

Cognitive function, origin, and evolution of musical emotions

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ABSTRACT

Cognitive function of music, its origin, and evolution has been a mystery until recently. Here we discuss a theory of a fundamental function of music in cognition and culture. Music evolved in parallel with language. The evolution of language toward a semantically powerful tool required freeing from uncontrolled emotions. Knowledge evolved fast along with language. This created cognitive dissonances, contradictions among knowledge and instincts, which differentiated consciousness. To sustain evolution of language and culture, these contradictions had to be unified. Music was the mechanism of unification. Differentiated emotions are needed for resolving cognitive dissonances. As knowledge has been accumulated, contradictions multiplied and correspondingly more varied emotions had to evolve. While language differentiated psyche, music unified it. Thus the need for refined musical emotions in the process of cultural evolution is grounded in fundamental mechanisms of cognition. This is why today's human mind and cultures cannot exist without today's music.

Keywords: music, cognition, emotions, mind, language, cognitive dissonance, prosody, culture, evolution, knowledge instinct

1. THEORIES OF MUSIC ORIGINS

Aristotle listed the power of music among the unsolved problems alongside with finiteness of the world and existence of God (Aristotle, IV BCE/1995, p.1434). Darwin called music "the greatest mystery" (Darwin, 1871). Current theories of musical emotions attempt to uncover this mystery by looking into its origins. Justus and Hustler (2003) and McDermott and Houser (2003) reviewed evidence for evolutionary origins of music. Their conclusions are similar, humans have innate predispositions to music. Yet, there is "no compelling reason to argue categorically that music... has been shaped by natural selection." In Nature's series of essays on music McDermott (2008) wrote: "Music is universal, a significant feature of every known culture, and yet does not serve an obvious, uncontroversial function".

Huron (1999) discussed social reasons for music origins however, according to Huron, the list of possible uses of music by itself does not explain musical power over human psyche; does not explain why music and not some other, nonmusical activities have been used for these purposes. Cross (2008a,b), concentrates on evolutionary arguments specific to music. According to Cross, evolution of music was based on already existing in animal world biological and genetic mechanisms. Language, because of its concreteness, could exacerbate oppositions between individual goals. Music properties are opposite. It creates 'shared intentionality.' Music's major role is social, it serves as an 'honest signal' (that is it "reveals qualities of a signaler to a receiver") with nonspecific goals.

Cross suggests that music evolved together with language. Evolution of language required change of neural control over

the vocal tract. This control had to become more voluntary for language. At the same time a less voluntary control, originating in ancient emotional brain regions, had to be maintained for music to continue playing the role of 'honest signal.'

Lengthening of juvenile periods was identified as fundamental for origin of music. Infant directed speech (IDS) has special musical (or proto-musical) qualities that are universal around the globe. This research was reviewed in Trehub (2003). Several researchers relate this sensitivity to the "coregulation of affect by parent and child" (Dissanayake, 2000), and consider IDS to be an important evolutionary mechanism of music origin. Yet, arguments presented later tell that IDS cannot be a full story of musical evolution.

Dissanayake (2008) emphasizes that proto-musical behavior has served as a basis for culture-specific inventions of ritual ceremonies for uniting groups as they united mother-infant pairs. She describes structural and functional resemblances between mother-infant interactions, ceremonial rituals, and adult courtship, and relates these to properties of music. This is why, according to Dissanayake, proto-musical behavior produces such strong emotions, and activates brain areas involved in ancient mechanisms of reward and motivation, the same areas that are involved in satisfaction of most powerful instincts of hunger and sex.

Neanderthals might have had proto-musical ability (Mithen, 2007). He argues that music and language have evolved by differentiation of early proto-human voice sounds "Hmmm" undifferentiated proto-music-language. Further evolution toward music occurred for religious purposes, which he identifies with supernatural beings. Currently music is not needed, it has been replaced by language, it only exists as inertia, as a difficult to get rid off remnant of the primordial Hmmm. I disagree with dismissing Bach, Beethoven, or Shostakovich in this way and present arguments below.

Juslin and Västfjäll (2008) as well as Juslin (2013) analyze mechanisms of musical emotions. They discuss a number of neural mechanisms involved with emotions and different meanings implied for the word 'emotion'. They conclude that musical emotions are no different from other emotions.

