THE CONCEPT OF *TEXTURAL VALUE*. ADOPTING TERMINOLOGY FROM THE THEORY OF LIGHT.

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1.1 Abstract

Could parts of the theory of light, as we know it since Newton's era provide us with adequate *terminology* for the analysis and appreciation of electroacoustic music? This paper examines the use of terminology that springs from parts of the theory of light, applied to electroacoustic music, highlighting the intimate connections between the visual and the auditory, and suggesting that music is not solely an auditory experience. Furthermore, the extra-musical nature of various sonic parameters cannot be addressed solely with *reference to musical language*, but should include possible relationships and analogies with other forms of art and, in general, with aspects of life. Hence, the concept of **Textural Value** is introduced as a unifying feature that relates sonic parameters and attributes with light, contributing to a meaningful understanding of music. The terms of *Frequency* and *Amplitude*, *Hue*, *Saturation*, and the *Brightness* of a sound are presented as co-ordinates that unify aspects of sound and light. This notion of unity manifests itself at two levels:

a) micro-structural.
This level is concerned with metaphorical applications of light (transparency-opacity) within local structural groups or topographies. The co-ordinates of textural value are manipulated in such a way to suggest representations of light and shadows that establish local environments.

b) macro-structural.
That level deals with temporal progress and morphological considerations at a higher level of application. Temporal transitions are significant structural tools, which emphasise the transformations between spectral transparency and opacity.

1.2 Textural Value

There is an amount of meaningless information concerning the sonic stimuli that can be processed by the listener and contribute to perception. This information carries data regarding the pitch and amplitude of a sound and its spectral position. The meaningless sensory data and the meaningful understanding of sound and sonic events take place within a context, which I refer to as *Textural Value.* Textural value contains the totality of meaningless and meaningful information that allows the listener to develop an interactive relation with the sonic material. Objective parameters, such as *amplitude* and *frequency* (meaningless), and subjective attributes, such as *hue*, *saturation* and *brightness* (meaningful) are co-ordinates that define the perceived textural value.

1.3 Spectral Energy Distribution (SED): amplitude and frequency

Spectral Energy Distribution indicates the energy, or power of the components in various regions of the sonic spectrum. It mainly refers to the distribution of monochromatic frequencies within the spectrum, and is defined by two objective, and therefore measurable, parameters: amplitude and frequency. SED contains the meaningless information that defines the amplitude of a sound and its spectral position. Hence, it provides a basic frame within which more subjective criteria regarding the perception of a sound can emerge.

Each monochromatic sound has a specific Spectral Energy Distribution. More complex sound typologies are the sum of individual components of the spectrum that are heard simultaneously. Figure 1 illustrates the particular SEDs for a sound typology that consists of three monochromatic frequencies: 65 Hz/C1, 329 Hz/E3 and 1567 Hz/G5. The amplitude of each frequency is measured by using the diapason tool of the Audiosculpt software. Figure 1 simply illustrates the measured amplitudes and frequencies constructing a C major triad.

