

# POSITIVE EMOTION LEARNING THROUGH MUSIC LISTENING

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## ABSTRACT

This paper focuses on a need to design of a template for an A.I. system that analyzes computer music and simulates the audience's emotional reaction. This system may possibly aid computer music composers in creating pieces that are more appealing to the wider audiences. Conceptual design of the proposed system is based on the most recent findings in understanding of how the human brain processes musical patterns

## 1. INTRODUCTION

Music, unlike the language, is a fuzzy concept. If you hear the words "Puntius Tetrazona" and are unaware that they refer to a kind of tropical fish, your brain will not respond at all—making a bivalent decision. On the other hand, essentially all music spawns at least some meaning to a brain. Even music that we have difficulties comprehending, such as Eskimo Inuit singing or highly original computer music, will sound like something to western-trained ear-mind of humans. Listening to this kind of music represents a fuzzy concept containing high noise capacity or high percentage of fuzzy entropy. Thus, in order to increase the human interest in any kind of information, one has to decrease its noise capacity. Let's see why is this particularly important to the computer music composers.

## 2. CREATIVITY AND MUSIC

It is very logical to assume that humans intelligently create musical pieces rather than producing them as random (high noise capacity) innovations. But, looking at the state of affairs in computer music will show more examples of innovations than creations. Let me clarify the distinction between the two. Quality of computer music and for that matter the quality of anything does not depend exclusively on its structural organization, but it is rather rooted in the transaction that occurs between the music and the audience. To evaluate music, is to find the quality of transaction between the musical configuration and its cultural response. If that response is positive, meaning

ecologically prudent for the given cultural environment, then it may be called creation. On the other hand, an innovation being just randomly new and not holistically related to the environment will certainly render a negative cultural response.

Assuming that computer music composers are streaming towards a positive cultural response, let's look at one particular way of how this difficult task may be achieved? I see such a possibility through designing an adaptive fuzzy analysis system that could help computer music composers in reducing the high noise capacity when making their musical pieces. By reducing its internal fuzzy entropy, the computer music may become more appealing to the audiences and possibly help them in making positive emotional responses while listening to it. Let me explain why.

## 3. BRAIN PROCESSING OF MUSIC

The most dangerous thing is to make generalizations, but I am going to make some anyway. Nobody with the sane mind would agree any more that music represents a universal language. However, the research tangibly shows that there are some things that appear universally. In order to make sense from the vast sonic events that enter its auditory cortex, the brain had to become a master of simplification. This process is nothing like filtering unwanted information, because such a mechanism would be tremendously complicated and utterly inefficient. What brain actually does, is a search for familiar devices and patterns.[Jourdain 1997] It latches on things that are in some respect already known, disregarding most of the unfamiliar information. The reason that human (but also animal) brain is doing this; lies in the fact that previously processed information can be very quickly reconstructed from the data stored in brain's long-term memory. Then, that reconstruction can be efficiently processed and compared with the similar incoming information, giving it the most pragmatic interpretation that fits the situation at hand.

Conversely, to create a musical pattern in human brain it is necessary to have a some sort of repetition of the sonic event in question, thus it can be remembered and used in

the future. Composing a piece of music, that will exhibit an appeal to the minds of the audiences, requires the existence of some sort of a clearly recognizable musical "point of reference." Human beings, on large, will not make positive emotional responses to anything which produces one unconnected innovation after another, never going back and reevaluating what has gone before in relation to what is going on now. Thus, when the brain receives sequences of musical tones, it does what it does with other "new" information: it attempts to "interpret" it by using the "old" already processed and digested information stored in its long-term memory about previous, similar music experiences. This information may allow some aspects of a future musical signal to be anticipated—as it happens when we hear the first line of a familiar song. The ability for predicting incoming patterns of information, in our particular case musical information, on the basis of past experience is one form of what we call "intelligence"; it can dramatically enhance an organism's chances of survival. Knowing what is coming is always much more profitable than being caught by total surprise.