Levitin (2008) considers six different types of music, eliciting six basic emotions. He suggests that music has originated from animal cries and it functions today essentially in the same way, communicating emotions. It is more difficult, he writes, "to fake sincerity in music than in spoken language." The reason that music evolved this way as an 'honest signal' because it "simply" co-evolved with brains "precisely to preserve this property."

This "simply" does not seem convincing. Birds can fake cries (Lorenz, 1981). Actors, singers, and poets fake emotions in songs, not only contemporary professionals, but also those existing in traditional societies (Meyer, Palmer, & Mazo, 1998) since time immemorial. Suggestion of the 'honest signal', it seems, has not been informed by views of Jung (1921) that some people better manipulate their emotions than their thoughts, or by the current psychological studies on emotional

intellect (Mayer, Salovey, Caruso, 2008). Trehub (2008) takes an opposing view and calls music a “dishonest signal.”

This paper discusses mechanisms of music evolution from differentiation of original proto-music-language to its contemporary refined states. Discussions of mechanisms that evolved music from IDS to Bach and Beatles in previously proposed theories are lacking or unconvincing. Why do we need the virtual infinity of “musical emotions” that we hear in music? Analysis by Dissanayake (2008) does not even consider music in its modern sense. Cross & Morley (2008) appropriately disagree: “...it would be impossible to remove music without removing many of the abilities of social cognition that are fundamental to being human.” They conclude that “there are further facets to the evolutionary story.” This paper discusses a theory that clarifies some of these remaining questions and suggests a fundamental role of musical emotions in cognition and evolution.

2. MECHANISMS OF THE MIND

Fundamental mechanisms of the mind include concepts, instincts, emotions, and behavior. The content of this section summarizes neuro-cognitive and mathematical arguments considered, in detail, in (Perlovsky 1987; 1994a; 1997; 1998; 2001a, 2006a,b; 2007b,d; 2009c, 2010c,f, 2011b, 2012d; Perlovsky & McManus 1991; Bar et al, 2006; Perlovsky & Kozma 2007a,b; Mayorga & Perlovsky, 2008) and in references therein.

The mind understands the world in terms of concepts. *Concepts* or mental representations model objects and situations in the world. A fundamental mechanism of conceptual perception and cognition is interaction of Bottom-up (BU) neural signals coming from sensory organs with Top-down (TD) neural signals coming from “Top” concepts-representations. Perception occurs when the Top representation image is matched to the Bottom representation in the visual cortex. The “mechanism of concepts” evolved for satisfaction of instinctual needs.

Instincts or inborn drives are mechanisms of survival that are much more ancient than mechanisms of concepts; they work similarly to internal sensors that measure vital organism parameters, important for normal functioning and survival. For example, a low sugar level in blood indicates an instinctual need for food. This sensor measurement and the requirement to maintain it within certain limits is considered an “instinct.” Human body-mind has dozens of these mechanisms.

Emotions designate a number of various mechanisms which are reviewed, for example, in (Cabanac 2002; Juslin 2013; Juslin & Västfjäll 2008). Here we consider emotions as neural signals connecting instinctual and conceptual brain regions. Emotions are neural signals communicating instinctual needs to conceptual recognition-understanding mechanisms of the brain, so that concept-models corresponding to objects or situations that can potentially satisfy instinctual needs receive preferential attention and processing resources in the brain (Grossberg & Levine, 1987; Perlovsky, 2000, 2006a, 2012b,f). Thus emotional signals evaluate concepts for the purpose of instinct satisfaction.

Language and cognition are closely interconnected, still significantly different. Mechanisms of language and cognition are located in different parts of the brain. Language concepts (words, phrases) are learned early in life from the surrounding language, where they exist “ready-made.” But cognition requires real-life experience. High cognition cannot be learned from experience alone, language “guidance” is necessary

(Cangelosi et al 2000; Cangelosi & Parisi 2002; Cangelosi & Riga 2006; Fontanari & Perlovsky 2007, 2008a,b; Fontanari et al 2009; Perlovsky 2009a; Perlovsky & Ilin 2010, 2012, 2013; Petrov et al 2013). Interaction between cognition and language requires motivation; this motivation is provided by emotionality of language, which resides in language sounds, prosody (Perlovsky 2004, 2006a,b, 2007a,c, 2009b, 2010d, 2011c,d,e, 2012e,f; Gutfreund 1990; Balasko & Cabanac 1998). The summarized theory of conceptual-emotional recognition and understanding explains mechanisms of intuition, imagination, planning, and many others, including aesthetic emotions.

