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# Considerations about reward mechanisms and maintaining the functional nature of tonal music

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**Abstract:** From the end of the 1990s, several studies based on imaging evidenced the participation of reward mechanisms in the hearing of tonal music. Tonal music is constructed from a set of discrete elements (musical notes) organized in time according to mathematical reasons and well-defined structural relationships, thus enabling, through the repetition of listening, the apprehension of the rules of construction and, consequently, the formation of expectations. Reward mechanisms correspond to systems which are responsive to expectations, comprising three components, formed by partially dissociable neural substrates, related to motivation, learning and hedonia. This paper seeks connections between the characteristics of tonal musical structure and material and the process of musical apprehension and activation of reward systems, suggesting the important role of such mechanisms in maintaining the longevity of tonal music in modern society, particularly in relation to its functional nature.

**Subjects: Auditory Perception; Perception; Cognition & Emotion; Music**

**Keywords: cognition; music perception; reward mechanisms; tonal music**

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## PUBLIC INTEREST STATEMENT

Although music in the last century has branched out into countless strands, fexibilizing itself in relation to compositional processes and musical material, in order to incorporate elements such as randomness, noise and the resignification of everyday sounds and processes, tonal music continues to have a massive presence in the daily life of modern society, be it as soundtrack of films, or background in the domestic environment, in television or in all sorts of shared spaces. This paper investigates possible biological roots that favor the longevity of tonal music, suggesting that the same neural mechanisms responsible for motivated behaviors, such as sexual or alimentary behavior, have a strong influence on the maintenance of tonal music in modern society.

## 1. Introduction

The dissociation between listening and sound sources, which began after the invention of the phonograph at the end of the nineteenth century, in conjunction with the possibility of transmitting sound at a distance, which began with telephony and telegraphy, coined as radio and television (Chion, 1994) in the early twentieth century, led to a process that would make music a ubiquitous phenomenon in modern society. On the other hand, although little can be said about some sort of biological function and its possible origins in the evolutionary course of the human lineage, it is a consensus that music awakens emotions,[1] and this bond is at least one of the factors responsible for the maintenance of music as an element widely present in societies across time.

The development of musical language in the West seems to have reached its peak with tonality, a system based on 12 transposable musical pitches, with well-defined mathematical relations between them, moved by tension and relaxation related to a tonal center. While in the twentieth century several different types of musical systems and propositions have flourished, with an intense expansion of musical materials and the subsequent flexibilization of compositional means, the tonal system has nevertheless remained the most widely present in current times.

Whether as background music in movies or TV commercials, in celebrations or social events, or in any kind of recreational activity, music constantly present in our everyday lives, especially music based on the tonal system. Therefore, while there is not any solid scientific theory which may attribute to music any biological function,[2] it is paradoxically reasonable to investigate our human biological constitution for elements that may sustain its maintenance in an eloquent manner.

In 1956, Leonard B. Meyer published "Emotion and meaning in music", establishing assumptions about the relationship between music and emotion that currently still resonate. According to Meyer (1956) emotion and meaning in music are directly related to the satisfaction or not of expectations the listener has based on his experience with a certain "style".

Tonal music, like language, is made up of discrete elements, so that in certain respects one can think of equivalence between them as systems formed by discrete and probabilistic governed sources or, as defined by Shannon (1948), as stochastic processes.[3] Meyer (1956) thus considers the emergence of meaning and emotio, in the course of listening to tonal music, in a manner similar to that Shannon (1951) used to quantify information regarding language.

As of the late 1990s, a series of imaging studies have revealed, in the process of musical hearing, activation of limbic and paralimbic regions, as well as of other neural circuits generally associated with emotional responses (Blood et al., 1999; Blood & Zatorre, 2001; Brown et al., 2004). Menon and Levitin (2005), using functional magnetic resonance imaging (fMRI) associated with mathematical methods of functional and effective connectivity, confirmed the modulation, during musical hearing, of the activity of neural structures involved in reward processing, among which the nucleus accumbens and the ventral tegmental area, as well as the hypothalamus and insular cortex, regions usually associated with autonomic regulation and physiological responses to emotional rewards and stimuli.

