Transgender Musicality, Crossover Tonality, and Reverse Chromaticism: The Ontological Substrate for Navigating the Ocean of Global Music

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Abstract- ***The contemporary model for global music distribution is based on cost-effective business models collectively convened by their brand names. Trademarks like Amazon, e-Bay, YouTube, or iTunes are readily recognizable and conceptually admissible for Software-as-a-Service virtualization platforms contributing to the extravagant increase in the supply chain over the Internet. In this ocean of performing communication media, aural dynamics like genres, styles, musical scales, melodic progress, rapidity of melody, direction of melody, music loudness, and harmonic relation mix in an omni linguistic platform with unprecedented depth in its diachrony and synchrony, revealing the evolutional course of music through centuries. As music promotes itself as the basis on which audiovisual arts are fostered, a practical method for correlating music performance with its visual surroundings is needed. This paper describes how our brain detects and allures music in a two dimensional visual space, and how the color superimposition may reversely lead to music production. The conversion of an image to sound based on the concept of chromatic bricks can be used to create unique musical compositions, using two dimensional transforms based on the chromatic index of music.***

Key Words:*Audio-visual Broadcasting and Distribution;Music - Image Transforms, Music Perception, Mobile Devices*

1. INTRODUCTION

The music we pervasively use steams up to huge numbers via Internet hubs and "cloud" networks. The crucial factor that has increased online listening for music is the widespread use of smartphones with an unprecedented penetration. It was mobility that made the difference, and not personal computing, for dipping into the ocean of music, anytime, anywhere, by anybody [1].

The concept of mobility is well perceived by contemporary interdisciplinary audiences, since a massive participation has occurred and an unprecedented penetration has been recorded in the synchrony of our societies, not withstanding racial, ethnical or sovereignty limitations. The property of mobility is indeed synonymous of existence: in a world where we cannot exactly record how many people have a "home", we can adequately enumerate the number of mobile phones. For an estimated 7,012,000,000 inhabitants in this planet, there are 6,800,000 active mobile phones [2]. For the next few years, an estimated 3,500,000 of these devices will be labeled as smart phones [3]. Indeed, this global audience, intercommunicating and simultaneously being plugged in an unprecedented flow of musical hearings, has primed to the cultural thrive of ethnic music. So, in terms of music dissemination an overwhelming system effectiveness and user satisfaction has been achieved. From a historical perspective, the road travelled during the last 25 years of this generation span, is unmatchable: starting from the trendy *Walkman™* that provided portable music reproduction, we have come up to the vital *smartphone*, a highly interactive component of a complex system ("the cloud") that enables the operator to interact with an ocean of multimedia content, nearly everywhere, anytime.

The notion for a Virtual Music Environment constitutes a generalization for iconifying a wide variety of musical contexts. In terms of Software Engineering and Computer Networks, global audiences take advantage of Software-as-a-Service networks, which using the vast penetration of mobility in parallel with the low charges for Wi-Fi connection have created an interactive, hybrid substitute for satellite audiovisual emission. This iconic world per se generalizes the acoustic impact of complex sound stimuli and acts as a multimodal source (for instance optical, acoustic, haptic, etc.), which is simultaneously a virtual space for interaction. The same time, the user can actively participate in this huge network either by recording audiovisual events or happenings, or, if he is skillful one, by producing his own music, taking advantage of the advanced Human-Computer Interface of his mobile devices along with production schemes and distribution services like Sound Cloud™.

In today's world we meet the most diverse music pieces co-existing together. To use a metaphor, it is like the transportation media that people around the globe use in a global perspective; we witness horse-drawn carriages, steam locomotives and hoy boats coexisting with luxury cars, lear jets, and deluxe cruisers. It is evident that not all of the above are based on the same principles; however, they all produce drift and movement, and some times, surprisingly, the most humble means prove to be serviceable under harsh situations while the lucrative ones fail over.

A similar situation evolves within the music scene.

We can clearly discriminate 3 axes that render our highly personalized music booth:

Axis 1 - The media

From the perspective of music reproduction, senior citizens can recall turntables, cassette players and Walkmans™, cross mixing with changes in sound equipment that come so quickly, that this year's state-of-the-art iPod™ may be a discount item next year! Along with the reproduction paraphernalia, rapid advances in computer technology shape accordingly the file formats for listening to or viewing music performances. Listeners worldwide, under varying living conditions, are for the first time merited with devices that offer high quality multimedia reproduction.

Axis 2: The instruments

From the viewpoint of musical instruments, indeed "analogue" devices like the clarinet, the trombone, the violin, the piano or the guitar seem to render in our senses a consistent pattern not only for decades, but in some cases for centuries; however, the advent of new instruments, namely the digital ones, has brought not only novel designs, but also new principles for sound production [4].

