurological processes that cause the emotions; then we react to the feeling of those emotions. Instead of proposing, like Rand, that the essence of music is epistemological - we react to the kind of cognitive work music causes - I would like to maintain that the essence is metaphysical, like the other arts - we react to the way the music makes us feel. That is, by neurologically inducing emotions, music shapes our feelings about the world. If painting is the concretization of sight, music is the concretization of feeling.

Rand recognizes this to some extent, "How can sounds reach man's emotions directly in a manner that seems to by-pass his intellect?" (1971, 54) This question seems to imply that she thinks the musical sensory integration affects feelings directly.

It is relevant to the issue that there are direct sensory projections from the ear to the amygdala, a nuclei of cells at the base of the temporal lobe (where so much music processing seems to occur). The amygdala is part of the limbic system, considered essential to the production and processing of emotion. Although part of the temporal lobe, the amygdala is not considered to be part of the cortical sensory analysis systems that process the objective properties of an experience. Instead the amygdala is believed to process our feeling or subjective sense of an experience (Kolb and Whishaw 1990) - that is, how we feel about an experience, such as the warm cozy feelings we might get at the smell of turkey and apple pie. It seems possible that the sounds of music could be directly processed by the amygdala, resulting directly in emotion, without going through the usual "objective-properties" processing of the other cortical areas. This might be how they "reach man's emotions directly in a manner that seems to by-pass his intellect?" (Rand 1971,)

However, we might find a resolution to the seeming duality of Rand's musical hypothesis by further reflecting on music's nature. I believe the key lies in the complexity of music. There are large elements of cognitive understanding and processing involved in more complex music, e.g., there is a definite process involved in learning to listen to classical music, or any kind for that matter.

Musicians are much more sensitive to and analytical about music, and, interestingly, apparently use different areas of their brains than do nonmusicians when processing music. Musicians do quite a bit of processing in the left hemisphere, in areas that apparently process in a logical/analytical manner. Some music triggers some emotion in almost everyone, although I think that perhaps mood, as suggested by Giomo, would be a better term to describe much of the psychophysical state that music induces. We can listen to music, know what emotion it represents, but not want or like that emotion. In this way, Rand seems right that music causes our minds to go through the cognitive steps which result in various emotions. However, in line with the arguments made by many, not everyone can follow the cognitive steps necessary in listening to all music: there is a certain amount of learning involved in the appreciation of music and it seems to be related, for example, to learning the forms, context, and style of the music of a culture. Beyond that, there is learning involved in absorbing and responding to music of different genres: jazz, blues, celtic folk, african folk, classical. One gets to understand the ways and the patterns of each genre such that one's mind can better follow the musical thoughts and respond to them with feeling (Aiello 1994).

Music can take on a cognitive life entirely its own, apart from and different from the kinds of thoughts and feelings resulting from life or the other arts. As the Greeks thought, it can teach us new things to think and feel. Certainly, the kind of utterly intense emotion felt through exalted music is rare, if possible at all, through other events of life. Listening to contemporary music such as the Drovers (Celtic style), I realized that it made me feel all kinds of wonderful and unusual bodily feelings, which had no regular emotional names, although they were *similar* to other emotions. This might explain why we like to listen to the same piece of music over and over. "Wittengenstein's paradox: the puzzle is that when we are familiar with a piece of music, there can be no more surprises. Hence, if 'expectancy violation' is aesthetically important, a piece would lose this quality as it becomes familiar" (Bharucha 1994, 215). We do not particularly like to think about the same things over and over, but we generally like to *feel* certain ways over and over. We listen to the same piece over and over because we enjoy the mood, the frame of mind, into which it puts us. Of what else does the end of life consist, but good experience, in whatever form one can find it? Thinking is the *means* by which we maintain and advance life, but feeling happy is an end in itself.

To resolve Rand's duality: the basis of music is the neurological induction of mood through sound (made possible, in my view, by our ability to respond to the emotional meaning of voice); however, humans have taken that basic ability and elaborated it greatly, abstracting and rearranging sound in many, many different ways in all the different kinds of music. Responding to more complex music requires more elaborate, specifically musical understanding of the sounds and their interrelationships. This understanding requires learning on the part of the listener and complex cognitive work - to which the listener responds emotionally.

Hence, there are two emotional levels on which we respond to music which correspond to the two aspects of Rand's hypothesis: the basic neurological level and the more complex cognitive level.

Future Research

My hypothesis on the evolutionary basis of music in our ability to respond to emotion in tone of voice would need a vast array of experiments to be proved, including further inquiry into the neurological structures which process voice tone and music. Presumably, if the hypothesis is true, a significant overlap would be found in the the areas that process voice tone and the areas that process music. Particular care would be needed to discover which neocortical structures are involved in these functions, including an examination of such structures as the associative areas including the temporal lobe, and the limbic structures. And subcortical areas such as the hypothalamus and brain stem, presumed to be involved in emotional processing (Siminov 1986), would need to be examined as well.

A technique such as Positron Emission Tomography (PET) (12) might be useful in such an inquiry. Experiments indicating that this overlap exists in young infants would show that this was an inborn, and not a learned ability. Care would need to be taken in arranging several experimental conditions for comparison. Techniques such as the one described earlier in this essay, wherein the verbal content was filtered out of sentences, would be useful. Comparisons of the response to (1) voice with no verbal content or music, (2) music with no voice, (3) voice with music, with and without verbal content and (4) nonemotionally meaningful sounds made without voice would be important.