3. THE KNOWLEDGE INSTINCT

To satisfy instinctual needs, or inborn drives such as for eating or procreation, the mind should perceive objects and understand situations and events. As discussed, this task requires matching concept-models to the surroundings. But objects in the world would never exactly match old memories. This has presented difficulties to artificial intelligence and pattern recognition since the 1950s until recently (e.g. see Perlovsky, 2001a, 2002a, 2006a, 2009c, 2010c). For overcoming these difficulties mental representations-models are vague and they approximately match many different objects. For perception of objects, the mind modifies concepts-representations so that they “fit” concrete objects and situations. This mechanism operates independently of human desire “to perceive,” it is an inborn autonomous mechanism, more fundamental than eating or procreation. It is aimed at satisfying a basic need, to understand the world by making concept-models “similar” to surroundings. The mind has an inborn instinct that “senses” this similarity and maximizes it. This mechanism is called the knowledge instinct, KI, (Perlovsky, 2001a, 2006a, 2009c; Levine & Perlovsky 2008; Perlovsky & Levine 2012; Perlovsky, Bonniot-Cabanac, Cabanac, 2010). Knowledge is the measure of correspondence between mental representations and the world.

Satisfactions or dissatisfactions of this drive or instinct are felt as emotions evaluating harmony or disharmony between the knowledge and the world. They are not related directly to “lower” bodily needs, but only to “higher” need for knowledge. In this sense they are “higher,” “spiritual,” aesthetic emotions, as they are called since Kant (1790). This way Kant explained the emotion of the beautiful (Kant 1790; Perlovsky 2000, 2002b, 2007b, 2010b).

4. DIFFERENTIATION AND SYNTHESIS

Mind mechanisms are organized in an approximate hierarchy. At every level TD signals generated by representations-concepts-models at this level are matched to BU signals coming from representations at lower levels. The mind involves a hierarchy of multiple levels from simple perceptual elements, to concepts of objects, to complex scenes, and up the hierarchy... toward the highest concepts. These highest concepts near the top of the hierarchy are essential for understanding the nature of the beautiful (Perlovsky, 2002b, 2006a, 2007b,d, 2010b; Perlovsky & Mayorga 2008; Mayorga & Perlovsky 2008; Perlovsky & Ilin 2010, 2012, 2013; Ilin & Perlovsky 2009).

KI operates with two main mechanisms, differentiation and synthesis, Perlovsky (2006a, 2007a, 2010a). Differentiation operates “down” the hierarchy; it creates more specific, diverse and detailed concepts. At the same time “up” the hierarchy KI

drives understanding of situations and abstract concepts as a unity of constituent notions—this is a mechanism of synthesis.

The main mechanism of differentiation is language. It gives our mind a culturally evolved means to differentiate reality in great detail. The evolution of language required neural rewiring of circuits controlling vocalization. Vocal tract muscles in animals are controlled from an old emotional center, and voluntary control over vocalization is limited (Deacon, 1989; Schulz, Varga, Jeffries, Ludlow & Braun, 2005; Davis, Zhang, Winkworth, & Bandler, 1996; Larson, 1991). Humans, in contrast, possess a remarkable degree of voluntary control over voice, which is necessary for language. In addition to the old mostly involuntary control over vocal tract human have conscious voluntary control originating in cortex. Animal cries engage the entire psyche, rather than concepts and emotions separately. Consider calls of monkeys (Seyfarth & Cheney, 2003), which convey information about different types of predators nearby; however understanding of a situation (concept of danger), evaluation (emotion of fear), and behavior (cry and jump on a tree) are not differentiated, each call is a part of a single psychic state with very little differentiated voluntary control (if any).

Concepts and emotions have separated in humans; they also separated from behavior. This differentiation destroyed the primordial synthesis of psyche. With the evolution of language human psyche started losing its synthesis, wholeness. Whereas for animals every piece of “conceptual knowledge” is inextricably connected to emotional evaluation of a situation, and to appropriate behavior, satisfying instinctual needs, this is not so for humans. Most of the knowledge is not connected emotionally to instinctual bodily needs. This is tremendously advantageous for development of conceptual culture, for science, and technology.

