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Domain-specific character of tonal cognition and its consequences for the semiotics of music

ABSTRACT: The experience of tonal relations elicits different emotions of stability in listeners. Thus, tonality can be understood as a tool of emotional communication. For many semioticians every communicative phenomenon should be explained in terms of the sign theory. However, the pre-conceptual character of emotions of stability raises doubts about the applicability of a semiotic framework as a means of interpreting tonality. According to the author's opinion, the applicability of a semiotic framework in music research is useful only if there is a single system for generating meaning in the brain, which is engaged in the processing of all kinds of meanings in language, music, and other communicative phenomena. Both music and language are complex phenomena which, in fact, share many communicative mechanisms. Nevertheless, they also possess traits which are specific solely to each. If the evolution of music and language branched out at some point in the anthropogenesis, some of music's communicative features (among them tonality) would have become domain-specific. This means that the interpretation of a tonal message is based on another rule, and not the one involved in the interpretation of meaning in language. Thus, interpreting the message of tonality in terms of the semiotic sign theory is not a legitimate procedure. From this point of view, the only way of applying the semiotic framework to research into tonality is to understand signs in a purely functional sense, independent of the process of interpretation. Such an understanding of signs necessitates, however, a reformulation of semiotics.

KEYWORDS: tonality, pitch syntax, musical meaning, emotions of stability, evolution of vocal communication, semiotics

Introduction

Undoubtedly, one of music's crucial functions is to serve communication.[1] Therefore, it is no surprise that music has become a research subject of semiotics understood as a study of communication by means of signs. However, from

[1] Cf. Anna Czekanowska, "U podstaw przesłania muzycznego: imperatyw dialogu czy potrzeba piękna," in *Muzyka w kontekście kultury*, ed. Melecka T.S.K., Janicka-Słysz M. (Kraków: Akademia Muzyczna w Krakowie, 2001), 575–88., Maciej Jabłoński and Piotr Podlipniak, "Music as a Medium of Communication. Two Visions of Musicology," *Interdisciplinary Studies in Musicology*, no. 7 (2008). David J. Hargreaves, Raymond A.R. MacDonald, and Dorothy Miell, "How do People Communicate Using Music?," in *Musical Communication*, ed. Dorothy Miell,

the behavioral point of view, people communicate by means of music in a specific way. Although there are definitely cross-cultural differences in the scope of musical communication,[2] the culturally insurmountable restriction of music seems obvious as far as the exchange of meaning is concerned. The restriction is evident if one contrasts music with natural language. Music and language are often compared on the assumption that both are culturally elaborated phenomena which belong to human universals.[3] The comparison of these two phenomena is all the more reasonable since among the forms of vocal communication specific to humans only music and language represent the complex, generative form of communication[4] known as the "Humboldt system".[5] Moreover, as far as it is known, this kind of communicative complexity is observed solely in our species,[6] which suggests that humans are endowed with some specific communicative abilities related to these two phenomena. All these observations provide grounds for the claim that music and language are the most advanced forms of human communication. Nevertheless, the specificity of language consists in the transmission of propositional meaning which is all but absent in music. As a consequence, music seems to be much more ambiguous than language even if language is used in an intentionally specific way, as in the case of poetry.[7] This fundamental difference between music and language causes some difficulties for every semiotic approach to music.

Raymond A.R. MacDonald and David J. Hargreaves (Oxford, New York: Oxford University Press, 2005), 1–25.

[2] Cf. Jerome Lewis, "A Cross-Cultural Perspective on the Significance of Music and Dance to Culture and Society: Insight from BaYaka Pygmies," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 45–65.

[3] Cf. Donald E. Brown, *Human universals* (New York: McGraw-Hill, 1991).

[4] Aniruddh D. Patel, "Sharing and Nonsharing of Brain Resources for Language and Music", in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 329–55.

[5] "Humboldt systems" are "[...] systems which generate infinite diversity by finite means [...]. [...] [T]he phenomenal diversity of forms exhibited by these systems is based upon the fact that the combining elements on which they are based, be they atoms, genes or phonemes/morphemes, are discrete and do not blend by averaging their properties on combining as do many other phenomena in nature, such as coloured liquids or quantities of heat." Björn Merker, "Music: The Missing Humboldt system," *Musicae Scientiae*, 6/3 (2002), 4.

[6] Björn Merker, "Is There a Biology of Music, and Why Does it Matter?," in *Proceedings of the 5th triennial conference of the European Society for the Cognitive Sciences of Music (ESCOM): Hanover University of Music and Drama, September 8–13, 2003*, ed. Reinhard Kopiez (Hanover: Inst. for Research in Music Education, 2003), 402–5.; W.T. Fitch and Klaus Zuberbühler, "Primate Precursors to Human Language: Beyond Discontinuity," in *Evolution of Emotional Communication: From Sounds in Nonhuman Mammals to Speech and Music in Man*, ed. Eckart Altenmüller, Sabine Schmidt and Elke Zimmermann, 1st ed., Series in affective science (Oxford: Oxford University Press, 2013), 26–48.

[7] Ian Cross, "Music and meaning, ambiguity and evolution," in *Musical Communication*, ed. Dorothy Miell, Raymond A. R. MacDonald and David J. Hargreaves (Oxford, New York: Oxford University Press, 2005), 27–43.

According to many semioticians the main goal of semiotics is to deliver a useful framework[8] applicable in all possible studies of meaning,[9] and music research is, after all, one of such studies. This assumption leads, however, directly to the fundamental question of the nature of musical meaning, which in turn is related to the more general issue of the human brain's interpretative function. As participants in the debate on the relationship between language, music and the brain, initiated by Michael A. Arbib, have recently emphasized, there are two possible solutions to the issue of musical meaning in so far as semiotic reasoning is linked to brain research. Either the different forms of meaning — e.g. propositional and affective — are processed by distinct neural systems, or a single meaning-creating system is engaged in the processing of all kinds of meanings in language, music, and action.[10]

Because the generation of meaning (i.e. the interpretation of signs) is always based on brain processes, only the latter solution justifies the application of one semiotic framework in order to explain all forms of communicative systems. The challenge in the application of such a framework is to demonstrate that the interpretative capabilities of people emerged as a result of a single system for creating meaning in the human brain. This system should be understood as an essential evolutionary innovation of *Homo sapiens* or our closest ancestors. According to Deacon, for example, in the course of evolution, structural changes occurred in the brain's motivational systems which made this general interpretative function possible.[11] From this perspective, music and language represent "[...] different regions of a language-music continuum'[12] or "[...] different aspects of the same domain [...]'[13] rather than two separate phenomena.