Also, it might be found that voice with no music, voice with music, and music with no voice are each processed in a different set of areas. Alternatively, it is possible that no subcortical emotional effects would be found from voice or music. Or, perhaps, the processing of the voice and/or the music would be found to be spread over both hemispheres of the brain in a way which did not become evident in the evoked potentials. Some of the brain damage studies found that right hemisphere damage did not universally cause amusia or failure to comprehend or express emotional tone, and that some subjects recovered their abilities to express or grasp emotion through language. Furthermore, it is difficult to know how varying individual brain organization might express itself in the processing of these tasks.

Interesting and observable differences might be found across languages or language groups. The relation, if any, of a language to it's folk music would be fascinating (13).

Here I'd like to recall Jackendorff's comments. He

remarked on the ability of music to make us feel like moving,
and that there are specific ways we seem to feel like moving
to specific kinds of music.

Ultimately, if we learn enough to specify exactly the relationships between the elements of music and what feelings are evoked, we will be able to decipher music as "the language of feeling." I look forward to the research which will resolve these questions on the biopsychology of music.

Again and Again

Music defies.

Rachmaninoff's sighs,
Haydn's Surprise,
Joplin's glad cries --
Make poetry pale.

Words fail.

--John Enright

NOTES

1. "An emotion is the psychosomatic form in which man experiences his estimate of the beneficial or harmful relationship of some aspect of reality to himself." (Branden 1966, 64). This definition is echoed in Carroll Izard's work *Human Emotions* (1977) "A complete definition of emotion must take into account all... of these aspects or components: (a) the experience or conscious feeling of emotion, (b) the processes that occur in the brain and nervous system, and (c) the observable expressive patterns of emotion, particularly those on the face...scientists do not agree on precisely how an emotion comes about. Some maintain that emotion is a joint function of a physiologically arousing situation and the person's evaluation or appraisal of the situation" (1977, 4).

2. "Prosody" is pitch, change of pitch, and duration of intonations and rests in speech.

3. "Pitch - 23. *Acoustics.* the apparent predominant frequenc sounded by an acoustical source." (Random House Dictionary of the English Language, New York: Random House Publishing Co., 1968)

4. The activites are "music-like" because they employ sequences of sounds made by periodic vibrations. However, because of the cognitive levels of the animals involved, the "songs" are not abstracted, arrayed and integrated into an artwork and thus are not music. It is even likely that the animals experience their "songs" as integrated perceptual experiences, which communicate valuable information to them, or trigger a series of valuable actions in them. Because our physiology is so different from that of birds and cetaceans, we may not experience the "songs" as perceptually integrated units, but the respective animals might. Regardless of whether the "songs" are perceptually integrated or not to the birds, dolphins or whales involved, the "songs" are still not artworks, because they are not conceptually organized (Nottebohm 1989). Likewise, animals usually seem indifferent to human music. There are at least two reasons for this: their physiologies are different, thus they do not hear and

perceptually integrate sound the same way humans do; and they do not have the power to abstract patterns from percepts the way humans do. Trehub (1987) found that, unlike animals, even human infants process music by relational means and do not rely on absolute pitch the way animals do.

5. In brain research, investigators have found evidence for the same general types of brain processes in the same areas for 95% of the subjects. I am reporting the kinds of functional asymmetries which have been discovered for those 95%. Thus, when I note that "language functions are in the left hemisphere and musical tone recognition in the right," I am referring to this 95% of the population.

6. In a dichotic listening task, the subject is presented with two different stimuli to his different ears, simultaneously. Whichever stimuli the subject tends to notice indicates that the ear to which it was presented has an advantage for that kind of stimuli.

7. "Timbre - 1. *Acoustics, Phonet.* the characteristic quality of a sound, independent of pitch and loudness but dependent on the relative strengths of the components of different fequencies, determined by resonance. 2. Music. the characteristic quality of sound produced by a particular instrument or voice; one color." (Random House Dictionary of the English Language, New York: Random House Publishing Co., 1968)

8. There is evidence that musicians in particular do what appears to be more logico-analytical processing of music in the left hemisphere (Bever and Chiarello 1974). Messerli, Pegna, and Sordet (1995) found musicians superior in identifying melody with their right ear. Schlaug and Steinmetz found that professional musicians, especially those who have perfect pitch, have far larger planum temporales on their left side (Nowak 1995).

9. Aphasia is a condition in which a person has difficulty in producing and/or comprehending language due to neurological conditions.

10. Polyphony is a type of music where multiple voices sing independent melodies. Often, the melodies selected do

harmonize beautifully, but polyphony is not considered harmonic in the ususal sense, because it does not use harmonic chords in its composition, but relies on the incidental harmonization of the tones of the multiple melodies into chords.

11. "Psycho-epistemology is the study of man's cognitive processes from the aspect of the interaction between the conscious mind and the automatic functions of the subconscious." (Rand 1971, 20)

12. Positron Emission Tomography is a technique which measures the rate of glucose metabolism in neurological structures during tasks. The brain uses a tremendous amount of glucose whenever it works. It is inferred that brain structures using the most glucose during a given task are the ones performing the neurological processes necessary for that task.

13. My thanks to Mr. Peter Saint-Andre for pointing out these possibilities.

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