The advantage of conceptual differentiation exerts a heavy price: human psyche is not automatically whole. Human knowledge accumulated in language is not automatically connected to instinctual needs; sometimes culturally developed conceptual knowledge contradicts instinctual needs inherited from the animal past. Various parts of knowledge may contradict each other. Synthesis, the feeling of being whole, is closely related to successful functioning of the highest models at the top of the hierarchy of the mind, which unify our experience and are perceived as the meaning and purpose of life (Perlovsky 2001b, 2007b,c, 2008b, 2010e). Therefore contradictions in the system of knowledge, disconnects between knowledge and instincts, the lost synthesis, lead to the internal crises and may cause clinical depressions. When psychic states missing synthesis preoccupy the majority of a population, knowledge loses its value, including knowledge and value of social organization, cultural calamities occur, wars and destructions (Perlovsky 2006b, 2007a, 2009b; Diamond 1997). The evolution of culture requires a balance between differentiation and synthesis. Differentiation is the very essence of cultural evolution. But it may lead to emotional disconnect between conceptual knowledge and instinctual needs, to the lost feeling of the meaning and purpose, to lost purpose of cultural knowledge, and to cultural destruction.

5. FUNCTIONS OF MUSICAL EMOTIONS

The balance between differentiation and synthesis is crucial for the development of cultures and for emergence of human consciousness. Our ancestors, who could develop differentiated consciousness, could better understand the surrounding world, had evolutionary advantage, if in addition to

differentiation they were able to maintain the unity of self required for concentrating will. Balance between differentiation and synthesis gave our ancestors evolutionary advantage. Maintaining this balance is the very fundamental function of music in cognition and the reason for evolution of this otherwise unexplainable ability.

History reveals a record of civilizations, whose synthesis and ability to concentrate will was undermined by differentiation. They were destroyed by less developed civilizations (barbarians) who’s differentiation lagged behind, but who’s synthesis and will was strong enough to overcome great powers of their times. These examples include Akkadians overrunning Sumerians some 3 millennia BCE, barbarians overcoming Romans and countless civilizations before and after these events. But let us concentrate on less prominent and more important events of everyday individual human survival from our ancestors to our contemporaries. If differentiation undermines the purpose and the will to survive, then differentiated consciousness and culture would never emerge.

The very essence of cultural evolution is differentiation, but it threatens synthesis and may destroy the purpose of culture, and the very culture (Perlovsky 2004, 2006b,c, 2009b). This instability does not exist in the animal kingdom because the pace of evolution and differentiation of knowledge from ameba to primates has been very slow, and instinctual mechanisms of synthesis have evolved along with the brain capacity. In human evolution, the origin of language changed this; accumulation of differentiated knowledge vastly exceeded biological evolutionary capacity to maintain synthesis. Along with the origin of language another uniquely human ability evolved for maintaining synthesis, the ability for music. Music evolved along with language for maintaining the balance between differentiation and synthesis.

Originally language and music were one (Darwin, 1871; Cross, 2008a; Masataka, 2008). In this original state the fused language-music did not threaten synthesis. Similar to animal vocalizations sounds of voice directly affected ancient emotional centers, connected semantic contents of vocalizations to instinctual needs, and to behavior. By relying on this mechanism Jaynes (1976) explained stability of great kingdoms of Mesopotamia up to 4,000 years ago. This synthesis was a direct inheritance from animal voicing mechanisms, and to this very day voice affects us emotionally directly through ancient emotional brain centers (Panksepp & Bernatzky, 2002; Trainor, 2008).

Language since its origin evolved in the direction of enhancing conceptual differentiation ability by separating it from ancient emotional and bodily instinctual influences. While language was evolving in this more conceptual and less emotional direction, ‘another part’ of human vocalization evolved toward less semantic and more emotional direction by enhancing already existing mechanisms of voice-emotion-instinct connection. As language was enhancing differentiation and destroyed the primordial unity of psyche, music was reconnecting differentiated psyche, restoring the meaning and purpose of knowledge and making cultural evolution possible (Perlovsky, 2013).