[8] Some semiotitians believe that a new "grand semantic theory" will regain authority and "[...] will transcend the discussion of just one cognitive capacity, or just one symbolical form" (Mihailo Antović, "Linguistic semantics as a vehicle for the semantics of music," in *Proceedings of the Conference on Interdisciplinary Musicology (CIM04)*, ed. Richard Parncutt, Annekatrin Kessler and Fränk Zimmer (Graz: University of Graz, 2004), 11).

[9] From this perspective the framework is not restricted only to the human specific communicative systems but should be applicable to all possible forms of communication observed in the living world (cf. Thomas A. Sebeok, *Perspectives in Zoosemiotics* (The Hague: Mouton, 1972).; Dario Martinelli, *Zoosemiotics: Proposals for a handbook,* Acta semiotica Fennica 26 (Imatra: International Semiotics Institute, 2007).

[10] Uwe Seifert et al., "Semantics of Internal and External Worlds," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29, 214.

[11] Terrence William Deacon, *The symbolic species: The Co-evolution of Language and the Brain*, 1st ed. (New York: W.W. Norton, 1998).

[12] Uwe Seifert et al., "Semantics of Internal and External Worlds," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29, 214.

[13] Michael A. Arbib, "Five Terms in Search of a Synthesis," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 3–44, 21.

Identifying the distinct neural system or systems responsible for the processing of music-specific meaning is necessary, in turn, to exclude at least some musical meaning from the explanation based on one universal semiotic framework. If such a distinct music-specific kind of meaning actually exists then the semiotic approach to music has to create new analytical and interpretative tools in order to explain the whole communicative potential of music. Although language and music share many communicative mechanisms, I claim that they also consist of some domain-specific elements which have evolved because of different selective pressures. These elements are, in evolutionary terms, the most recent communicative innovations which have occurred in the *Homo sapiens* lineage and which are related to the aforesaid characteristics of the "Humboldt system" observed both in language and music. In my opinion, tonality belongs to these innovations in the domain of music.[14] It does not mean that music is entirely devoid of the potential for transmitting referential meaning. In fact music is a powerful means of eliciting memories, imagery and associations[15] which are definitely propositional by their very nature. Apart from this, musical sounds or phrases can be used as iconic, symbolic or even indexical signs.[16] This kind of meaning is called "designative meaning'[17] or "extra-musical meaning".[18] Moreover, there is evidence that listening to music evokes the event-related potential (ERP) N400[19] which is an electrophysiological marker of conceptual (semantic[20]) processing.[21] However, these kinds of meanings are not

[14] Cf. Piotr Podlipniak, "Tonality as One of the "Music-Specific" Adaptations," in *E-proceedings of the XIIth International Congress of Musical Signification*, ed. Mark Reybrouck et al. (Louvain-la-Neuve: Université catholique de Louvain and Académie Royale de Belgique, 2013).

[15] David J. Hargreaves, Raymond A. R. MacDonald, and Dorothy Miell, "How do People Communicate Using Music?," in *Musical Communication*, ed. Dorothy Miell, Raymond A. R. MacDonald and David J. Hargreaves (Oxford, New York: Oxford University Press, 2005), 1–25, 1–25.

[16] Maciej Jabłoński, *Muzyka jako znak: Wokół semiotyki muzyki Eero Tarastiego,* Prace Komisji Muzykologicznej 11 (Poznań: Wydawn. Poznańskiego Towarzystwa Przyjaciół Nauk, 1999).

[17] Leonard B. Meyer, *Emotion and Meaning in Music* ([Chicago]: University of Chicago Press, 1956), 35.

[18] Stefan Koelsch, "Towards a neural basis of processing musical semantics," *Physics of Life Reviews,* 2011, doi:10.1016/j.plrev.2011.04.004, 89–105, 90.

[19] The N400 component in the ERP is elicited by the processing of such stimuli as words, environmental sounds, pictures, faces, and odors (Ibid., 92). All these stimuli are related to conceptually meaningful information.

[20] It is worth mentioning that the term "semantics" is used here not in a narrow linguistic sense i.e. as lexical or propositional semantics but in a broad meaning as every semiotic relation. In this sense (used e.g. by Koelsch, ibid.), however, it can be applied to relations which, according to Reich, "[...] constitute a basic property of all cognitive systems of human beings and thus are relevant both for music and language — and for the whole meaningful world of human experience" (121). Yet, it seems that some meaningful experiences (such as affective or sensorimotor impressions) have to be excluded from these semiotic phenomena.

[21] Cf. e.g. Ellen F. Lau, Colin Phillips, and David Poeppel, "A cortical network for semantics: (de)constructing the N400," *Nature Reviews Neuroscience* 9, no. 12 (2008), doi:10.1038/nrn2532.

specific solely to music and language.[22] Meanwhile, various sensations of stability which accompany music perception seem to exemplify another, qualitatively different kind of meaning which represents a distinctive musical feature.[23] Thus, the features of music which are responsible for these sensations cannot be explained in terms of the traditional semiotic approach (e.g. as mere Peirce's signs: index, icon or symbol of something).[24] One such feature is tonality.

Affective and propositional meaning and the evolution of vocal communication

One of the shared communicative components of music and speech is "expressive dynamics'[25] also known as "affective prosody".[26] This form of communication conveys emotional information by means of modulation of acoustic cues such as sound intensity, fundamental frequency (F0), and tempo.[27] There is evidence that affective prosody is an evolutionarily old form of vocal communication which is understandable not only by all humans but also by species of other mammalian taxa.[28] Moreover, some elements of affective prosody (e.g. intensity

[22] According to some scholars, the process of semiosis can be evoked by the process of auditory scene analysis (Albert S. Bregman, *Auditory Scene Analysis: The perceptual organization of sound* (Cambridge, Mass: MIT Press, 1990).) in which the smallest sound segment corresponds to a defined meaning (A. Frey et al., "An experimental validation of Temporal Semiotic Units and Parameterized Time Motifs," *Musicae Scientiae* 18, no. 1 (2014), doi:10.1177/1029864913516973.). Frey et al (Aline Frey et al., "Temporal Semiotic Units as Minimal Meaningful Units in Music? An Electrophysiological Approach," *Music Perception: An Interdisciplinary Journal* 26, no. 3 (2009), doi:10.1525/MP.2009.26.3.247.) suggest that "Temporal Semiotic Units" function as such minimal units at this level.