Although the set of traditional instruments constitutes a rich sound space, the interpolation and extrapolation of musical instruments morphs not only a digitally tuned replica of the original sounds found in nature, but extends musicality beyond limits.

A representative sample for this process is shown in Fig. 1, focused on the interface of piano-like instruments the last 100 years.

Axis 3: Musicality and Identity

This third standpoint has to do with the advances in computer music. Indeed, any sound produced by a loudspeaker, from the simplest to the most complex, can be simulated by software driven synthesizers [4]. It is obviously manifested that the potential for computer music synthesis launches perpetually an extraordinarily richer sound space. Since this kind of sound generation "is the bridge between that which can be imagined and that which can be heard" [5]. For instance, when it comes to rhythmic music, the predominant music paradigm of our contemporary Western music is the 4/4 beat, which is so often used that it becomes "something of a mystery". "Other cultures of the world, such as in India or the Middle East, for example-think nothing of using more exotic groupings of beats such as 7/8 or 11/4, and so on" [5].

These more unusual asymmetric metric cycles result from a different way of thinking about rhythm, the so-called divisive or multiplicative rhythm. While the notion for additive and divisive rhythms can cause a theory headache, global audiences can easily overcome the obstacle by listening the tons of songs that circulate on vast music repositories, collectively known as "ethnic music".

What should be made clear here is that the huge number of more than 300 million songs currently freely available to the global public do not pose only a matter of musical absorption and understanding, but also a matter of governance in technical terms [6]. We are driven to musical "cloud networks", accessed perpetually by computers, mobile devices and electronic paraphernalia

Fig-1: The piano derivatives within a century's drive: Left, wood harmonium (courtesy of Professor I. Kaimakis), center, SYNTHI Sequencer 256, circa late '70s, right, multi touch MusicStudio™ for iPad.

that have inherent issues of federation, presence, identity, and privacy in their web delivered services.

The usual classification scheme adopted for handling the multiplicity of vast collections, adopted unanimously from the software industry, is the genre. A music genre is a conventional category that identifies pieces of music as belonging ontologically to a shared tradition; additionally, it may encompass a set of conventions or rules, dynamically varying with time, that characterize music by similarities in form, style, or subject. For instance, hip-hop music, clearly identifiable and easily recognized on a global audience basis, is strenuously rhythmic, backed by its electronic instrumentation, simultaneously being little or not melodic at all, since it relies on its ardent articulation of the lyrics. As a result, it is sentimentally effusive, charging accordingly performers and listeners.

A key role in the aforementioned process of approximation is the notion for ontology, in its diachrony probably as old as Musicality. Perhaps the most accepted definition (at least amongst Computer Scientists) is that enunciated by Gruber [7]: "ontology is an explicit specification of conceptualization". Within this context, it is profound that conceptualization renders an abstract model of some aspect for the world, taking the form of a definition of properties for important concepts and relationships. In more concrete words, the model should be expressed in some unambiguous language(s), so that it becomes amenable to processing for both humans and machines [8].

Genres therefore infer similarities in"kind", "form", or "subject matter". Stemming from the Latin gens (from Greek: genos, γένος) it has undergone, as we will see, a long route in categorizing music, or other forms of intellectual activity, as is literature, performing arts, either audial or visual, based on some set of stylistic criteria. However, in its present meaning it first appeared in 19th century French, hence its uncanny form in the English-speaking world.

Hence, genre appeared as an absolute classification system for ancient Greek literature. Poetry, prose and performance had a specific and calculated style complying with the theme of the story. Speech patterns for comedy were misfit for tragedy, and even performers were restricted to their genre under the assumption that a type of person could tell one type of story best. In later periods genres proliferated and adapted to the social, linguistic and artistic changes.

Genre bears the same ills of any classification system. It has taxonomical meaning, in an attempt to group music into types or structurally related categories. It helps music stores, repositories, on-line libraries to sort their astonishing range of merchandise, but since music is not only science, any classification system would prove at least partially subjective. For instance, at the highest level you might distinguish between instrumental and vocal music. This approach is sound historically, since in Ancient Greek Music even the notes used to codify instrumental and vocal rendition were different [9]. However, in practice it would create steeply unbalanced repositories since contemporary pop music, with whatever "pop" may refer to, not only in the West, but also globally, is predominantly vocal.