Koelsch, Gunter, and Zysset (2002), on the other hand, found activation of nerve structures generally associated exclusively with language processing, during harmonic sequence processing, while (Fitch & Martins, 2014), corroborating the hypothesis formulated by Lashley (1951), based on research centered on the area of Broca, suggest that the hierarchical structuring of temporal sequences is an underlying capacity for music and language, with deep phylogenetic roots in the domain of action.

## 2. Music, emotion, and expectation

The relationship between music and emotion has long been the subject of intense debate. Over the last few centuries, theorists have discussed the content of this connection and have often used it to classify music in relation to other forms of artistic expression.

In 1854, Eduard Hanslick published the essay "On the Musically Beautiful: a Contribution Towards the Revision of the Aesthetics of Music", a landmark in this relationship, whose objective was to revise the esthetic theory of music of his time, seeking, through the pertinent scientific objectivity, to deny the referential nature of music or esthetics connected to subjective factors such as feelings,[4] as well as to establish new esthetic parameters to attribute to music an autonomous nature.

Hanslick (1994) argues that music, like other arts, would have *the beautiful* as its primary purpose. Perceiving the beautiful, however, at first, would imply the same physiological pathways used by any other type of sensation or feeling, thus causing the same bodily reactions attributed to them.

As a result, two forms of music listening would be identified. Genuine esthetic enjoyment would be the result of attentive, reflective listening, while another form of music listening, a naive form, would be the sole result of sound matter on the body. The second form of listening to the second type would be designated *pathological reception* by Hanslick (1994).

Therefore, there is no denial of the fact that music stirs feelings, but these would be secondary products, thus only genuine when connected to the esthetic enjoyment. Hanslick (1994) observes that the same sound material awakens different feelings in different individuals, consequently there is no condition of regularity that allows feelings to be determined as content of music. Said author states: "the effect of music on feeling, therefore, does not convey the *necessity* or the *constancy* or even the *exclusivity* that a phenomenon should convey to provide the grounds for an aesthetic principle" (Hanslick, 1994, p. 20).

And he exemplifies: "The rose exhales a perfume, but its 'content' is not the 'representation of the perfume'"; "a forest provides shady freshness, but it does not represent 'the feeling of shady freshness'" (Hanslick, 1989, p. 9).

Sound material, according to the author, should only express *musical ideas*, and *sound forms in movement* should be the exclusive content and object of music.

Pure and conscious contemplation of a musical work, the only genuine form of "artistic enjoyment", would take place through the apprehension of musical ideas.

"The most important factor in the process of the soul accompanying the apprehension of a musical piece and transforming it into enjoyment is the most commonly overlooked, i.e. the *spiritual satisfaction* the listener finds in continuously anticipating the composer's intentions, predicting his hunches, pleasantly clarified afterwards" (Hanslick, 1994, p. 82).

Hanslick's esthetic position in relation to educated listeners, where musical meaning must emerge exclusively from musical material, is classified by Meyer (1970) as a "syntactic-kinetic"[5] one. This type of listening understands music as a dynamic process in which "enjoyment and understanding depend on the perception and response to attributes such as tension and relaxation, stability and instability and ambiguity and clarity" (Meyer, 1970, p. 43).

Proposing musical listening as the "anticipation of the intentions of the composer" assumes prior knowledge of the syntactic structure used by such composer, allowing the formation of expectations. These expectations would subsequently emerge from a zone of probabilities arising from a context previously experienced by the listener.

Meyer (1956) therefore suggests that musical meaning emerges within a stylistic environment with which the listener must be familiar. Meyer understands that a musical style operates as a "system of probabilities; music, in movement, defines the probabilities of what will happen later" (Aiello & Sloboda, 1994, p. 4). However, according to Meyer (1956) musical meaning does not emerge from correct anticipations, but instead from deviations, from the occurrence of a less likely event rather than a more likely one, thus more expected.