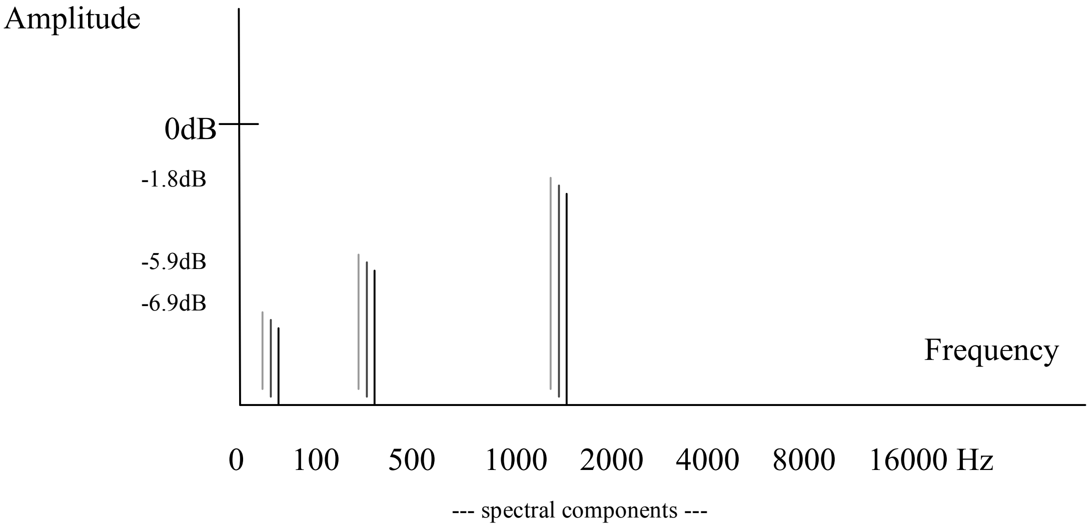

Fig. 1: SED for low, medium and high components of a C major triad. (65Hz/C1, 329Hz/E3 and 1567Hz/G5).

Spectral Energy Distribution can be regarded as the sum of "local colours" or "local energies" presented at any given moment in the spectrum. However, unlike the *Spectral Power Distribution* of light, which defines the colour portions of the spectrum of white light, as separated by a prism (Williamson and Cummins, 1983:15-17), the Spectral Energy Distribution of sound is very much dependent on the temporal dimension. A colour could be static and be perceived as such, but this is not the case with sound: sound entities, however simple or complex they might be, exist in a continuous temporal evolution. For this reason the SED of a sound is never fixed nor static, and its temporal development is interconnected with the duration of a sound and its spectromorphological evolution. A typical example of the interconnection between the Spectral Energy Distribution of the components, time and spectromorphology is the glissando. The illusion of moving up or down within the spectral space is actually produced by the continuous change of all the SEDs of the monochromatic components of the sound. The fact that alterations in pitch result in different spectral positioning of the sound means that the spectromorphology is also continuously altered.

1.4 Hue, Saturation and Brightness

Even the most attentive and meticulous observer has no way of specifying colour in an absolute and quantitative sense (Williamson and Cummins, 1983:15). Colours, which are the expressions of light, or the way light is perceived by humans, resist a forensic examination. This is why all the efforts to associate colour and sonic frequencies are subjective approaches with little scientific merit[1]. However, these associations can prove useful when they are used in a *comparative* way, comparing the attributes of one colour with those of another. Colour attributes such as hue, saturation and brightness are comparative co-ordinates, which are stored in the memory base and can be used for reference.

In trying to understand sonic phenomena one is confronted with a similar situation: there is no way to "put a number" to sound. Understanding the sonic structures and the behaviour of individual sounds means comparing them with other sounds and structures within the same piece of music. Coherence is thus important because it offers a criterion of comparison that unveils the dynamic balance of a piece. Apart from amplitude and frequency that indicate the Spectral Energy Distribution of a sound, hue, saturation and brightness can be used as attributes for the comparison and perception of sonic events and their textural value. I refer to them as "attributes" because they describe the perception of a sound and not the physical properties of the sound itself. The description of a sound in terms of hue, saturation and brightness applies only to what is perceived.

According to Williamson and Cummins "…hue is the attribute that we denote by such adjectives as red, yellow and green. It is an obvious feature of monochromatic light that varies with wavelength and therefore is used to denote various regions of the spectrum." (1983:16). In sonic terms, hue can be described as the wavelength classification of a sound within the low, medium or high regions of the spectrum. It may

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[1] See Colla (2001), and Burgmer (1995). Composer Robert Normandeau presented a similar argument during the festival "L'Espace du Son", 2000, in Brussels, Belgium.