Therefore, music industry and on-line libraries infer and scrutinize genre to weigh works on their unique merit. Broadly shared aspects for musical compositions, most often aspects of the music's instrumentation or its particular use, ethnicity, etc. could serve as a classification basis for the audiences it is aiming to. E.g. pop, rock, metal, concert/classical, religious, jazz, world/ethnic, film music, Broadway music, ... etc.

It is expected in taxonomy that genres would yield subgenres, or as it has prevailed in the industry for music distribution, styles. Style has to do with conventions in rhythm, melody, arrangement, beat progression, harmony and production that are usually associated with music of a particular type, from a particular area, or of a particular genre.

So, from rock stem hard rock, punk rock, heavy metal. From jazz traditional jazz, bee-hop and improvisatory jazz. Latin American music yields samba, tango, rhumba. From vocal music we may get opera, choral music, vocal-quartet music. Classical music could engulf orchestral and symphonic music along with concerto or even opera. And again, concerto could submerge violin concerto, piano music, duet-quartet and so on.

Style also refers to characteristic features of how music is played or is expected to sound. Inherently, this notion encompasses musical diachrony and synchrony. In practice this involves specific set of music instruments, musical patterns, mannerisms and hitherto expressive devices it conventionally makes use of. "Baroque" for instance is a subgenre of "Classical" and it is readily recognizable by its characteristic musical idioms. For a specialist in Renaissance music, "madrigal", "motet" and "canzona" are clearly distinguishable entities [10]; even further, they were spread to Russia and South Eastern Europe. "Sonata" similarly denotes a particular style confined by an expected formal succession of events or logical organization plan. On the contrary, "Free-style" indicates compositions not subjugate to any predetermined form, usually incorporating a diversity of arbitrarily chosen stylistic idioms.

Within the synchrony of Western world, genre has a definite taxonomical consignment in its attempt to group music into *somewhat arbitrarily* structured multilayered schemes, referred to as genres, sub genres and styles. The term "arbitrarily" confers subjectiveness to the whole matter, because music is not merely anamalgam of science and art, but predominantly a highly inner core intellectual activity. Therefore, any classification system should seek to find out, how in a world of 7,200 spoken languages our brain encodes vocal music in languages we do not fully understand.

As Barsky has stated, we have witnessed rapid development of 20th century music, and the conventional classification methods many times fail short [11]. E.g., if a listener seeks for contemporary electronic dance music like "techno" or "house", how can he trace electrical guitar songs that have "blues" elements from the "funk" style of the 80's?

Although in terms of taxonomy for the Western music paradigm more or less a viable model has been proposed, for the rest of world music the situation is chaotic. For instance, one may search in the category of "film-music" (which is a thriving scheme for 21st century music production) for highly emotional music, appraised equally highly in people's preferences and ratings, and may end to *duduk* music, which is well rooted in the diachrony of Caucasian and East Indo-European traditions for more than two thousand years![1]

It is obvious that the massive exchange of "ethnic hearings" throughout the 20th century, already accelerated to unthinkable levels today, has given impetus for the study of specific music cultures, the creation of "musical languages" and finally, the formation their modal thinking. In terms of computer support for solving the issue, we need to provide a mapping interpreter, i.e. process the mapping relations to transform the domain knowledge instances (including case data) into corresponding method instances – which can be handled by intelligent systems directly. After that, the classifiers will provide a reliable form of knowledge-based reasoning. An ontology can provide a principled framework for modeling the important characteristics of problem solving methods – and in this case we cope with a description ontology. However, to move from a mere description to a classifier system, we need an operational description.

For example, what is the difference between "house" and "garage" music? Here, a viable answer may be yielded.

What is the difference between "Mode Plagal B" and "Hijaz"? Things get more difficult. The classifier system needs to encompass problematic complexity scales, modes, genuses (like diatonic, chromatic, enharmonic) [11] and after that it may come to some propositions referring to genres and styles.

Thus, the attempts made by European musicologists to extrapolate the terms and concepts in European musical practice to other cultures have failed in most cases. For instance, the application of diatonicism, alteration and so on, which are basic elements of the European modal theory, to some Eastern cultures, fails to reveal the singularity of their modal systems. By treating highly chromatic modes with an augmented second as "modified diatonicism" we impart a shade of imperfection to the basic structural principle underlying the ethos of such modes and their exotic colorfulness for European consciousness – as is the case of the so called "Russian music in the Oriental style". Generally speaking, for countries of the "old world" that have remained at the "crossroads" of many cultures, and perhaps, many languages, the predominant model for music making relies on the Middle Eastern paradigm, which is based on the prevalent model of vocal music (=language dependent) and consequently, the development of instruments without fixed tuning [12]. Although this is inherently plausible for the Eastern Music theorist, for Westerners, this concept was slowly conceivedafter Renaissance music styles, like the chromatic madrigals for mid-sixteenth century music. Interestingly enough, this wild cross mix of contemporary styles and genres, like film music, with ancient music traditions has provoked much interest for Western scientists [13].