The construction of meaning, as well as affective responses, from this point of view, operate in the domain of communication, and collectively depend on previous experience and similarity, at least to some extent, and on responses to sound stimuli, since "without a set of gestures common to the social group, and without common habit responses to those gestures, no communication whatsoever would be possible. Communication depends upon, presuposes and arises out of the universe of discourse which in music aesthetics is called style" (Meyer, 1956, p. 42).

The dynamics of musical enjoyment, according to this conception, depends on a common environment defined by elements (musical material) and well-defined rules, and is only effective in view of past experience within a context, because only the confrontation between past experiences and the actual musical material makes it possible to build expectations. The term "past experience" may be understood both in relation to learning and remote memories and to recent memory, by recognizing, for example, rhythmic or melodic motifs, phrases, or sections during the process of musical listening.

This point of view aligns with the traditional communication system, where a message is encoded and, subsequent to recognition of the code, may be reconstituted. Music, as sound representation, emerges from the organization of musical material according to certain patterns, creating what Meyer calls the "common gesture" (emitting source) established by style.

"Reception", however, infers common responses, since "if you dont't have a group of listeners who respond broadly similar fashion, then you can't create a musical culture - at least not one based on the psychology of expectation" (Huron, 2007, p. 99).

## 3. Prediction and reward

The influx of new knowledge about the nervous system gradually transforms the way it is interpreted. The brain has been understood as a mirror of external reality and as its interpreter. Several research lines are beginning to understand the brain as a predictor (Nobre, Correa, & Coull, 2007).

In evolutionary terms, the capacity of predicting events is extremely advantageous and may be the difference, for example, between obtaining success in the search for food or suffering injuries and physical damages, since anticipation allows targeting resources for a certain purpose.

Discovering the action of reward mechanisms and the dopaminergic system during the process of listening to tonal music by Menon and Levitin (2005) contributed to understand not only emotional responses to music, but also musical apprehension and, consequently, the formation of expectations within the tonal context.

Reward, according to Schultz, Dayan, and Montague (1997, p. 1593), "is an operational concept for describing the positive value that a creature ascribes to an object, a behavioral act, or an internal physical state".

The reward system involves multiple psychological components mediated by partially dissociable neural substrates, and the three main components are: affection (pleasure), motivation, and learning. In summary: (1) affection is a hedonic component of the reward system, and it may or may not be a conscious process. (2) The motivational reward process may be conscious, for cognitive purposes, or unconscious. (3) Learning includes projections and associations based on past experiences, including explicit cognitive predictions and implicit knowledge, as well as associative conditioning (Berridge & Kringelbach, 2008).

Therefore, it is possible to suggest, in relation to music, that reward mechanisms are linked not only to emotional responses, but also to the apprehension of the tonal system, and both processes are closely related to the formation of expectations.

Animal studies show that dopaminergic activity encodes expectations about external stimuli or rewards in terms of duration and magnitude, sending out a positive signal when an appetitive event is better than predicted, a negative signal when the event is worse than predicted and not emitting any signal if the event occurs within the predicted time (Schultz et al., 1997). "This fundamental property of predictions leads to the observable phenomenon of learning, as defined by changes in behavior based on updated predictions" (Schultz, 2010, p. 2).

However, considering tonal music as a dynamic process where each "perceptual atom"[6] is related to past musical material, it is possible to locate a continuous flow of expectations formation that may be analyzed in this paper from two different perspectives: on the one hand, the repetitive hearing of musical constructions originated from the same musical material and governed by the same rules (in this case, by the tonal system) would offer an environment of regularity favorable to the statistical apprehension of its elements. In this case, the apprehension of regularities is directly related to the apprehension of the very rules of organization of the system, and consequently the number of occurring events that accumulated from past hearing would set the grounds for the probability of occurrence of future events. On the other hand, past experience would be responsible for building the reference system that would allow the formation of listener expectations in the act of listening to music.