The fundamental function of music in cultural evolution was maintaining synthesis in the face of increasing differentiation due to language. KI was described as an internal mind’s “sensor” measuring similarity between concept-models and the world and related mechanisms of maximizing this similarity. But it is a great simplification. It is not sufficient for the human mind to maximize an average value of the similarity between all concept-models and all experiences. Adequate functioning requires constant resolution of contradictions

between multiple mutually contradicting concepts and between individual concepts quickly created in culture and slowly evolving primordial animal instincts. Human psyche is not as harmonious as psyche of animals. As Nietzsche (1995/1876) put it, “human is a dissonance,” a contradictory beings. Some of our ancestors were able to acquire differentiated contradictory knowledge and still maintain wholeness of psyche necessary for concentration of will and purposeful actions; those had tremendous advantage for survival.

KI itself became differentiated. It became directed not only at maximizing the overall harmony between knowledge and the world, but also at reconciling constantly evolving contradictions, cognitive dissonances. Emotions related to knowledge were differentiated along with KI. Each concept acts as a separate part of KI: evaluates other concepts for their mutual consistency; this is the mechanism of the differentiated knowledge instinct. Virtually every combination of concepts has some degree of contradictions, cognitive dissonance. The number of combinations is practically infinite (Perlovsky, 2006a). Therefore aesthetic emotions that reconcile these contradictions are not just several feelings for which we can assign specific words. There is a virtually uncountable infinity; “almost continuum” of aesthetic emotions. We feel this continuum of emotions (not just many separate emotions) when listening to music. We feel this continuum in Palestrina, Bach, Beethoven, Mozart, Chaikovsky, Shostakovich, Beatles, and Eminem... (and this mechanism extends to all cultures in the world). Musical emotions have evolved for synthesis of differentiated consciousness, for reconciling contradictions that every step toward differentiation entails, for reconciling cognitive dissonances, for creating a unity of differentiated Self.

6. EMPIRICAL AND EXPERIMENTAL EVIDENCE

Much evidence has been accumulated about parallel evolution of culture, consciousness, and music (Weiss and Taruskin 1984; Jaynes 1976; Perlovsky 2005, 2006c,e, 2008a, 2010a, 2011a, 2012a,c, 2013b). This evidence demonstrates that advances in consciousness and cultures were paralleled by advances in differentiation of musical emotions. Contemporary consciousness emerged approximately 2,500 years ago, in Ancient Greece (the first philosopher Thales), Israel (end of prophetism), and China (Confucius 6c.BCE/2000; Lao Tzu 6c.BCE/1979). Advancements in consciousness multiplied cognitive dissonances. To reconcile these cognitive dissonances, a new type of music evolved, antiphony, two choruses responding to each other; antiphony is the mainstay of church psalmody to this day.

Cultural acceptance of human emotions as a fundamental part of human psyche occurred during Renaissance. To reconcile emerging psychic contradictions, a new musical style, tonality, was developed for creating diverse emotions, corresponding to evolving psyche. Tonality has remained the basis of western music for more than 500 years. Reformation in the 16th c. reduced the irreconcilable split between spiritual and material, good and evil, - the contradiction between good and evil was taken from the heights of Heaven and the depths of Hades and placed into the human soul. The fundamental contradiction of human nature between finite matter and infinite spirit, which formed the mystical foundation of Christianity, was brought by the Reformation into everyday culture and made a part of collective consciousness. Tragic tensions originally projected onto the Christian symbol were assimilated by human psyche. Tensions in the human soul reached the maximum. To reconcile these tensions new type of music was

developed during Baroque, and perfected by Buxtehude and Bach; till this day many consider this music the peak of spirituality.

Multitudes of cognitive dissonances are created today in people souls by the diversity of our culture (Cabanac et al 2011; Bonniot-Cabanac et al, 2012). Popular songs play a vital role in unifying the split culture and souls: by unifying conceptual contents of lyric with emotional contents of music songs reconcile cognitive dissonances. This cognitive role of pop songs is much enhanced in rap music. In style and performance it is similar to Ancient Greek dithyrambs. In both dithyramb and rap – quite regular thoughts are cried out at the edge of frenzy. As in Ancient Greece 2,500 years ago, so today in a complex multiform culture, people, especially young people, are losing their bearings. Words no longer call forth emotional reactions, their prime emotional meaning is lost. By shouting words along with primitive melody and rhythm, a human being limits his or her conscious world, but restores synthesis, connection of conscious and unconscious. An internal world comes to wholeness, reunites with a part of the surrounding culture.