[23] Uli Reich, "The meanings of semantics," *Physics of Life Reviews*, 2011, doi:10.1016/j.plrev.2011.05.012.

[24] Cf. Koelsch, "Towards a neural basis of processing musical semantics,'

[25] Björn Merker, "Is There a Biology of Music, and Why Does it Matter?," in *Proceedings of the 5th triennial conference of the European Society for the Cognitive Sciences of Music (ESCOM): Hanover University of Music and Drama, September 8 - 13, 2003*, ed. Reinhard Kopiez (Hanover: Inst. for Research in Music Education, 2003), 402–5.

[26] Elke Zimmermann, Lisette Leliveld, and Simone Schehka, "Toward the Evolutionary Roots of Affective Prosody in Human Acoustic Communication: A Comparative Approach to Mammalian Voices," in *Evolution of Emotional Communication: From Sounds in Nonhuman Mammals to Speech and Music in Man*, ed. Eckart Altenmüller, Sabine Schmidt and Elke Zimmermann, 1st ed., Series in affective science (Oxford: Oxford University Press, 2013), 116–32.

[27] Klaus R. Scherer, "Emotion in Action, Interaction, Music, and Speech," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 107–139.

[28] Elke Zimmermann, Lisette Leliveld, and Simone Schehka, "Toward the Evolutionary Roots of Affective Prosody in Human Acoustic Communication: A Comparative Approach to Mammalian Voices," in *Evolution of Emotional Communication: From Sounds in Nonhuman Mammals*

and tempo) have their counterparts in the domain of gestures.[29] This indicates additionally that affective prosody does not depend solely on vocal control. What characterizes this way of communication[30] is its continuous (non-discrete) character.[31] But language and music are complex phenomena which do not just consist of such a continuous ingredient.

While affective prosody constitutes an inseparable part of the suprasegmental level of language and music structures, the generative character of both is possible thanks to their segmental levels which are composed of a restricted number of discrete components. Since these discrete components are generatively used in language[32] and music[33], which is a specific trait of the human species, it is reasonable to assume that the complexity of music and language has a hierarchical form whose particular elements reflect the stages of the evolution of vocal communication in the *Homo sapiens* lineage.[34] Nevertheless, the presence of affective prosody both in language and music indicates that these phenomena have a common evolutionary origin. In fact, many present-day theories of the origin of music and language assume the existence of a "protolanguage'[35] or a "musilanguage'[36] as the precursors of contemporary music and language. Only the appearance of a discrete set of units allowed the transformation of the precursor

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to Speech and Music in Man, ed. Eckart Altenmüller, Sabine Schmidt and Elke Zimmermann, 1st ed., Series in affective science (Oxford: Oxford University Press, 2013), 116–32.

[29] Cf. Manfred Clynes, *Sentics: The Touch of Emotions*, 1st ed., A Doubleday Anchor book (Garden City, N.Y: Anchor Press, 1977).

[30] Iris Berent calls such a system — i.e. composed of non-discrete elements — "blending systems" (Iris Berent, *The phonological mind* (Cambridge, New York: Cambridge University Press, 2013), 19).

[31] Björn Merker, "Is There a Biology of Music, and Why Does it Matter?," in *Proceedings of the 5th triennial conference of the European Society for the Cognitive Sciences of Music (ESCOM): Hanover University of Music and Drama, September 8–13, 2003*, ed. Reinhard Kopiez (Hanover: Inst. for Research in Music Education, 2003), 402–5.

[32] In the case of language an example of such a combinatorial system is a phonological system which is composed of a set of discrete building blocks — phonemes whose concatenation is based on some tacit combinatorial principles (Berent, *The Phonological Mind*, 21).

[33] In the case of tonal music, the examples of discrete elements are tones which represent pitch classes and possess a particular duration. Thus, pitch and time relations between successive notes are usually treated as their distinctive features (cf. Ludwik Bielawski, "Muzyka jako system fonologiczny," *Res Facta*, no. 3 (1968).

[34] Edward J. Gorzelańczyk and Piotr Podlipniak, "Human singing as a form of bio-communication," *Bio-Algorithms and Med-Systems*, 7/14 (2011).

[35] W. T. Fitch, "The biology and evolution of music: A comparative perspective," *Cognition* 100, no. 1 (2006), doi:10.1016/j.cognition.2005.11.009.

[36] Steven Brown, "The "Musilanguage" Model of Music Evolution," in *The Origins of Music: [consists of papers given at a Workshop on the Origins of Music held in Fiesole, Italy, May 1997, the first of a series called Florentine Workshops in Biomusicology]*, ed. Steven Brown, Björn Merker and Nils L. Wallin (Cambridge, Mass. [u.a.]: MIT Press, 2000), 271–300.

into the “Humboldt system”.[37] As a result, both music and language consist of a segmental level of organization.

Yet, the segmental components of speech (phonemes) differ from those of music (single sounds of an established music pitch and duration called tones or notes),[38] and the discrimination of phonemes is based on another cognitive strategy different from the discrimination of tones. The difference between music and language is even more conspicuous in the domain of the juxtaposition of these segmental components into larger entities. However, what constitutes the cardinal difference between music and language is the relation of these larger entities to meaning. The reason why the chunks of units in language, unlike in music, are connected to propositional meaning is, in my opinion, the different adaptive functions fulfilled by the syntactic relations of the elementary units of language and music.

In the semiotic tradition, the combinatorial relations between signs in formal structures are called “syntactics’[39] or “syntax”.[40] In the case of language the most obvious example of syntax is grammar. Despite Chomsky’s claims about the separation of grammar from semantics there is evidence that some grammatical rules are actually strictly connected to propositional meaning.[41] In other words, in order to check the grammatical correctness of some expressions, a knowledge of semantics is necessary. In addition, the semantic restrictions of grammar indicate that grammatical forms can be understood as broad categories of propositional meaning. Even morpho-syntax whose units are deprived of propositional meaning[42] leads eventually to the retrieval of meaning in the process of speech recognition. This process — i.e. the comprehension of words and larger expressions (phrases and sentences) — is based on the principle of semantic compositionality. The rule of compositionality states that “[...] the meaning of an expression is a function of the meanings of its parts and the way they are syntactically combined”.[43] Although in the process of language comprehension nonlinguistic information influences the

[37] Merker, “Music: The Missing Humboldt system.”