The same reward activates different neural representations (in relation to learning, motivation and hedonia) in the accumbens–ventral pallidum pathway of the mesocorticolimbic circuitry, and the released dopamine is involved in the learning and motivation modulation, whereas the μ-opioid receptor in the nucleus accumbens is responsible for the hedonic modulation (Smith, Berridge, & Aldridge, 2011).

The hedonic response is modulated by whether or not the expectations constructed by past experience are met, operating to reinforce positive responses and weaken negative ones (unmet expectations). In general, it is possible to understand "pleasure", in this case, as a product of the reinforcement of expectations, which, on the other hand, acts jointly with the learning of the motivational component to direct and reproduce statistically positive responses.

According to Berridge and Kringelbach (2008), sensory pleasure in non-humans is closely connected to social pleasure, including visual sensory features such as faces or touches, while in humans pleasure is linked to "more abstract and cognitive features of social reward" (Berridge & Kringelbach, 2008, p. 459):

> In addition to these basic sensory and social pleasures, there are a large number of higher-order pleasures that are prominent in humans, including monetary, artistic, musi- cal, altruistic, and transcendent pleasures. Such higher- order pleasures depend on learning and might be conceptualized as higher-dimensional combinations of the basic pleasures, and as such may reuse some of the same brain mechanisms. (Berridge & Kringelbach, 2008, p. 459)

## 4. Melodic expectation

In 1979, Krumhansl and Shepard published a study where the experimental subjects were exposed to ascending and descending diatonic scales, with their last notes omitted, followed by the presentation of thirteen possible finalizations. The subjects had to judge the relevance of each finalization, by assigning concepts, on a scale of 1 to 7, with concept "1" corresponding to the worst suitability and "7" to the best possible suitability.

The experiment showed three distinct patterns of responses, according to the participants' expertise. As expected, the tonic achieved the highest grade assessed by all groups. However, it was observed that, in the group of more experienced subjects, the tonic had a similar evaluation, regardless of the octave it was in (octave equivalence), whereas in the other two groups there was a tendency to better evaluate the notes closer to the octave of the scale (distance from pitch height in relation to the context). The group formed by more musically experienced subjects better assessed the probe tones which belonged to the diatonic scale, and the notes which belonged to the triad, demonstrating a response pattern in accordance with the projection of the tonal hierarchy.

The formation of hierarchies within the tonal context would be responsible for better adequacy evaluation of notes with a higher occurrence rate, in the scope of behavioral experiments. The results shown in Krumhansl and Shepard (1979) were corroborated by a later study by Frankland and Cohen (1990) using a technique which tracks the time of reaction.

We have replicated, as part of a larger study, the Krumhansl and Shepard (1979) experiment, yielding results that once again are in line with the results of the original study.

Our study grouped 16 subjects by correlation matrix, according to evaluation standard, and they were divided into two groups, i.e. Group 1—formed mainly by subjects with musical training,[7] and Group 2—formed mainly by non-musicians.[8] As in the study of Krumhansl and Shepard (1979), the parameters (1) octave equivalence, (2) tonal hierarchy, and (3) pitch height distance in relation to the tonal context were evidenced, as well as the influence of expectations within the tonal context.

Several studies carried out statistical surveys of large amounts of Western music scores to identify invariances in the tonal context. Huron (2007) reported several findings in this sense. Such findings, in general, correlate with the behavioral data experimentally collected. The delineation of data meanings, however, is extremely complex, considering the high number of variables involved in the process of apprehending musical material.

Meyer (1970) draws attention to some of the precautions to be taken in evaluating the data: (1) The need to differentiate between probabilities of systemic origin and those deliberately introduced by the composer[9]; (2) Tonal probabilities exist at different hierarchical levels, such as inside sentences or between sentences or sections. The choice of a specific set of data to be analyzed should consider the hierarchical level to be analyzed, since different stereotypes occur at different levels. Accordingly, existing subsystems should be analyzed within large probabilistic systems. (3) It is also important to consider the historical development of musical styles. The occurrence of perfect cadences in Wagner's music, for example, is small, and this cannot be considered a norm in relation to the tonal system.