Experimental laboratory evidence supports this analysis, music helps reconciling cognitive dissonances. Cognitive dissonance (CD) is a discomfort caused by holding conflicting elements of knowledge. It is well known that this discomfort is usually resolved by devaluing and discarding a conflicting piece of knowledge (Festinger, 1957; Cooper, 2007; Harmon-Jones et al, 2009).

In a classical CD experiment (Aronson & Carlsmith, 1963) children devalued a toy if they were told that they couldn't play with it. This experiment has been reproduced thousands of times with both children and adults (Cooper, 2007) in various situations, confirming CD theory. The desire ‘to have’ contradicts the inability ‘to attain’; this CD is resolved by discarding the contradiction. Aesop described this predicament 2500 years ago: the fox unable to attain the grape devalues the contradictory cognition by deciding that “the grape is sour.”

However, when the above experiment was reproduced with music playing in the background the toy was not devalued (Masataka & Perlovsky, 2012). Another experiment reproduced the so-called Mozart effect: student's academic test performance improved after listening to Mozart (although this was later ‘debunked’, any improvement was proven to be short-lived, Thompson, Schellenberg, & Husain, 2001). However, Perlovsky et al (2013) used the Mozart effect to explore cognitive functions of music, this publication demonstrated (1) that students allocate less time to more difficult and stressful tests (as expected from CD theory), and (2) with music in the background students can tolerate stress, allocate more time to stressful tests, and improve grades.

These experiments confirmed that music helps overcome undesirable consequences of CD. It follows that music performs a fundamental cognitive function; music makes possible the accumulation of knowledge and thereby enabled human evolution.

The origin, power, and evolution of our musical abilities were considered the “greatest mystery” by Darwin (1871), as well as a topic requiring explanation by Aristotle (1995). Unifying a psyche split by language, enabling the accumulation of knowledge and human evolution is the fundamental cognitive function of music – explaining music's origin and evolution from animal cries to Bach and Lady Gaga (Perlovsky, 2013a).

7. SUMMARY AND FURTHER DIRECTIONS

From Aristotle to the 20th century cognitive science musical power over human soul and body has remained mysterious. Contemporary evolutionary psychologists have recognized music as a cultural universal of tremendous power; still its fundamental role and function in cognition, its role in evolution of consciousness and culture have remained hidden. The paper discussed past scientific hypotheses of the role and function of music, their insufficiencies, and a new theory that musical emotions fundamental role in cognition is to reconcile cognitive dissonances created by knowledge, and enable the evolution of consciousness and culture.

This theory explains musical emotional mechanisms by relating them to primordial connections between voicing and emotions. It explains the function of music in differentiating emotions for the purpose of restoring the unity of self. Musical emotions help maintain a sense of purpose of ones life in face of multiplicity of contradictory knowledge, or what we called the “synthesis of differentiated consciousness.”

According to this hypothesis, the origins of music are tied to the origins of language. Language emerged by differentiating the original unity of primordial self. Original psychic states of unified concept-emotion-behavior-vocalization were differentiated, so that concepts shed off their inextricable connections to emotions and motivation, and deliberate thinking-conversations became possible. The price for this differentiation was the loss of the unity of self, lost concentration of will. Our ancestors, who could maintain concentration of will, while differentiating the knowledge about the world, received unparalleled evolutionary advantage. Thus an evolutionary pressure originated to enhance the emotional part of primordial vocalization that became transformed into music.

I discussed empirical evidence confirming this theory. One line of evidence is parallel changes in musical styles, cultures, and consciousness. Laboratory experimental studies confirmed theoretical predictions that music helps overcoming cognitive dissonances and cognitive interference (Masataka & Perlovsky 2012, 2013; Cabanac et al, 2013; Perlovsky et al, 2013).

The proposed theory of the origins and functions of musical emotions addresses numerous questions, many of which remained open for millennia. Therefore, a program revealing neural mechanisms as well as studies of the function of music are necessary along with experimental laboratory tests, empirical ethnomusicological, anthropological, and historical studies.

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