2. MUSICAL PERCEPTION, MUSICAL ILLUSION AND AUDIOVISUAL PERFORMANCE

As we listen to music or view an audio-visual production, our brain focuses on the aural characteristic of the performance: pitch, loudness, and timbre for starters are perceived; other psychoacoustic phenomena also take place, and cerebral activity is induced tracing rhythm, melody and harmony. Also, we may sort out the performance of solo instruments or the sound of a group of instruments out of the mixture of sounds. Simultaneously, we are able to trace the scales, the pitch combinations (in the case of polyphonic music), and the overall structural characteristics of the music piece [14]. The latter is perhaps the subtlest characteristic in terms of the neurological aspects for music perception [15]

The aim of this research is to offer the network of ethnomusicology an indicator measurement for the acoustic fluctuation in a musical environment, using the color as musical genus discriminator [9][11]. The genders or types [16] are not distinguished here with the significance of modern types of music, as hip-hop, disco or jazz. That is to say the chromatic indicator does not constitute a method of discrimination for genre, as the one that was proposed by Tzanetakis and Cook [17] (2002), but is mainly a classification method based on the intervalistic characteristics of the musical systems incorporated; it covers a spectrum beyond the paradigm of Western music, importing metrics for the progress of chromaticism within the music structure. Consequently, the musical pieces analyzed within this method are categorized in "less or more chromatic"genuses (and not genres). The approaches and the definitions that are used

[1]The readers are counseled to indulge in these cross mix hearings by tracing Yanni's"Nostalgia" in concert with Pedro Eustache or listen to the corresponding *duduk* scenes of H. Zimmer's & L. Gerrard's music for the "Gladiator"film (2000), both available on YouTube and similar channels. They provide an excellent aural paradigm for what this research is about.

for the characterization of music based on its color coefficients are described in the next sections.

While in the West chromaticism started creeping slowly, with an apogee after mid 20th century, which lead to free 12-tone systems, the 21st century proved to be the apex of crossover modality; popular music shifted decisively from polytonic renditions to monophonic or homophonic performances. The same time, microtonal or not, this enhanced type of Greek monody accepted the complementary harmony of beat music, which rhythmically characterizes most songs circulating over the globe. While the former is a clear movement of Eastern horizontal chromaticism over Western music patterns, the latter is the apogee of Digital Music influence from the West over the East.

Therefore, when complementing horizontal chromaticism with vertical chromaticism, we offer an integrated theory that can explain in 21st century musicians how the potentialities of a 12-tone chromatic systems, more or less “Oriental”, may combine articulating chromatic pitch structures for building up contemporary musical entities, like the ones we so often see in global audience broadcasts[2].

For the mathematical background of melodic or horizontal chromaticism, the reader is directed to a detailed analysis byPolitis and Margounakis [18]. With the "chromatic" classification, is proposed a way for visualising music based on its color attributes. This visual perception is based on the real meaning for the Greek word color (“chroma”)and, obviously, imports a representation of music with real colors. There have been recorded in the past quit a few efforts for the modelling of sound with colors, based mainly on the cross-correlation between natural dimensions of sound and color. In Padgham [19], Caivano [20], and Giannakis and Smith [21], one can find a review on audio-visual cross-correlations, as these were recorded by researchers on computer musical and relative fields of research.

In this research it is essential to establish a correlation between musical color with the sentiment that music provokes to listeners; after all, music and colors are connected with sentiments. The musical patterns influence the listener’s emotional world [22], and he senses them as forms of intensity and relaxation [23]. The progress of melody creates “chromatic” impressions, that proportionally can be imprinted as a simultaneous "chromatic" elements. This progress, in combination with psychoacoustic theories, results to graphic representation of relations created between humans, music, sentiments, colors and musical color. In the form of semiotic triangles these relations appear in Fig. 2.