The formation of expectations is related to references from previous experience and, given the correlation with the statistical supply of musical material, it is reasonable to suppose that the apprehension of musical material is itself established statistically. Evidence in this sense has been confirmed by studies, usually linked to verbal language, through the use of artificial grammars.

## 5. Music, language, and implicit cognition

Although the discussion about a possible common evolutionary origin between music and language is still ongoing, it is a fact that both establish themselves as well-organized cognitive functions that present interesting similarities (Besson & Schön, 2001).

According to Deustch (2010, pp. 38–39):

> They are both governed by a grammar, in which basic elements are organized hierarchically into sequences according to established rules. In language, words combine to form phrases, which join to form larger phrases, which in turn combine to make sentences. Similarly, in music, notes combine to form phrases, which connect to form larger phrases, and so on. Thus, to understand either language or music, listeners must infer the structure of the passages that they hear, using rules they have assimilated through experience.

Moreover, both, music and language, can be acquired implicitly, without help of explicit instruction (Ettlinger, Margulis, & Wong, 2011).

In 1967, Arthur Reber published the article "Implicit Learning of Artificial Grammar", which is considered a landmark in the studies of implicit cognition. The study created a finite-state language containing five letters (P, S, T, V, X), governed by a set of sentence creation rules, forming a grammar.

Two tasks were proposed, the first one a memorization task and the second one a discrimination task. The memorization task involved words created using as base the proposed grammar, and such words were shown to subjects for a short period of time, after which they should be rewritten. Subsequently, said subjects were informed about the existence of a grammar underlying the given words. Subsequently, such subjects had to classify words shown as created or not created using rules as a base. No reference was made to the nature of such rules.

The results showed a success rate significantly higher than chance, suggesting that memorization enabled the apprehension of the underlying grammar rules. However, when asked about the criterion for inference used in the test, the subjects were unable to respond, thus characterizing a type of learning, namely implicit learning, which was also observed in later studies.

Jenny Saffran, Johnson, Aslin, and Newport (1999) conducted a series of experiments with adults and children, demonstrating that artificial grammars applied to words formed by linguistic material (letters of the alphabet) or non-linguistic sounds are apprehended solely based on the transitional probability of their elements, even when the stimuli are demonstrated concomitant with distracting tasks, corroborating the possibility of learning based on the statistical supply of perceptual elements and the relationships between them.

Based on the Reber (1967) experiment, Tillmann and Poulin-Charronnat (2010) conducted a study using artificial language with grammar created in the manner employed by Reber (1967), but replacing the linguistic characters with musical notes and using measures of reaction time to assess apprehension.

The results suggested that the knowledge acquired by the participants went beyond bigrams, and included frequency of trigrams, as well as second-order transitional probability, thus enabling the differentiation between "grammatically" correct and "grammatically" incorrect sequences, as well as the formation of expectations for future sounds.

Kutas and Hillyard (1980), using event-related potentials (ERPs), found that the detection of a semantically inappropriate word in a sentence elicits a negative electrical pulse occurring 400 ms after detecting the incongruity (N400). In addition, Kutas and Hillyard (1984) later found that the pulse amplitude was modulated inversely to the expectation of words expected at the end of sentences. On the other hand, Besson and Faïta (1995) found that, as in language, the detection of incongruities in tonal music also elicits electrical potentials correlated with the degree of expectation violation, however, positive, 600 ms after detecting the incongruity (P600), bringing empirical evidence regarding the formation of expectations in music, as well as in language.