[38] Bielawski, “Muzyka jako system fonologiczny.”

[39] Charles W. Morris, *Foundations of the Theory of Signs* (Chicago: The University of Chicago Press, 1938).

[40] Uwe Seifert et al., “Semantics of Internal and External Worlds,” in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29.

[41] Daniel Dor, “From the autonomy of syntax to the autonomy of linguistic semantics: Notes on the correspondence between the transparency problem and the relationship problem,” *Pragmatics & Cognition*, 8/2 (2000).

[42] Since morpho-syntax is deprived of propositional meaning some authors suggest that actually morpho-syntax or syntax of phonology, rather than grammar, are the more relevant analogy of musical syntax (cf. Fred Lerdahl, “Musical Syntax and Its Relation to Linguistic Syntax,” in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 257–272, 260).

[43] Peter Hagoort and David Poeppel, “The Infrastructure of the Language-Ready Brain,” in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 233–255, 235.

interpretation of an utterance, the meaning of the lexical-syntactic frame is the main source of propositional meaning.

Although tonality in music is hierarchical, like phonological or grammatical systems in language, the tonal hierarchy is different in essence from phonological or grammatical hierarchies. The specific character of tonality is related to the psychological representation of stability upon which every tonal hierarchy is based.[44] This means that certain tones are perceived as more stable than others. Tones in a well-formed tonal sequence are alternated depending on their stability. Thus, ill-formed tonal sequences are perceived as wrong because some more or less stable tones have appeared in the wrong place. In contrast, an ill-formed syllable is not unstable in terms of our psychological experience.[45] It shows that, as Iris Berent observes, "[...] despite their common reliance on hierarchical organization, musical and phonological hierarchies are different in kind".[46] The same is true as far as language grammar is concerned. The grammatical hierarchy in a sentence does not depend on feelings of stability. A noun in a sentence is not more or less important in a grammatical grid due to its emotional tinge but to its propositional meaning. Since psychological stability is absent from all language generative systems but is crucial for the correctness of tonal sequence, it is reasonable to suppose that it is stability itself which is the main information transmitted by tonality. However, the feeling of stability is a positive reaction to a stimulus which is important to survival. Although, according to David Huron, the specific emotional reactions to tonal features are explained by the mechanism of misattribution,[47] the unique character of tonal stability suggests a specific adaptive function of tonality.[48] From this point of view tonal sequences inform us about the realization of this function. Yet people are usually unaware of the actual ultimate function of their behavior[49] even if they are conscious of their emotional reactions to its fulfilment. This is

[44] Fred Lerdahl and Ray Jackendoff, *A Generative Theory of Tonal Music* (Cambridge, Mass: MIT Press, 1983).

[45] Berent, *The Phonological Mind.*, 31.

[46] Ibid.

[47] Huron claims that the fulfilled or unfulfilled predictions of stimuli cause emotional reactions due to the adaptive value of the general ability of prediction. The feeling of stability which accompanies the perception of tonic is incorrectly attributed to a particular tone because our brains have learned statistically to expect it and thus associate the feeling of stability generated by successful prediction with melodic context specific to the appearance of tonic (David Brian Huron, *Sweet Anticipation: Music and the Psychology of Expectation*, 1st ed. (Cambridge, Mass, London: MIT, 2006).

[48] Cf. Piotr Podlipniak, "Specific Emotional Reactions to Tonal Music - Indication of the Adaptive Character of Tonality Recognition," in *Proceedings of the 3rd International Conference on Music & Emotion (ICME3)*, ed. Geoff Luck and Olivier Brabant (Jyväskylä: University of Jyväskylä, Department of Music, 2013).

[49] Candace S. Alcorta, Richard Sosis, and Daniel Finkel, "Ritual harmony: Toward an evolutionary theory of music," *Behavioral and Brain Sciences*, no. 31 (2008), doi:10.1017/S0140525X08005311.

because emotion acts as an evaluative and motivational mechanism which tells us what we should do and what is good or bad for us rather than why it is good or bad.[50] All in all, the feeling of stability by itself can be understood as a meaning.

Different kinds of psychological stability experienced during listening to tonal music are often described as emotional qualia.[51] Thus, in contrast to conceptual meaning whose transmission seems to be the main function of language, the communicative content of tonal sequences consists of affective meaning which is pre-conceptual.[52] This kind of meaning is often related to an "internal world" whereas propositional meaning[53] is related to an "external world".[54] Importantly, tonality seems to be the only natural generative system whose function is to transmit affective meaning. Although people express affective meaning in speech they do that by means of prosody which is not generative. However, are the affective meaning of tonality and the propositional meaning of the lexical-syntactic frames in language actually different in kind? Is there any dissimilarity in the brain's activity during the processing of language and tonal syntaxes?

The processing of music and language syntaxes

Although not all scholars accept that musical structure is syntactic,[55] there are studies which provide evidence for an overlap between the processing of music and of language structures.[56] This overlap is often interpreted as evidence of

[50] Cf. Marcello Mortillaro, Marc Mehu, and Klaus R. Scherer, "The Evolutionary Origin of Multimodal Synchronization and Emotional Expression," in *Evolution of Emotional Communication: From Sounds in Nonhuman Mammals to Speech and Music in Man*, ed. Eckart Altenmüller, Sabine Schmidt and Elke Zimmermann, 1st ed., Series in affective science (Oxford: Oxford University Press, 2013), 3–25.

[51] Huron, *Sweet Anticipation*.; Elizabeth Hellmuth Margulis, *On Repeat: How Music Plays the Mind* (New York: Oxford University Press, 2014).

[52] Uwe Seifert et al., "Semantics of Internal and External Worlds," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29.

[53] Sometimes concepts can be used to describe an "internal world" as in the case of language descriptions of pain, sensations, emotions etc. However, these descriptions refer to the concepts of pain, sensations, and emotions while pre-conceptual affective meaning works by direct elicitation of emotions.

[54] Ibid.

[55] Justin London, "Schemas, not syntax: a reply to Patel," in *Language and music as cognitive systems: [volume based on an eponymous conference, Cambridge, 11–13 may 2007*, ed. Patrick Rebuschat, Martin Rohrmeier and John A. Hawkins (New York, N.Y: Oxford University Press, 2012), 242–247.