Semiotic triangles clarify how meaning is created, iconyfing the relations between the smallest units of meaning. In music semantics, signs and symbols bear the

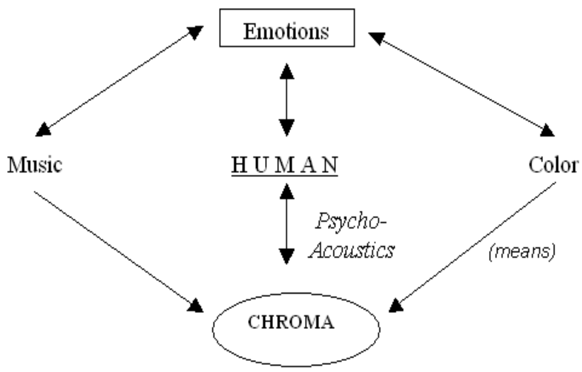


Fig.-2: Two semiotic triangles that depict the human interaction with reference to music chroma, when subject listen to music.

information, and researchers try to decipher their use or interpretation. However, at a user level, humans are not obliged to be proficient in music theory, which is the case for most surfers of YouTube, Dailymotion, Rhapsody et al.

Consequently, colors are substantially used for the representation of sentiments. Although in medical terms the measurement on sentiments is an open subject for criticism, Schubert [24] managed to model the ongoing sentiment correlated to perceived musical characteristics. Previously Sheirer [25] explored the psychoacoustic characteristics in relation with music surfaces. He used these relations as a measurement for similarity and a criterion for a high level semantic description of the phenomenon. Therefore, music chroma, as defined in this research is a perpetual and a pervasive psychoacoustic characteristic.

In strict mathematical terms, however, the similarity between music and color needs to surpass the factor of different dimensions. Images are conceived as two-dimensional signals, while audio signals are thought to be one-dimensional. However, psychologists and doctors when examining the brain-computer interface of aural perception tend to consider phenomena that are certainly beyond a mere one-dimensional entity. Not to perplex things, the reader is directed towards Shepard's literature in [26], that is supporting this attitude doctors and physicians are experiencing in their everyday practice.

In our attempt to move from one-dimensional signals to two sounds that are perceived as two-dimensional

[2] Apart from the well-known musical pieces referred to in the previous footnote, the annual “Eurovison” song contest provides feedback on how Westerners assimilate chromatic elements. See for instance the songs that have excelled, performed by SertabErener (2003), Ruslana (2004), Elena Paparizou (2005) and Alexander Rybak (2009).

entities, we use images are though as entities with more dimensions. Indeed, all the sounds that the human auditory channel may perceive are assorted within the 50 Hz – 20 kHz frequencies range. Therefore, sound signals, and especially the musical ones, are characterized by a vector $\boldsymbol{v} = (f, \Delta t)$ depicting their frequency and their duration. In terms of music perception this seems to be a coarse approach, waiving the artistic dimension of music as a *performing* art [27]; however, it has served as the basis for developing algorithms for sound to image and image to sound transforms.On the other end, images are signals characterized by a frequency within the optical range, or, as it has been the tradition in Physics, with a wavelength λ. According to the International Commission on Illumination (CIE) any real color can be expressed as a mixture of three CIE primaries **X**, **Y**, **Z** [28]. Therefore, a given color C of wavelength λ can be expressed by (1):

$$C\lambda = X\mathbf{X} + Y\mathbf{Y} + Z\mathbf{Z} \qquad (1)$$

On the coefficients *XYZ*, called *tristimulus values*, can be calculated using the CIE color matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ (see Fig. 3):

$$X = k\int_{\lambda} \bar{x}(\lambda)\Phi(\lambda)\mathrm{d}\lambda \quad Y = k\int_{\lambda} \bar{y}(\lambda)\Phi(\lambda)\mathrm{d}\lambda$$

$$Z = k\int_{\lambda} \bar{z}(\lambda)\Phi(\lambda)\mathrm{d}\lambda \quad (2)$$

$\Phi(\lambda)$ is the spectral distribution of light stimulus, and k, a normalizing constant.

The normalization of the *X*, *Y*, and *Z* values results in the production of the *x*, *y*, and *z* values respectively:

$$x = \frac{X}{X+Y+Z} \quad y = \frac{Y}{X+Y+Z} \quad z = \frac{Z}{X+Y+Z} \quad (3)$$

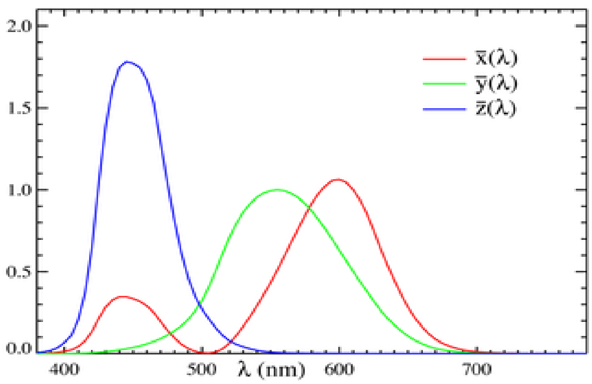


Fig-3: The color matching functions with wavelengths in nanometers. Since 1931 they serve as a common denominator for the quantitative analyses of colored objects.