The way human brain handles this comparison-based process is grounded in the workings of neural mappings that correlate to a specific sonic event. For the sake of simplicity, let's say that there is a sound of an oboe playing A=440 Hz. Now, in most of the western-trained musicians' brains there is a neural correlate for A=440 Hz sound. These neural mappings are physical representation in the brain of a "formula" for the reconstruction of person's memory about an A=440 Hz tone. This "formula" will be put in use when the ear receives an external stimulus of an oboe playing and passes this stimulus to the auditory cortex. Then, in turn, the auditory cortex would use the "formula" to reconstruct the memory of the closest similar experience and its context stored in the long-term memory that matches the one of the external stimulus just being received. Through the process of semantically matching the "new" and the "old" mental image of an oboe playing A=440 Hz, the brain would assign meaning to the event in question, based on the context in which the new information was received. If that context happens to be tuning an orchestra, rather than starting the first note of an A-minor scale, the brain will call up a specific neural mapping of the semantic correlate for the given context and react appropriately. The self-adjusting nature, or plasticity of the human brain, also makes your interpretation of music today depend on: who you are, what are you doing at that moment, and your past experiences that are stored in brain's long-term memory. But, the next day, you are going to be different, what you will be doing is going to be different, and your past experiences in your long-term memory will change as well. This will in actuality physically change the neural mappings which correlate in your brain with a sound of an oboe playing A=440 Hz in all kinds of different contexts.

In strictly neural terms the synapses that are kept are the ones that are active and connections that are not used are eliminated.[LeDoux 2002]

Since we know that humans constantly judge by comparison, and our judgment of any item depends upon what we are comparing it to at that moment, let's be wise and use this knowledge in composing music. If there is a pattern that reflexively reoccurs throughout the musical composition it will create its memory in the brain and that will become a "point of reference" to which future transformations of the same pattern may be compared to. If humans are able compare, then in return, they will be also able to evaluate. If this evaluation process keeps going on, that probably means there is a growing interest in what is going on. This still does not mean by any means that a musical composition containing reoccurring patterns of some sort and their transformations will be a guaranteed recipe for the creation of a successful music. It simply means that unless there is a point of reference, which may be just about anything previously digested and recognizable to the ear-minds of the audience, there is a significantly much lesser chance for produced musical piece of being able to catch on and make people react to it with positive feelings. How successfully one is going to play with musical patterns will, in the end, always remain the matter of human musical talent.

Research of Aniruddh D. Patel from the Neuroscience Institute in San Diego shows that interactions between human brain regions are the greatest when subjects listen to a melody-like (pattern) structures, rather than when listening to random structures.

Ongoing timing patterns in the neural signal showed a strong dependency on the structure of the tone sequence. At certain sensor locations, timing patterns covaried with the pitch contour of the tone sequences, with increasingly accurate tracking as sequences became more predictable. In contrast, interactions between brain regions (as measured by temporal synchronization), particularly between left posterior regions and the rest of the brain, were greatest for the tone sequences with melody-like statistics. This may reflect the perceptual integration of local and global pitch patterns in melody-like sequences.[Patel 2000]

*See illustration attached at the end of the paper.*

It is also important to keep in mid that humans can only recall memories that are related to our present situation—where you are and what are you doing. In other words, to some kind of a "point of reference" which helps the brain to determine the context in which has to operate. If you are composing an orchestral piece your brain more likely focuses on recalling memories related to the instrumental ranges, rather than memories of how to change a flat tire on your car.

So our memories, as exact, recorded, fixed images of the past, are an illusion. We believe we are stable, but this is one of the built-in illusions of the mental system. We believe we remember specific events, surely. Yet we don't. We make them up on fly. We change our minds all the time, from our estimate of the odds on a bet, to how we view our future. And we are unaware that the mind is doing this.[Ornstein 1991]

The "mass of soothing sound" your mother made while singing lullabies to you in childhood, is reduced to "Twinkle, Twinkle Little Star," later on in life. Our memory of a certain musical event is influenced not only by previous knowledge but also by events that happen between the time an event is perceived and the time it is recalled.[Ornstein 1991]

#### 4. EMOTIONS AND MUSIC

Now, another significant point to make is, to try to understand how the human brain deals with emotions and feelings. Here is just one of many perspectives, but the one that definitely needs a "point of reference" in order to be explained.

The human body, as represented in the brain, provides a fundamental frame of reference for the neural processes that we experience as the mind. We use the physical state of our very organism as the ground reference for the mental constructions which we make about the environment we live in.[Damasio 1994] In short, the background state of our body landscape provides a rather neutral "mood," against which we can judge any changes shaken by emotions. When the brain consciously appraises emotional changes in that equilibrium, we are having an emotional response—a feeling. Thus we may say that feeling greatly depends on the juxtaposition of an image of the body, correlated to an image of something else; such as the auditory mental image of a musical pattern.[Damasio 1994] This differentiation between emotions and feelings is very important because:

... all emotions generate feelings if you are awake and alert, but not all feelings originate on emotions.[Damasio 1994]

Pretty much like being aware of the goose bumps, that your body creates while your mind is listening to an effective piece of music. It is generally agreed that feelings are strongly related to a need (desire) for something. Thus, in order to feel something, two things are necessary:

... a body and some disturbance signal from the body, but also presupposes some mind—endowed with beliefs—attributing this sensation to the lack of needed resource/action, and motivating in such a was the search for something. [Castelfranchi 1998]

So, what could be the need when listening to a piece of music? To generalize again, most of the western music listeners expect to get some kind of "positive" feeling generated by the listening process. I guess we can all agree that hardly anyone would listen to a piece of music that would generate the feeling of pain. Conversely, we may assume that intentional activity of listening to music is indeed induced by some need for pleasure. Conscious feeling of pleasure, generated by the process of listening to music, will create in your brain a memorized history of such intellectual experiences. Therefore, later on in life, under the similar listening conditions, your brain may recreate this correlation of "incoming" and "stored" mental images, and you may experience the feeling of goose bumps again. So far my personal research shows that goose bumps are always called up as evocation of the memory about the previous emotional experiences.

#### 5. CONCEPTUAL SYSTEM DESIGN

Knowing all this, the question arises: How to approach a design of an adaptive fuzzy system that would help computer music composers in making their musical pieces more appealing to the audiences? At this point let me define the social context in which this system were suppose to function. The application of the proposed system would work only when applied to the certain kinds of music, that is predominantly practiced in the western cultures. This is the music that engages its listeners in making insightful intellectual and emotional responses rather than music that helps their audience in achieving specific unique states of mind. Most of the later kind of music may be found within the eastern and African cultures. Therefore, my impression is that within the western socio-cultural context, a system for evaluation of computer music is increasingly needed, as I outlined in the beginning of this paper.

It is also essential to keep in mind, that when proposing this analysis system, I am going to generalize a lot. That is because we need simplicity when trying to understand the complex processes that trigger emotions and feelings when humans listen to music. This system, like any other system, seeks to reduce the aspect of the real world it represents, to its essential components. As we know, an integral part of doing science necessarily involves generalization (i.e., disregarding details) and simplification of the complex phenomena under study.[Spitzer 1999]

The practical application of our knowledge about the human brain could be put to use in the proposed adaptive fuzzy system that utilizes deviations from a self-adjusted neural net cognitive algorithm. This algorithm would simulate the "formula" for generation of positive feelings. Proposed system should be capable of analyzing the

structure of computer music pieces in terms of musical patterns and their anticipation and predictability by the human brain. Such analysis would be able to suggest if a composed piece of music has the necessary "ingredients" needed to present itself in as appealing way to the audience.

In order to do this, the system should first be able to identify a musical pattern, as the stream of cognitive data feeds into a neural or statistical network and out come the fuzzy rules for musical pattern analysis. The system could learn from experience and may use fresh data to tune its stock of knowledge. Pattern mapping and identification within a given musical piece, should be based on a search for the possible similarities inside the musical fabric of the piece in question. The most fundamental matching ought to be performed on the rhythmic level, then on the pitch level, and finally on the timbral level. After identifying a pattern of some sort, the system should be able to follow its behavior throughout the musical piece. It would search if too many deviations from the mapped pattern fall together, and conclude that in such case the listener is most likely to lose track of the underlying musical stability, suppressing anticipation of the coming patterns forcefully. We know that significant deviations from pattern predictability tend to weaken subsequent pattern anticipation and thereby undercut the impact of further musical deviations. Every single mismatch in musical pattern anticipation may be countered by adjustments to the next expectation. For the listener, with too many deviations the music becomes increasingly incoherent, while with too little deviations, music becomes cold and mechanical.

The behaviours of most interest will be neither fully predictable nor completely random, but exhibit dynamic and occasionally emergent behaviour, as in the nature of natural systems.[Impett 1998]

Thus, the proposed adaptive fuzzy system could be, in fact, searching for a "point of reference" within the musical composition, and finding out if the computer music piece that is being analyzed, refers in some way from time to time to the initially established patterns, while refreshing audiences' memory. Furthermore, the system should be able to tell us if the manipulations of the patterns throughout the musical piece make the audience to be reasonably prepared for their occurrences. This is important because we know that the human brain perceives by anticipation, formulating perceptual hypotheses and then confirming them.[Jourdain 1997] Successful confirmation of the human expectations, coupled with reasonable challenge for making such a confirmation, could be the impetus needed for generation of a positive feeling while listening to music.

Concluding, I hope that the working principles of the human brain that I have dealt with in this paper may help

us in designing a template for an adaptive fuzzy analysis system capable of audience simulation. This would hopefully guide a computer music composer towards more successful compositions and wider audiences.