[56] Aniruddh D. Patel et al., "Processing syntactic relations in language and music: an event-related potential study," *Journal of cognitive neuroscience* 10, no. 6 (1998).; Burkhard Maess et al., "Musical syntax is processed in Broca's area: an MEG study," *Nature neuroscience* 4, no. 5 (2001), doi:10.1038/87502.; Steven Brown, Michael J. Martinez, and Lawrence M. Parsons, "Music and

the existence of at least some neural resources whose specific function is syntactic processing and which are thus specific both to language and to music processing.[57] On the other hand, in order to process musical syntactic structure, it is necessary to analyze some aspects of music which are absent from language. One of them is definitely the recognition of pitch hierarchy. Apart from cognitive segmentation of a heard sound stream into discrete units – pitch classes, this process necessitates sequencing them, abstracting a pitch center, and keeping the pitch center in working memory.[58] Although analogous tasks are important for language syntax processing (segmentation of speech into discrete entities, sequencing the phonemes, syllables and words listened to, retrieval of syntactic and semantic information, and keeping the words in working memory[59]), the statistical analysis of subsequent events (pitch classes in the case of music;[60] phonemes, syllables or words in the case of language) is crucial only for the processing of music syntax. After all, statistical analysis of events is necessary for the recognition of a pitch center but not for establishing whether a word is the object or subject etc. Even in the case of morpho-syntax, the statistics of phonemes and morphemes are less important for their arrangement than phonological rules and processes which depend on other factors,[61] although the application of these rules and processes definitely results in some statistical regularity of phonological sequences.

The performance of all analogous tasks by the human brain is interpreted as the reason behind the aforementioned neuronal overlap observed between the processing of music and language structures.[62] However, the activity of shared neuronal

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language side by side in the brain: a PET study of the generation of melodies and sentences," *European Journal of Neuroscience* 23, no. 10 (2006), doi:10.1111/j.1460–9568.2006.04785.x.; Evelina Fedorenko et al., "Structural integration in language and music: Evidence for a shared system," *Memory & Cognition* 37, no. 1 (2009), doi:10.3758/MC.37.1.1.

[57] Aniruddh D. Patel, "Language, music, syntax and the brain," *Nature Neuroscience* 6, no. 7 (2003), doi:10.1038/nn1082.

[58] Stefan Koelsch, "Response to target article "Language, music, and the brain: a resource--sharing framework"," in *Language and Music as Cognitive Systems: [volume based on an eponymous conference, Cambridge, 11–13 may 2007*, ed. Patrick Rebuschat, Martin Rohrmeier and John A. Hawkins (New York, N.Y: Oxford University Press, 2012), 224–234, 225.

[59] Peter Hagoort and David Poeppel, "The Infrastructure of the Language-Ready Brain," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 233–255.

[60] Carol L. Krumhansl, *Cognitive Foundations of Musical Pitch,* Oxford psychology series 17 (New York: Oxford University Press, 1990).

[61] Michael Kenstowicz, "Phonological Rules and Processes," in *The MIT Encyclopedia of the Cognitive Sciences*, ed. Robert A. Wilson and Frank C. Keil (Cambridge (Mass.) [etc.]: MIT Press, op. 1999), 637–639.; Berent, *The Phonological Mind.*

[62] Patel, "Language, music, syntax and the brain,'; Stefan Koelsch, "Response to target article "Language, music, and the brain: a resource-sharing framework"," in *Language and Music as Cognitive Systems: [volume based on an eponymous conference, Cambridge, 11–13 may 2007*, ed. Patrick Rebuschat, Martin Rohrmeier and John A. Hawkins (New York, N.Y: Oxford University Press, 2012), 224–34.

structures during the processing of music and language syntaxes does not necessarily mean that these structures are dedicated merely to syntactic processing. Neither does this prove beyond doubt that music and language syntaxes are based on the same adaptive functions in terms of evolution. As has been indicated, the same neural structures which are active during syntax processing are also involved in other tasks. For example, premotor areas, mainly the ventrolateral premotor cortex, are activated during the prediction of sequential order.[63] Similarly, Broca's area, whose activity is usually associated with music and language syntax processing,[64] is also involved in other types of analysis such as mathematical tasks,[65] aspects of action representation,[66] and goal-directed behavior.[67]

These functional heterogeneities of cortical areas weigh in favor of the existence of functional neural systems dedicated to processing complex phenomena instead of modular organization specific solely to syntax processing. From this point of view, a particular neuroanatomical structure can support many different circuits that perform different tasks.[68] Only the specificity of a given circuit's connections represents the functional specificity of processing a particular complex phenomenon. The possible evolution of such new slightly modified (extended or reduced) circuits is consistent with evolutionary logic i.e. tinkering in an opportunistic way instead of constructing new tools from scratch.[69] From the evolutionary point of view, however, the main question concerns the genesis of a particular circuit structure, whether its connectivity develops in response to genetic predispositions or it is molded mainly by environmental influences during ontogenesis. The ubiquity of tonal music which is based on a pitch hierarchy and the intuitive recognition of tonic suggest that the processing of music pitch organization is instinctive – i.e. at least some of the abilities required for the processing activity emerged in the process of natural selection.[70]

[63] Ibid.

[64] Luciano Fadiga, Laila Craighero, and Alessandro D'Ausilio, "Broca's Area in Language, Action, and Music," *Annals of the New York Academy of Sciences* 1169, no. 1 (2009), doi:10.1111/j.1749–6632.2009.04582.x.

[65] Roland Friedrich, Angela D. Friederici, and André Aleman, "Mathematical Logic in the Human Brain: Syntax," *PLoS ONE* 4, no. 5 (2009), doi:10.1371/journal.pone.0005599.

[66] Fadiga, Craighero and D'Ausilio, "Broca's Area in Language, Action, and Music,'; Etienne Koechlin and Thomas Jubault, "Broca's Area and the Hierarchical Organization of Human Behavior," *Neuron* 50, no. 6 (2006), doi:10.1016/j.neuron.2006.05.017.

[67] John Duncan, "The multiple-demand (MD) system of the primate brain: mental programs for intelligent behaviour," *Trends in cognitive sciences* 14, no. 4 (2010), http://linkinghub.elsevier.com/retrieve/pii/S1364661310000057.