Since $x + y + z = 1$, z may be omitted. Therefore, one may use only the x and y values, known as the *chromaticity coordinates*, to plot the *CIE(x,y)* diagram in Figure 4.

This research is focused on musical hearings from all over the world, and especially from around the Mediterranean. Non Common Music Notation based songs and recordings have been taken into account, characterized by different "ways" [29] and sounds. Consequently, it is necessary to use an ardent identification for "musical color" and for what is "chromatic". As chromatic in practice we perceive as any sound that has a pitch different from the distinguishable frequencies of scale, with its alterations included.

We can also calculate how much chromatic is a sound from the intervals that he forms with his "neighboring" sounds (previous and next). Also, characterizing a musical hearing as chromatic or not is a consequence of its cross-

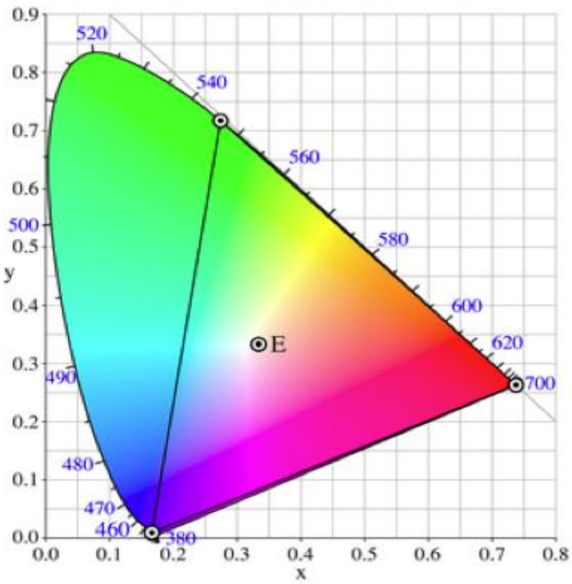


Fig-4: The CIE color space chromaticity diagram with wavelengths in nanometers (x axis) and in RGB gamut.

correlation with psychoacoustic phenomena, e.g. an artist can "color" a song with his voice, while some others may not [30]. If hearing a melody causes emotional charges, then obviously we have some form of chromatic fusion. In this case, chrominance is defined as the difference between a color and a predetermined color level corresponding to a concrete chromaticity level and equal brightness.

3. REVERSE ENGINEERING A CHROMATIC NAVIGATOR

Although not every music tradition applies the same colored"sentimental values" to musical environments, a global culture has been shaped that more or less convenes to the same gamut regions. For instance, in most audio-

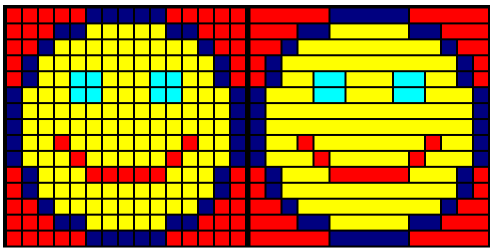
visual productions, black or grey colors are reserved for unhappiness, mourning, or devastation.
Therefore, the theory of chromaticism is demonstrated in this section as a reverse procedure. The user may pick a photo, which has clearly distinguishable regions, and try to come up with music that has the same chromatic behaviour.
As a demonstration for the ability to correlate colors and sounds, the happy face  icon has been used, explained in Figure 5. The temporal segmentation of music leads to the chromatic slicing in Figure 5a, while the musical motivic segmentation is more easily detected in figure 5b.

Nonetheless, nor (a) not (b) can produce music. If the chromatic transform described by Politis and Margounakis [18] is applied we get the music in Fig. 7. To get there, we evolve in three steps:

Step 1: Image pixelization

Step 2: Image segmentation

Step 3: Transform of color cohesive elements to musical segments



(a) (b)

Fig- 5: The reverse process:
(a) Colorful grid elements for the "happy face" icon.
(b) The chromatic bricks used in the composition "Happy Face".

The second step for the acoustic representation of the "happy face" picture concerns the equivalence of "chromatic bricks" with music segments. The rule that is used for this aim is that neighbouringcolor elements (bricks) belong in the same musical segment. The process is materialised with the use of *a single point* as described by Yeo and Berger [30]. We scan the picture 6a commencing from the first uppermost left element and heading to the last element on the under right brick. We move from line to line, from the upper part to the lower part. When we detect bricks with the same color, we group the together. The chromatic bricks of "Happy Face" appear in evident ensembles in Figure 6b.