refer to monochromatic frequencies but does not contain information regarding their spectromorphological behaviour. Hue may also specify the prominent frequency of a complex sound thus indicating the primary spectral region (low, medium or high). In the first case, the hue of a sound can be compared to monochromatic light. It indicates a sine wave, the individual and atomic existence within the spectrum that cannot be further subdivided (*monochromatic hue*). In the second case of a more complex sound, *polychromatic hue* gives an indication of the spectral region within which the sound appears. Although pitched complex sounds with the same prominent frequencies can be perceived as completely different entities, depending on their partials, their hue will remain the same as long as the prominent frequencies are the same. For example, let us assume that a C major chord has a polychromatic hue of 261 Hz (C-fundamental). If we add a seventh on the top of the chord, that is the frequency of 466 Hz (B flat), our perception of the chord and its structural role will be completely altered. However, we shall still refer to it as a chord of the same fundamental or hue.

Although the hue of a sound is objective and measurable, I choose to refer to it as an attribute rather than a parameter because the notion of colour or hue applies only to the perception we have, and not to the stimulus that produces it. Hence, when we associate a colour with a sound, we really mean the colour that is evoked in our mind by a specific sound. As Williamson and Cummins put it, "For convenience we may talk about a *yellow light*, but we really should say a *light that we perceive as yellow.*" (1983:14).

Williamson and Cummins point out that "Saturation refers to the lack of *whiteness* in a colour, or more precisely, how much a colour differs from white" (1983:16). This means that white light contains no saturation at all and, to the contrary, the state of a monochromatic light is associated with saturation. Monochromatic is regarded as the most saturated form of a particular colour[2]. In the sonic world we are used to referring to saturation in an opposite way: the overloading of the spectrum. Also, during the electronic production of sound, the strength of a signal can create saturation. As John Backus explains, "There is…an upper limit on the strength of signal that may be recorded, because the oxides [of the tape] can be magnetised only so far, at which point they become *saturated* and refuse to retain more magnetism no matter how strong the current in the recording head. This effect will produce distortion, so that the reproduced signal is no longer an accurate copy of the recorded one" (1977:320). It is obvious that Backus refers to saturation as an undesirable effect or by-product, a technical error that has nothing to do with the sound itself and which is produced because of the limitations of the recording medium.

In my approach, saturation should be regarded as an integral characteristic of the sound rather than a technical by-product. Hence, for my purposes, I will draw analogies from the visual world and will be referring to saturation as the state where a sound cannot be further divided into pure constituents: the state of atomic existence. In other words, saturation is how much a sound differs from white noise. For example, a monochromatic frequency (sine wave) is totally saturated. On the contrary, white noise is completely unsaturated. If we assume that white noise (whole spectrum) is a living organism, then we can think of monochromatic frequencies living within the spectrum as individual nuclei that cannot be further split. Hence, the degree of saturation, or how much

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[2] *Colour* and *light* have the same meaning here: colour is a particular form of light, and light is formed through colour.

saturation a sound has, indicates the ability or inability to be further subdivided into simplest sonic entities. Consequently, saturation is connected to hue. A monochromatic hue is characterised by maximum saturation whilst a polychromatic hue is less saturated. At the other end of this continuum, white noise is completely unsaturated because it lacks a dominant hue and accordingly should be called *achromatic*.

Brightness is the most difficult attribute to define. According to Williamson and Cummins "Brightness…describes the perceived intensity of light" (1983:16). In everyday terms, the sun at noon in a cloudless sky is perceived as very bright. Towards the end of the day, the sun becomes more blurred and dimmer. Although we can reach the conclusion that there is nothing bright about a romantic sunset, that does not help us to identify what the "perceived intensity" of a sound might be.