[68] Cf. Philip Lieberman, *Human Language and our Reptilian Brain: The Subcortical Bases of Speech, Syntax, and Thought,* Perspectives in cognitive neuroscience (Cambridge, Mass: Harvard University Press, 2000), 6.

[69] François Jacob, "Evolution and Tinkering," *Science*, 196/4295 (1977).

[70] Cf. Eva Jablonka and Marion J. Lamb, *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life,* Life and mind (Cambridge, Mass: MIT Press, 2005), 286.

What differentiates music syntax from language syntax, apart from structural differences between music and language, is the specific role of emotions in music syntactic organization. The emotional quality of every pitch class experience is necessary to establishing tonal hierarchy.[71] Therefore, the difference between the processing of language syntax and music syntax concerns not only the type of elements processed (phonemes, syllables, words in language, tones in music) but also the way of inferring the syntactic function of a particular element (e.g. recognition of word order, inflectional endings, grammatical tone etc. in the case of language; statistical analysis of pitch occurrence in the case of music). In both cases, however, the results of the analyses allow individuals to create a sequence of expectations which are believed to be a source of emotional experience.[72]

However, the emotional reaction related to music expectancies seems to be much stronger than that to speech predictions. Importantly, in the process of speech recognition the contextually based predictions are equally important.[73] Yet, while in the case of speech perception they are crucial for the comprehension of grammatical and lexical meaning, in the case of music they are used to establish the psychological representation of stability. This indicates that the predictions play another, specific function during the apprehension of music syntax. For example, the statistically-based prediction of pitches which allows recognition of a particular pitch class as a pitch center is facilitated by a feeling of relaxation. Thus, the expectancy-based emotional assessment of a particular pitch indicates the syntactic function of a particular pitch. Although from the structural point of view, the syntactic functions of pitches are related solely to their pitch contexts,[74] the actual apprehension of pitch syntactic relations in music is based on a subtle coupling between emotional assessment and the analysis of pitch structure. Similarly, the apprehension of the grammatical meaning of a language sentence often necessitates an understanding of semantics.[75] However, while in the case of musical pitch structure its syntactic order depends on pre-conceptual emotional assessment, in language syntax it is strictly connected with a conceptual and propositional meaning. This observation has important evolutionary implications.

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[71] Nikolaus Steinbeis, Stefan Koelsch, and John A. Sloboda, "The role of harmonic expectancy violations in musical emotions: evidence from subjective, physiological, and neural responses," *Journal of cognitive neuroscience* 18, no. 8 (2006), doi:10.1162/jocn.2006.18.8.1380.; Stefan Koelsch, Thomas Fritz, and Gottfried Schlaug, "Amygdala activity can be modulated by unexpected chord functions during music listening," *NeuroReport* 19, no. 18 (2008), doi:10.1097/WNR.0b013e32831a8722.

[72] Meyer, *Emotion and Meaning in Music.*; Huron, *Sweet anticipation.*

[73] Peter Hagoort and David Poeppel, "The Infrastructure of the Language-Ready Brain," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 233–255, 234.

[74] Huron, *Sweet anticipation.*

[75] Dor, "From the autonomy of syntax to the autonomy of linguistic semantics".

On the one hand, if the ability to recognize pitch centricity evolved earlier than language, it is very probable that language perception involves partly the same neuroanatomical structures which are necessary in pitch sequence perception. After all, both pitch and speech perception operate in the same modality and their structures serve as communicative tools. Their structural complexity necessitates application of extended working memory which implements sound rehearsal. In order to act efficiently, both systems need implicit knowledge acquired during their development in a cultural environment. Finally, because both systems are parts of culturally elaborated phenomena, the processing of pitch syntax and language syntax must be open to include in their systems some culture-specific innovations. In fact, neuroimaging studies show that non-musicians during rehearsal of tonal information rely on neural structures that overlap in their brain topography with those involved in the rehearsal of verbal information.[76] This overlap indicates that in the course of evolution many neuronal structures involved in the working memory of sounds appeared useful in both speech and music processing. However, in musicians, who devote more time to music training than non-musicians, the aforementioned overlapping structures are activated more strongly compared to non-musicians.[77] Apart from that, musicians rely during tonal rehearsals on additional neural subcomponents.[78] These observations suggest that the cultural environment (i.e. musical training which consists in the long-term learning of associations between pitch information and motor schemas) can create specific cognitive strategies which are based on specific functional neuronal circuits. In the case of musicians who are regularly exposed to musically elaborated circumstances, the specificity of cognitive strategies is realized by including in the existing neuronal circuit new neuronal structures instead of creating a completely new module.

On the other hand, while the pitch hierarchy recognition involves neuroanatomical structures which are shared with language processing, the structural difference between music pitch sequences and speech sound organization necessitates at least some specific neuronal resources. First of all, tonality as a feature which is

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[76] Robert J. Zatorre, Alan C. Evans, and Ernst Meyer, "Neural mechanisms underlying melodic perception and memory for pitch," *The Journal of Neuroscience: the Official Journal of the Society for Neuroscience* 14, no. 4 (1994).; Stefan Koelsch et al., "Functional architecture of verbal and tonal working memory: An FMRI study," *Human Brain Mapping* 30, no. 3 (2009), doi:10.1002/hbm.20550.

[77] Katrin Schulze and Stefan Koelsch, "Working memory for speech and music", *Annals of the New York Academy of Sciences* 1252, no. 1 (2012), doi:10.1111/j.1749–6632.2012.06447.x.

[78] Katrin Schulze, Karsten Müller, and Stefan Koelsch, "Neural correlates of strategy use during auditory working memory in musicians and non-musicians," *European Journal of Neuroscience* 33, no. 1 (2011), doi:10.1111/j.1460–9568.2010.07470.x.

cross-culturally ubiquitous[79] and easily recognizable by non-musicians[80] must be processed by a neuronal circuit whose development does not demand elaborate long-term learning (like the learning of writing). It suggests that people are endowed with a propensity for the development of a neural circuit dedicated to the processing of sound stimuli which are characterized by such occurrence of pitches that allows inferring a pitch center and, in consequence, creating tonal hierarchy. In fact, according to a neuroimaging study by Daniela Perani and colleagues,[81] neonatal neural activity depends on the pitch structure of music stimuli. In this study, it was only the processing of the tonal music excerpt that was characterized by right-hemispheric dominance similar to adult non-musicians. Interestingly, the differently lateralized activation of subcortical areas related to emotional processing was also observed in response to different stimuli (tonal music excerpt versus altered music with short-lasting key shifts), which suggests that emotional assessment is a part of the structural analysis of pitch order (the stimuli used in the study differed only in pitch organization[82]). All these characteristics of a functional neuronal specificity at such a young age (none of the neonates examined were older than three days) imply a developmental facilitation of structural pitch processing by some genetic predispositions which, in turn, suggest the functional specialization of the structural pitch processing.