The method described thus far represents the machine-induced composition by using as input color elements. According to Barsky [11], there exist two types of chromaticism in music: horizontal (i.e. having to do with the melodic line) and vertical (coping with harmony). In the present study, to make things easier, we see only the impact of horizontal transforms.
As we may recall from [18], the chromatic index is defined as follows:
A tone corresponds to 200 cents, as usual. Therefore, a half-tone corresponds to 100 cents, a quarter-tone to 50 cents etc.

- For each interval ***i*** in the scale calculate K_i:

$$K_i = 200 / \boldsymbol{c_i} \qquad \boldsymbol{c_i} \leq 200 \qquad (4)$$

$$K_i = -0{,}0002 * \boldsymbol{c_i}^2 + 0{,}12 * \boldsymbol{c_i} - 15 \qquad 200 \leq \boldsymbol{c_i} \leq 400 \qquad (5)$$

where
c: the interval cents

Each scale, diatonic or not, corresponds to a Scale Base Indicator (SBI) denoting the inherent chromaticism a song bears as its melody is progressively deployed

- For *SBI* is equal to:

$$\chi^{o} = [(\sum_{i=1}^{n} K_i) + j]/n \qquad (6)$$

where
n: the number of whole tone steps in the scale (number of notes – 1)
j: the amount of the extra accidentals on the scale notation, different from the accidentals at the key signature.

Then the following are valid:
Lemma: if $\boldsymbol{c} \rightarrow \boldsymbol{0}$ then $\chi \rightarrow \infty$
Explanation: The smaller the interval, the more *chroma* is added to a melody. However, a historically accepted threshold of about 30 cents (2 echomoria) is defined as the least interval of two distinguishable tones [31].
Proof: Obvious, if (4) is considered.

According to this method, fixed bricks, which are stored in a database, are used. Obviously, the composer, other users, or even a random brick generator may create additional bricks and thus enrich this database. This method supports two kinds of bricks: *absolute bricks* and *relative bricks*. An absolute brick is defined in a different way from a relative one. Also, different notation is used to represent each of those kinds.
Every icon-element (aka "brick") represents a full measure. The rhythm chosen was 2/4 as more representative for global vocal music instead 4/4- recall what was earlier said [5]. After all, rhythm 4/4 is somewhat a composite 2/4.

To simplify things, yellow bricks are considered as having chromatic index χ=1.2857 (instead of 1.3), while red bricks have χ=1.4857 (instead of 1.5). This induction permits the effective use of the Western major scale simultaneously with the 8th Mode (Mode Plagal D) of Byzantine Music, which historically is the most diatonic scale in Eastern Mediterranean civilizations. For these two scales we have SBIs χ^0 1.2857 and 1.4857 respectively.
Recall also from [18] that there is a “Scale Bank”, i.e. a database that contains scales and modes, each of which is expressed in terms of its individual attributes. This “Scale Bank” contains more than 100 scales, which can be classified in categories like: Western, Oriental, Byzantine etc.
The proportionality of the “happy face” brick colors corresponds to the adequate scale from the ones listed within the Scale Bank. “Happy face” has:

- 120 yellow icon-elements (χ=1.2857) → 53.3 %
- 57 red icon-elements (χ=1.4857) → 25.3 %
- 40 dark blue icon-elements (χ=1.7) → 17.8 %
- 8 sky blue icon-elements (χ=1.2) → 3.6 %

Taking into account that the yellow color is predominant in this figure, we choose from the Scale Bank a scale with SBI χ^0 = 1.2857. This chromatic index corresponds to the major scale, and somewhat randomly we choose G major. Had we accepted χ^0 = 1.3, than another scale should had been picked up, very close to G major, but not G major it self! However, such a decision would complicate things obscuring the proposed navigation scheme. The musicologist intrigued is exhorted to relish with [18].
Some twelve heuristic rules were used to transform χ fluctuationsto music sphere semantics. For the sake of simplicity, we present only two, engaged when significant $\Delta\chi$are encountered.