Daltrozzo and Schön (2009) suggest that the N400 may be linked to the idea of concept, in an unspecific way, with overlapping mechanisms underlying concepts, whether musical or linguistic. Also, it is suggested that, in language, the P600 is related to the reanalysis of syntactic structures (when necessary), varying in amplitude as a function of probability (Friederici & Mecklinger, 1996). Patel, Gibson, Ratner, Besson, and Holcomb (1998) compared the P600 elicited by syntactic incongruities in language and by harmonic incongruities in music, finding no significant differences in both amplitude and scalp distribution, suggesting that this component of the ERP reflects the operation of a mechanism shared by linguistic and musical processes. Finally, using functional magnetic resonance (Koelsch et al., 2002), brain structures, usually associated exclusively with language processing, were activated during a chord sequence task that was infrequently terminated in unexpected chords. These events activated the areas of Broca and Wernicke, the superior temporal sulcus, Heschl's gyrus, both planum polare and planum temporale, as well as the previous superior insular cortices, besides showing great integration of both hemispheres in the processing, both of music and of language. The study thus strongly suggests that the cortical language network is less domain-specific than previously believed, corroborating the closeness between music and language processing.

Computational models are another very effective research source in the study of musical cognition. Models designed to study the perception of tonal music show similar behavior to those observed experimentally, when "fed" with large samples of tonal repertoire, strengthening the assumption of statistical apprehension by exposure to musical material.[10]

## 6. Exposure vs. apprehension

Creating expectations is closely related to (1) exposure factors and (2) the regularity of the perceptive material. During the development of the tonal system, several factors contributed to both aspects.

The introduction of musical writing, on the one hand, by providing visual support to the composer, strengthened the possibilities of writing, leading to the subsequent complexation of repertoire, but on the other hand set musical pitches and their relationships, thus increasing the possibilities of the perceptive apprehension of musical material.

> [...] the mutation caused by Western music writing was profound. Unable to later establish the subtle agogic fluctuations of musical acts (which, nevertheless, was its original purpose), it inaugurates a manner in which it later establishes how sounds should be produced. (Candé, 2001, p. 25)

In addition, establishing a certain writing also strengthens the figure of the interpreter, who with such establishment has the possibility of faithfully reproducing musical works, as well as musical works that he has never heard before. Therefore, writing expands, by repetition, the statistical supply of musical material, consequently enabling the apprehension of its elements and favoring the formation of expectations.

However, if writing at its time was an important driver of musical diffusion, consequently such writing would be strengthened to the maximum, based on the possibility of phonofixation, as of the end of the nineteenth century.

Benjamin (1935/1980, p. 7) refers to the peculiarities created by reproduction techniques in the following manner:

> At the same time, technique may lead to the reproduction of situations where the original material itself would never be found. In the form of a photography or a disc, reproduction enables, above all, the greater approximation of the artwork with the spectator or listener. A cathedral abandons its real location in order to locate itself in the studio of an amateur; a music lover may listen at home a choir performing in a concert hall or outdoors

The increase in the statistical supply of musical material through repetition not only increases the probability of syntax apprehension impacting the creation of expectations, but also seems to act on the quality of the affective connection created by the listener, as pointed out in the studies by Loui and Wessel (2008) and Szpunar, Schellenberg, and Pliner (2004), who suggest that the preference for melodic sequences increases according to the time of exposure to such sequences.

## 7. Final considerations

Evidence of the involvement of reward circuits in the passive hearing of tonal music initially fostered great interest in the understanding of emotional responses to music. This paper pointed out elements which suggest that the involvement of reward circuits may play a much broader role, encompassing learning, apprehension, and musical enjoyment at various levels.

Studies on artificial language studies cited in this paper demonstrate that grammatical rules may be acquired by simply exposing (musical or linguistic) material (Reber, 1967; Saffran et al., 1999; Tillmann & Poulin-Charronnat, 2010), with apprehension connected to the statistical supply of material and detached from the voluntary mobilization of attentional mechanisms. Therefore, it is possible to suggest that in the context of tonal music system even subjects without formal musical knowledge are able to create expectations from the structural apprehension of such system, as evidenced in the studies by Krumhansl and Shepard (1979), Frankland and Cohen (1990) and corroborated by our study.