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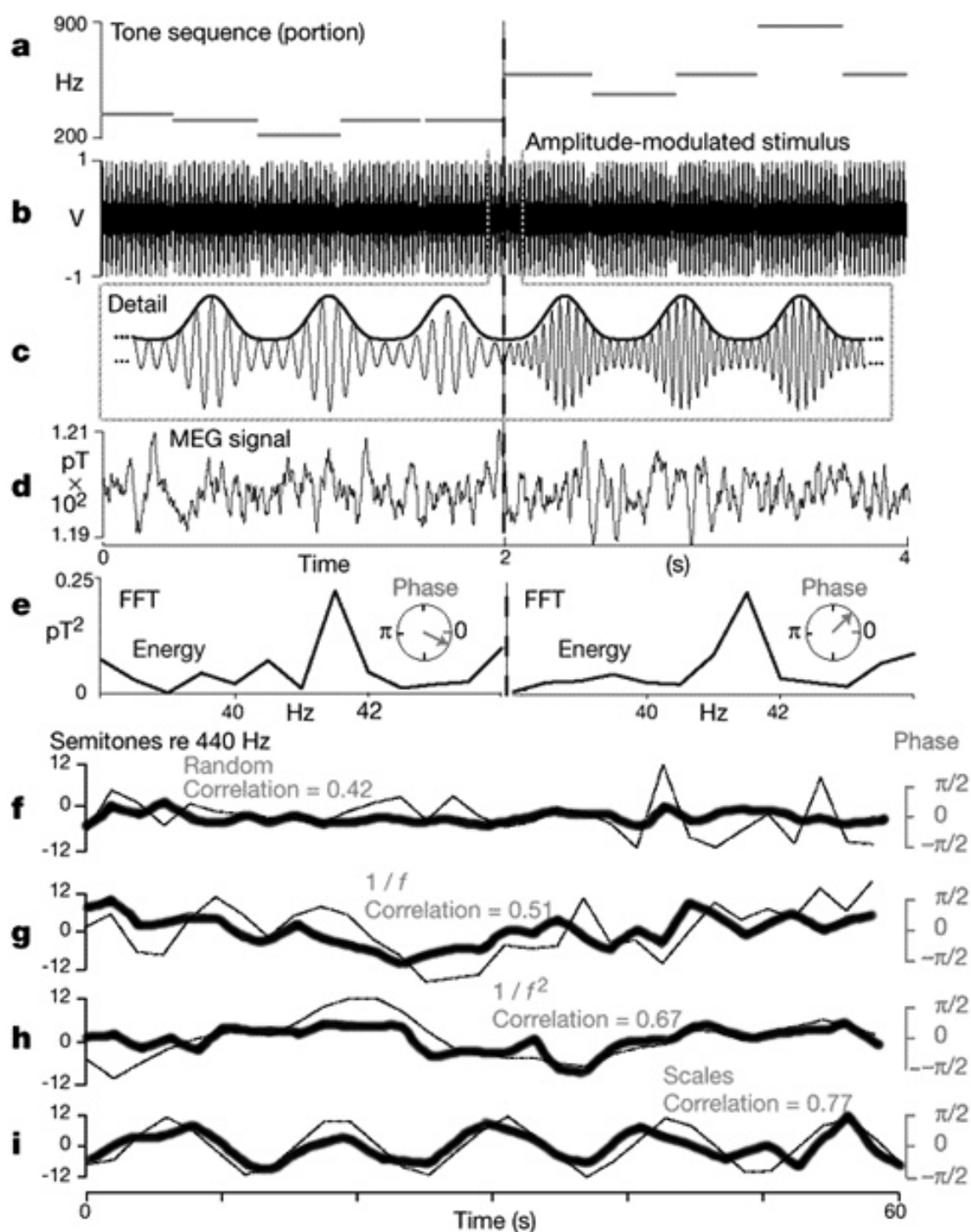


Figure 1. (a-d): Example of stimulus and brain response over 4 seconds: (a) Tone frequencies; (b) Stimulus waveform; (c) Waveform detail (150 msec), showing constant modulating frequency (41.5 Hz, blue line) overlaid on changing carrier frequency; (d) Neural signal from one sensor. (e) Successive 2-second spectra of neural signal. The brain signal shows an energy peak at 41.5 Hz, whose phase (inset arrow) varies with carrier frequency. (f-i): Phase-tracking of individual tone sequences. Pitch-time contours (thin lines) illustrate the four different stimulus categories. Associated neuromagnetic phase-time series (thick lines) from a single sensor during one trial in one subject were randomly drawn from the top 10% of sensor correlation values for each stimulus. The correlation between the resampled pitch-time series and the neuromagnetic phase-time series is given in the inset to each graph.