Evidently, the processing of tonality is a complex phenomenon which involves many sub-processes, among which pitch hierarchy recognition is only one element. As a matter of fact, in the complex music phenomena tonally stable pitches co-occur with metrically stable temporal positions creating a tonal-metric hierarchy.[83] However, the fact that a tonal hierarchy is observed also in free rhythm music suggests the relative autonomy of this hierarchy. Moreover, tonally stable pitches facilitate the recognition of on-beat position in the bar whereas temporal position seems to have no effect on tonal assessment.[84] This observation suggests that a pitch structure is probably a more important musical feature as a source of stability sensation. All

[79] Nicholas Bannan, "Harmony and its role in human evolution," in *Music, Language, and Human Evolution*, ed. Nicholas Bannan (Oxford: Oxford University Press, 2012), 288–339, 309–310.

[80] Carol L. Krumhansl, "The Cognition of Tonality — as We Know it Today," *Journal of New Music Research* 33, no. 3 (2004), 253–268.

[81] Daniela Perani et al., "Functional specializations for music processing in the human newborn brain," *Proceedings of the National Academy of Sciences* 107, no. 10 (2010), doi:10.1073/pnas.0909074107.

[82] Ibid., 4759.

[83] Jon B. Prince and Mark A. Schmuckler, "The Tonal-Metric Hierarchy," *Music Perception: An Interdisciplinary Journal* 31, no. 3 (2014), doi:10.1525/MP.2014.31.3.254.

[84] Jon B. Prince, William F. Thompson, and Mark A. Schmuckler, "Pitch and time, tonality and meter: How do musical dimensions combine?," *Journal of Experimental Psychology: Human Perception and Performance* 35, no. 5 (2009), doi:10.1037/a0016456.

these aforesaid characteristics of tonality suggest that the circuit connections which are responsible for the processing of tonal relations are domain-specific. This means that these connections represent a functionally specialized unit.

Tonality and semiotics

What does the knowledge of processing and functional specificity of tonality tell us about its semiotic character? First of all, if the function of tonal structure is to highlight group cohesion by means of sensation of stability, tonal relations can be understood as indexes. In such a case, the sensations of stability are the direct effects of group consolidation. Thus, there is a causal relation between the state of cohesion and experienced emotions of stability which are communicated by means of music pitch structure. Importantly, the process of communication is realized here without any conceptual analysis. However, such an interpretation can cause some problems. For example, according to Stefan Koelsch, the analysis of harmonic context gives rise to so called "intra-musical" meaning.[85] Because "intra musical" meaning is not referential, it is neither indexical[86] nor iconic. For the same reason it is also not symbolic.[87]

Koelsch admits, however, that "[...] the structural relations of musical events can also lead to emotional responses (such as surprise, increase in tension, etc.) [...]'[88] which, according to Koelsch, represent another type of meaning namely "mu-

[85] Koelsch, "Towards a neural basis of processing musical semantics,", 95–96.

[86] According to Koelsch, "[...] intra-musical meaning is not the iconic meaning (or a metaphorical meaning) of extra-musical concepts such as "build-up", "extent", "stability", etc., but the meaning emerging from harmonic integration due to the establishment of a structural model, its modifications, etc." (99).

[87] Some authors e.g. Scherer and Zentner suggest that certain "[...] suprasegmental features seem to carry emotional information primarily through *symbolic coding* [italics original], as based on a process of historically evolved, sociocultural conventionalization" (Klaus R. Scherer and Marcel R. Zentner, "Emotional Effects of Music: Production Rules," in *Music and Emotion: Theory and Research*, ed. Patrik N. Juslin and John A. Sloboda, Series in affective science (Oxford, New York: Oxford University Press, 2001), 361–392, 364). However, feelings of stability which are specific to the experience of tonal relations depend both on conventions (pitch classes statistics characteristic of a particular musical idiom) and the species-specific cognitive mechanism of pitch structure prediction which functions independent of culture (cf. Huron, *Sweet Anticipation*.). Thus, different emotions of stability which are experienced during listening to tonal relations are neither entirely conventional nor arbitrary and, because of that, they cannot be understood as symbols. Of course it is possible that some tonal relations become symbols similar to words in language (e.g. key categories can act as a symbolic emotional code cf. Jarosław Mianowski, "On Three Paradigms of Emotional Communication in Music," *Interdisciplinary Studies in Musicology*, 2008). In such a case, however, the meaning of the tonal relations in question is extra-musical. Importantly, the symbolic meaning of tonal relations does not exchange for, or annihilate, their intra-musical meaning.

[88] Koelsch, "Towards a neural basis of processing musical semantics", 99.

sicogenic" meaning.[89] Nevertheless, the emotional responses of stability are, in my opinion, not only inseparable from the experience of music syntax but, because they determine the comprehension of tonal relations, they are actually a part of music syntax processing. In other words, we know that a perceived pitch class or chord is tonic not because of the conceptual analysis of the pitch structure but because of the feeling of stability which accompanies the perception of such a pitch class or a chord.[90] This explains the intuitive and pre-attentional character of tonality perception. Thus, the meaning evoked by tonal relations should be interpreted as at least partly affective. Musical affective meaning is sometimes understood as iconic.[91] The reason for such a semiotic interpretation of emotional content of music comes from the assumption that music does not express emotions but mimics them.[92] In fact, even if music really mimics[93] something, it is more likely to be other vocal expressions of emotions rather than emotions themselves. Moreover, insofar as it is possible to search for imitations among the so called "music performance features," tonal relations do not resemble any human (or nonhuman) vocal expressions. As far as the expressive character is concerned, the means by which tonality elicits emotion is unique. Because of that, no tonal relation can be understood as an icon of a particular emotion.[94]

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[89] Ibid., 100.

[90] This clearly does not exclude the possibility that, apart from the intuitive recognition of tonal relations, some people (e.g. musicologists, musicians) are able to conceptualize them.