By now we have seen that we can measure in absolute values the amplitude and frequency of a sound (SED). We can also specify more or less accurately the monochromatic, polychromatic or achromatic state of a sound and whether this sound is totally saturated or unsaturated. For hue and saturation we can vaguely identify their boundaries and therefore create a continuum within which we can locate, describe and characterise the perceived sounds. The attribute of brightness however resists this categorisation. It is impossible for example, to specify what total brightness is. For the sake of simplicity, I will associate brightness with transparency and/or opacity. Using this association, one can accept that whenever a sound is perceived without any obstructions, distractions or masking effects it is characterised by transparency. A transparent spectrum is thus a spectrum that contains a small number of frequencies, which are not close together. On the contrary, a dense spectrum within which masking effects and other distractions, such as differences in amplitude occur is characterised by opacity. Consequently, if we necessarily need to identify a pair of boundaries for the continuum *transparency-opacity* I suggest we accept that a monochromatic and saturated hue, which is perceived with no obstructions or other sounds near to it, is characterised by transparency while achromatic and unsaturated white noise is associated with opacity. Therefore, brightness, or the lack of it, refers to how transparent or opaque a spectrum is perceived to be. *Luminosity* and *obscurity* can also be used as alternative terms for the description of brightness.

Hue, saturation and brightness are comparative attributes that result from opposite associations and describe the textural value of a sound. An opposite association for example, is that the less saturated a sound is, the more polychromatic its hue becomes. An illustration of a hypothetical axis of brightness is given below by the triangle in Figure 2.

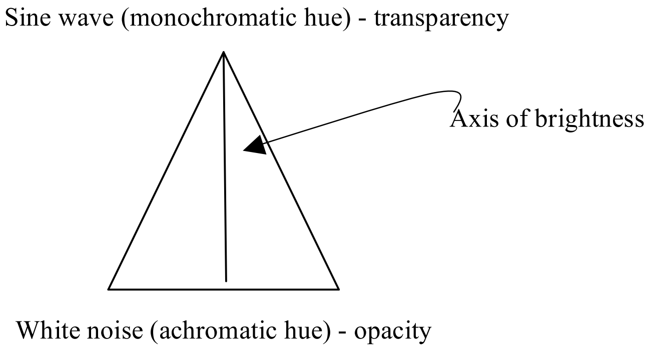

Fig. 2: Axis of brightness

If we accept this hypothetical scale of brightness we can describe a sine wave at the peak of the triangle as having a specific monochromatic hue (frequency), which appears in its most saturated form (lack of partials), and is characterised by transparency since there are no other sounds or partials to obstruct it. At the base of the triangle, which defines the audible spectrum, the white noise lacks hue since there are no dominant frequencies. It is totally unsaturated and opaque.

Although hue, saturation and brightness can be used as basic linguistic terms for the description of isolated sounds or sound structures, in more complex situations of audition their use is cumbersome and often inadequate. At the macro-structural level of describing a piece of music for example, our judgement of the sound typologies and their interaction may be influenced not only by the type of individual sounds but also the context, the sonic surroundings, the properties of the listening space and our attention. It is more or less easy to determine the textural value of an isolated sound, but doing the same at a macro-structural level can prove a seriously difficult task.

1.5 Spectrum Circle

An effective way to visualise the interaction between hue and saturation is the circle shown in Figure 3.