The multiplication of means of musical diffusion in modern society has made music an omnipresent phenomenon, thus favoring, through the reiteration of listening, predictability and the subsequent formation of expectations. Therefore, the evidence of modulation of the activity of the neural structures involved in the reward system during passive tonal music hearing (Blood et al., 1999; Blood and Zatorre, 2001; Brown et al., 2004). Menon and Levitin (2005) suggests that the features of musical material and structures used in the creation of tonal music, in conjunction with the ubiquous nature of tonal music in society, especially in relation to its functional nature, operate jointly to feed a cycle that involves apprehension, the formation of expectation and hedonic responses, through the fundamental action of reward mechanisms, mediated by dopamine (motivation and learning) and μ-opioid (hedonic response).

Although musical apprehension and enjoyment are extremely complex processes involving broad mobilization of the most diverse systems encompassing perception and processing, and therefore unable to be reduced to specific neural structures, it is understood that the engagement of reward systems has a relevant role to play in order to preserve tonal music in modern society. Consequently, in this sense, we expected that the findings of this paper may serve as a starting point for further studies in the area.

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**Notes**

1. Although the relation between music and emotion is admittedly genuine, the center of the discussion about this connection encompasses two lines of thinking with different points of view. Emotivists understand that music actually elicits emotional responses, while cognitivists understand that music expresses emotions, but these emotions, albeit perceived, are not “felt” as everyday emotions.
2. According to Pinker (1997, p. 553): Music is an enigma. [...] In all cultures, certain rhythmic sounds provide listeners with intense pleasure and deep emotions. [...] Many suggestions were made in this sense—music unites social groups, coordinates action, enhances ritual, releases tensions—but they simply outline the puzzle rather than explain it. Why do rhythmic songs unite a

group, dispel tension, etc.? As far as cause and biological effects are concerned, music is useless. Nothing indicates the existence of a plan to achieve a goal such as living a long life, grandchildren, accurate perception, and prediction of the world. Music seems to be the pure technology of pleasure, a cocktail of recreational drugs that we intake through our ears to stimulate all at once the whole circuits of pleasure.

3. According to Shannon (1948, p. 11): we can think of a discrete source as generating the message, symbol by symbol. It will choose successive symbols according to certain probabilities depending, in general, on preceding choices as well as the particular symbols in question. A physical system, or a mathematical model of a system which produces such a sequence of symbols governed by a set of probabilities, is known as a stochastic process. We may consider a discrete source, therefore, to be represented by a stochastic process. Conversely, any stochastic process which produces a discrete sequence of symbols chosen from a finite set may be considered a discrete source.
4. Hanslick emphasizes the difference between sensation and feeling: “Sensation is the perception of a certain sensitive quality: a certain sound or color. Feeling is the act of becoming aware of an incitement or impairment of our mood, therefore of a certain well-being or displeasure. When I simply perceive the smell or taste of a certain thing, its shape, color or sound with my senses, I perceive these qualities; when melancholy, hope, joy, or hatred evidently awakens me beyond my usual state of mind, or depresses me also in relation to such state of mind, then I have a feeling”.
5. According to Meyer (1967), the “syntactic-kinetic” group demonstrate internal differences of opinion. “Some, such as Hanslick, argue that the syntactic-kinetic process is purely and exclusively intra-musical. Others believe that the design and forms of the musical process symbolize the life of a feeling or directly evoke affective responses” (Meyer, 1967, p. 43).
6. A term coined by Murail (1992).
7. Group 1 was composed of three subjects with higher education musical training, a subject with incomplete higher education music training, a subject who stated he played guitar for 12 years, and only one subject who stated he had no musical knowledge.
8. Only one subject in Group 2 has taken higher education music training. All others stated that they had no formal knowledge of music.
9. Meyer bases his arguments on the information theory, in which uncertainty diminishes with the development of a system of symbols (whether letters of the alphabet or musical notes). The “natural” development of the system is what Meyer designates “systemic”. A composer’s inventiveness, on the other hand, intervenes in the natural course of the system, introducing deviations and creating uncertainties of another kind, which are qualitatively different from systemic uncertainty.
10. To have access to a broad study, see: Todd and Loy (1991).

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