- IF { $||\Delta\chi||$ > 1.3 (i.e. roughly the SBI) } AND { the second brick has the dominant color } THEN { [rests are inserted in the measure corresponding the current brick] AND [the adjacent next brick starts with the chosen scale, for instance in our melody G Major] }.
- IF { by using the 11 other rules no metabolized melodic sequences come up } THEN {[the measure corresponding to the current brick is pudded with rests] AND [the adjacent next brick is initiated within a new scale with SBI χ^0 as close as possible to the chromatic index of the second brick] } // Scale change rule

The smallest accepted interval for this composition is the quarter-tone (i.e. 50 cents) and for this reason the symbols half-flat (𝄳) and half-sharp are used (𝄲), so common in Eastern traditions.
By applying the compositional rules and considering the bricks of picture 5 as absolute ones the following come to surface: Absolute bricks have two musical elements explicitly defined: notes and their values (they may even contain rests). For example, the absolute brick of the first brick in Figure 5a is described with the following sequence of linear music events

$$\{ (G_4 , 0.5) , (G_4\#, 0.5) , (A_4 , 0.25) , (A_4\#, 0.25) \ ((B_4 , 0.25) \ (C_5 , 0.25) \} \quad (7)$$

or, the Common Music Notation melody seen in Fig. 6.

Unlike absolute bricks, relative bricks do not contain information about the absolute notes position, but only the relevant intervals between the notes. They serve better for Delta systems, like Byzantine Music.

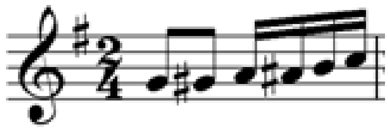


Fig-6: An absolute brick in notation staff.

The quantitative differences lie in the intervals used in Western and Byzantine music. Byzantine chants contain certain intervals, accidentals, and tonal attractions which result in pitches that do not exist on the equally tempered keyboard, the standard for pitch relationships in contemporary Western compositions. These subtle differences add a unique beauty to Byzantine Music melodies. Although there was a tendency to consider these differences of minor significance for transcription to the Common Music Notation corpus [32], recent advances in computer music reproduction schemes pose the need for a detailed and documented incorporation of these attributes to the digital interfaces of contemporary instrumentation.
Since not only Byzantine Music but other variants surviving in the East, like Japanese music, have different scales, semantics and perception, this research does not dip into the quantitative approach a machine-induced processing scheme. Under this consideration, the "happy face" icon may yield the melody of Fig. 7, which is indeed rather happy!
Some applied examples will be presented here, to clarify how these two rules are applied to the brick sequences of Fig. 5. However, the complete algorithm for transposing images to music will not be presented, since its complexity is beyond the scope of this paper.

- The first rule previously mentioned was used every time the sequence {dark blue brick, yellow brick} came up.
- The second mentioned heuristic rule was used in two cases: A. in measure 29, when the sequence {dark blue brick, red brick} appeared. B. In measures 44 and 60, when a yellow brick was succeeded by a dark blue brick with time length equal exactly to one staff measure. In this case, as it can be readily seen in Fig. 7, the G minor

harmonic scale was initiated, with SBI corresponding to χ^0 =1.857.

- Measures 1-5 in Fig. 7 represent the first red segment of Fig. 5b. As we clearly see in the grid of Fig. 5a, it corresponds to 5 bricks, i.e. 5 measures. Its chromatic index is χ=1.4857. Measures 6-10 represent the second dark blue segment, bearing χ=1.7.

Repetitions are clearly visible in the composed melody; that is somewhat expected, since the "happy face" icon is recognizably symmetric, yielding the symmetry of melodic repeats.

The exposed algorithm saves the first melodic motive that was composed within the scale of the composition (G Major - measures 21-25) and uses it as much as possible, i.e. in any brick that no other melody is suggested with strong confidence. Indeed, this motive is repeated in measures 37-41, 52-56 ... A variation of it, in another tonality appears in measures 29-33.

It could be said that this melodic piece is characteristic motto of the "happy face" icon. It is interesting in terms of psychology to decipher what color elements and under which shape give a vague depiction of the aforementioned icon.

It is interesting enough that musicologists with profound insight on practical chromaticism, reaffirm one way or the other, the mathematical background or the compositions that computers proliferate and propagate [29].

Fig-7: The "happy face" melody in Common Music Notation semantics.

4. CONCLUSIONS

Music perception and cognition involves the generation of expectancies in the form of pitch-time patterns. These depend on the prevalence (frequency of occurrence) of specific patterns and continuations in the music to which a person has been exposed. It should therefore be possible to reconstruct the musical expectancies of listeners from a specific historical period by statistical analysis of a large databank of representative music of that period. This approach assumes musical learning by neural networks or similar AI tools, and is consistent with the stylistic diversity of music across cultures and periods.

The visualization of an audio piece can be used both as an addition to the musical experience or as a unique "fingerprint" that marks and characterizes the file. The ability to easily identify chromatic patterns in a song enables its quick analysis and categorization, elevating the visualization as one of the strongest potential audio metadata.

The conversion of an image to sound based on the concept of chromatic bricks can be used to create unique musical compositions, as long as two dimensional transforms to one dimension astutely represent accurately melodic lines.

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