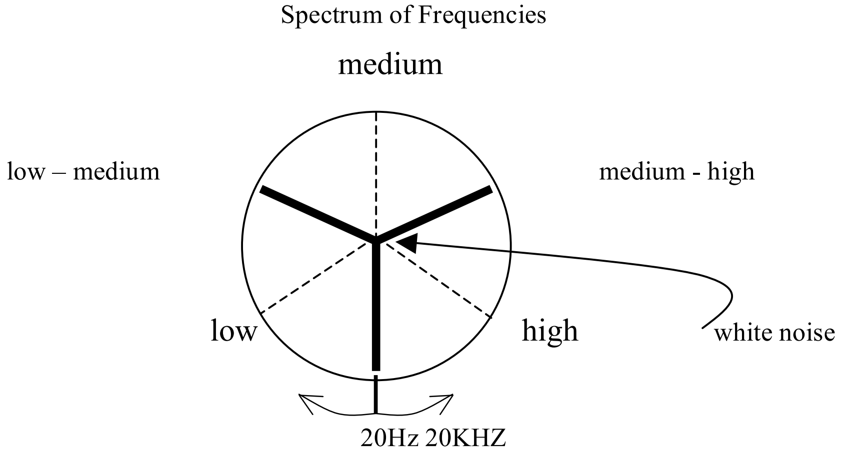

Fig. 3: Spectrum Circle

The Spectrum Circle is a two-dimensional map showing unsaturated white noise in the centre and progressively more saturated sounds towards the circumference. The complete series of sine waves, from 20 Hz to 20 KHz, is situated on the circumference. The more frequencies are added, the closer to the centre of the circle a sound is. This is a useful way to represent visually parts of the textural value of a sound, because it includes information regarding hue and saturation. Although it is a subjective visualisation, since it does not assign numerical values to sounds, it is presented here as a tool for hue and saturation categorisation: a sonic palette.

1.6 The "maypole" of textural value: the projection of mindscapes

Until now I have been suggesting that the description of sonic events can be defined by a number of objective parameters and subjective attributes. The objective parameters include the amplitude and frequency of a sound, or its Spectral Energy Distribution (SED), and the subjective attributes, the hue, saturation and brightness. Following the Spectrum Circle which represents two dimensions of the textural value of a sound (hue and saturation), I now add a third dimension to include brightness. Hence, the Spectrum Circle will be transformed to a three-dimensional map that describes the co-ordinates of the textural value of a sound, as shown in Figure 4. Amplitude is not included in this description because its level of interaction with the other co-ordinates is not influential. Frequency is also omitted because it is related to hue.

In Figure 4, textural value is represented by a kind of map that resembles a maypole. The axis of brightness has three primary regions: *transparency*, *translucency* and *opacity*. It is represented by the subjective and therefore unjustifiable continuum of transparency-opacity, and has its starting point on the centre of the spectrum circle where white noise is situated. Transparency includes all the sine waves or monochromatic frequencies of the audible spectrum (20 Hz - 20 KHz). One can think of transparency as the situation where an object or an entity transmits virtually all its light. In sound terms, transparency refers to the situation where a sound is perceived without any obstructions or masking effects, therefore projecting all its characteristics. Translucency is the state where light is partially transmitted or, in sound terms, the situation where a sound coexists with other sounds and its perception is subjected to some masking effects caused by them. Opacity is the situation where light is either not transmitted or absorbed. The