[91] Cf. e.g. Klaus R. Scherer and Marcel R. Zentner, "Emotional Effects of Music: Production Rules," in *Music and Emotion: Theory and research*, ed. Patrik N. Juslin and John A. Sloboda, Series in affective science (Oxford, New York: Oxford University Press, 2001), 361–92, 364; see also Susanne K. Langer, *Philosophy in a New Key: A Study in the Symbolism of Reason, Rite, and Art*, 3rd ed. (Cambridge: Harvard University Press, 1957).

[92] One such assumption is evident in the so called "contour theory" (Peter Kivy, *The Corded Shell: Reflections on Musical Expression* (Princeton: Princeton University Press, 1980).

[93] The problem of music's emotional mimicry is related to the debate between cognitivists and emotivists i.e. theoretical statements concerning the question whether music only expresses emotions or elicits them directly (Stephen Davies, "Philosophical Perspectives on Music's Expressiveness," in *Music and Emotion: Theory and Research*, ed. Patrik N. Juslin and John A. Sloboda, Series in affective science (Oxford, New York: Oxford University Press, 2001), 23–44.). In the case of mimicry emotional reaction to music is due to association between musical elements and that what is imitated, e.g. expression of sadness. However, in the light of contemporary knowledge of cognitive mechanisms responsible for emotional reactions to music – that the processing of emotions during listening to music involves many different brain mechanisms (cf. Patrik N. Juslin et al., "How Does Music Evoke Emotions? Exploring the Underlying Mechanisms," in *Handbook of Music and Emotion: Theory, Research, Applications*, ed. Patrik N. Juslin and John A. Sloboda, Series in affective science (Oxford: Oxford University Press, 2011), 605–42.) – any general statement which explains the connection between music and emotions by means of one mechanism is a dangerous simplification.

[94] Note that no tonal relation can be understood as a symbol of stability either. Although there is an arbitrary component of tonal relations (there are different statistics of tone occurrences in music of various cultures thus the same sequences of tones may cause slightly different emotional

Another semiotic explanation of music's emotional communication refers to indexes. In fact, from a broad perspective emotional reactions are always caused by some circumstances which are important for an organism. In general, the fundamental biological function of emotions is to assess and control the survival value of the organism's interactions with the environment.[95] In other words, where there is emotion there is something important for an organism. Therefore, every emotional reaction can be understood as an index. Because particular musical features are a direct effect of an experienced emotion, these features can be understood as indexes of this emotion. There is however, another problem with postulating the indexical character of tonality, which is related to the legitimacy of the application of the semiotic framework mentioned at the beginning of this article. The emotional experience of music is pre-conceptual. This means that the phenomenon of music as a whole, or at least some of its components, precedes symbolic communication.[96] The more so, according to some scientists,[97] since music in its contemporary complex form evolved as a parallel branch to language[98] rather than being a direct language predecessor, as was suggested by Darwin.[99] In this perspective, the music-specific features — e.g. pitch syntax — are biological innovations of vocal communication which evolved separately from (and probably simultaneously with) language-specific traits such as morpho-syntax or propositional semantics. Thus, although certain authors suggest that every meaning might be generally referred to as a sign's processes,[100] the lack of direct connections between pre-conceptual experience of tonality and the conceptual character of other meanings raises doubts about the justifiability of such a reference. It seems that the process of communication by means of pre-conceptual mode differs

effect depending on cultural experience (cf. Huron, *Sweet Anticipation.*)) which can suggest that they have a symbolic character, the actual mechanism of eliciting the emotion of tonal stability is independent of culture (Krumhansl, *Cognitive Foundations of Musical Pitch.*; Huron, *Sweet Anticipation.*). Thus, one cannot describe e.g. pitch center (tonic) as a conventional sign as it is in the case of words.

95 Jaak Panksepp, *Affective Neuroscience: The Foundations of Human and Animal Emotions*, Series in affective science (New York: Oxford University Press, 1998), 48.

96 Per A. Brandt, "Music and How We Became Human-a View from Cognitive Semiotics: Exploring Imaginative Hypotheses," in *Communicative Musicality: Exploring the Basis of Human Companionship*, ed. Stephen Malloch and Colwyn Trevarthen (Oxford, New York: Oxford University Press, 2009).

97 Cf. e.g. Fitch, "The biology and evolution of music: A comparative perspective."

98 There are, however, scholars who treat language as a specific kind of music (Anthony Brandt, Molly Gebrian, and L.R. Slevc, "Music and Early Language Acquisition," *Frontiers in Psychology* 3 (2012), doi:10.3389/fpsyg.2012.00327.

99 Charles Robert Darwin, *The Descent of Man and Selection in Relation to Sex* (London: John Murray, 1871).

100 Uwe Seifert et al., "Semantics of Internal and External Worlds," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29, 123.

qualitatively from the conceptual one. Even if, as Ian Cross proposes, music is an exaptation[101] which is used nowadays, among other ways, as a tool of emotional manipulation,[102] (in such a case the musical sounds can be understood as indexes of the emotional state of a person who creates a tonal pitch sequence) the pre-conceptual character of this communication means that the message is not conceptually interpreted by the receiver as an index.[103] Thus, the interpretation of tonal message is based on another rule, other than the interpretation of, e.g., fever as an index of illness.

Is there any possible use of a semiotic framework as an explanation of communication by means of tonal relations? It seems that the only way of applying a semiotic framework in the research of tonality is to understand signs only in a purely functional sense independent of the process of interpretation. Such a point of view is, however, inconsistent with traditional semiotics which presupposes that the generation of meaning is based on different kinds of reasoning, namely induction, deduction, and abduction.[104]

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[101] Exaptation is a feature which possesses a function for which it was not originally adapted or selected in the process of natural selection.

[102] Ian Cross, "Music and Evolution: Consequences and Causes," *Contemporary Music Review* 22, no. 3 (2003), doi:10.1080/0749446032000150906.; I. Cross, "The evolutionary nature of musical meaning," *Musicae Scientiae* 13, 2 Suppl (2009), doi:10.1177/1029864909013002091.

[103] In the case of classical index, e.g. smoke, one infers that smoke is an index of fire because of the conceptual knowledge of the causal relation between the process of burning and smoke. Nothing similar happens while people listen to tonal relations.

[104] Cf. Uwe Seifert et al., "Semantics of Internal and External Worlds," in *Language, Music, and the Brain: A Mysterious Relationship*, ed. Michael A. Arbib, Strüngmann Forum Reports, 203–29, 213.

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