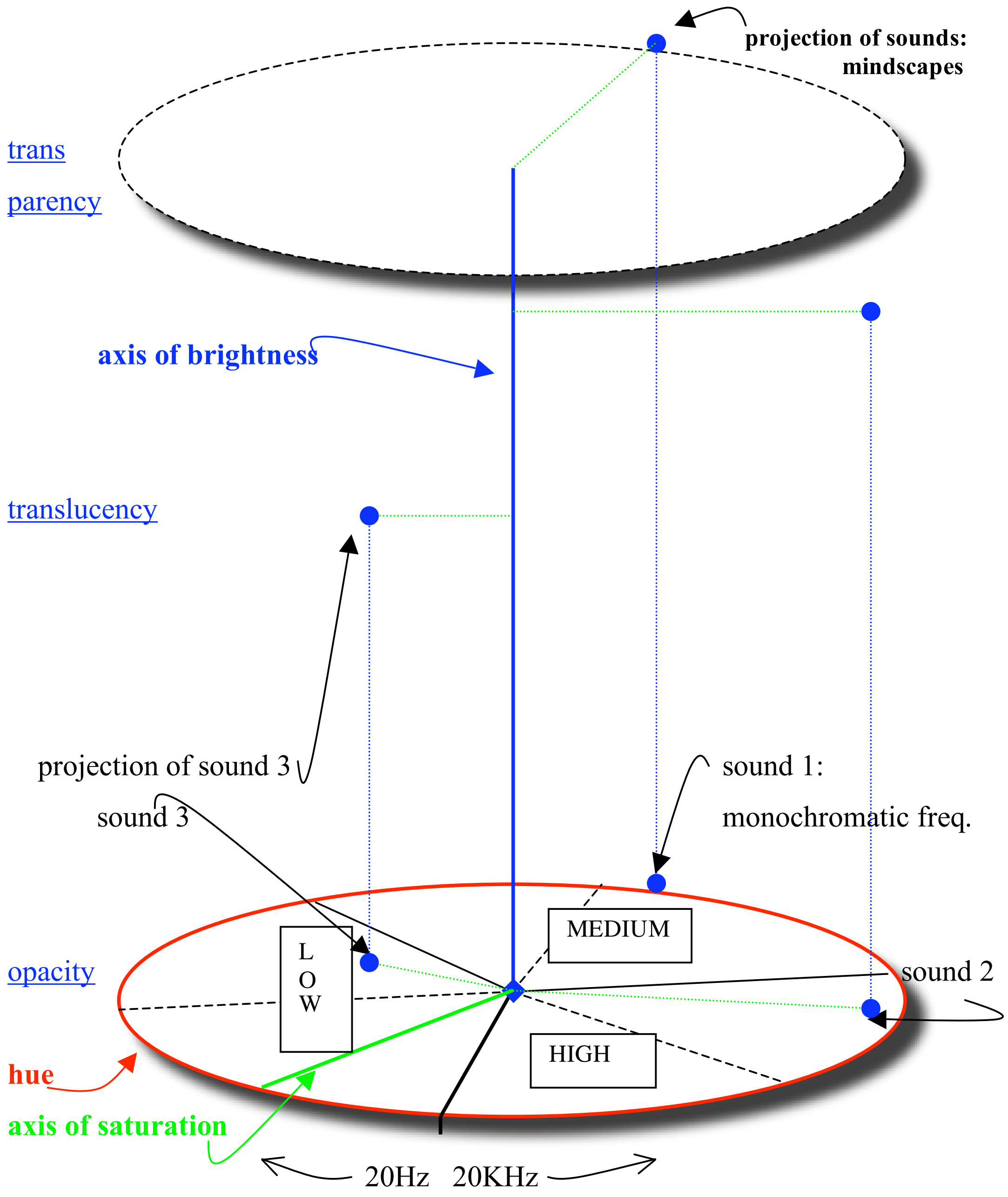

Fig. 4: The maypole of Textural Value and the projection of mindscapes

state of maximum opacity in the scale of brightness concerns only white noise because none of the individual monochromatic frequencies of which it consists has a dominant presence.

Hue is represented by the circumference of the spectrum circle where all the monochromatic frequencies of the audible spectrum are situated (monochromatic hue). The more towards the centre of the circle a frequency is, the more partials are added to it (polychromatic hue). The centre of the spectrum circle represents white noise (achromatic hue). The axis of saturation is the radius that starts from the centre and reaches the circumference. The circumference of the circle is thus associated with maximum saturation whilst its centre has no saturation.

Physical stimuli (sounds) are positioned on the spectrum circle according to their hue and degree of saturation. The upper circle represents the projection of the stimuli to include their degree of brightness. The more towards the circumference of the circle a sound is located, the more transparent it is.

The maypole of textural value enacts, in a way, the process of musical perception. When a listener hears a sound, he/she decodes very quickly its spectral position and its main or fundamental frequency/ies, thus gathering the first information regarding the hue of the sound in question. The next step concerns the sound's texture: how poor or rich in partials it is, or what degree of saturation describes its texture. Then, the investigation of the texture that has just started, moves a step further: how far this texture is subjected to masking effects that occur due to co-existence with other spectrally close frequencies, or, how transparent or opaque the spectrum sounds.[3]

Each of the steps we take in our effort to investigate and comprehend the texture of a sound takes us further from its acoustic properties and leads us to more abstract aspects, which concern all the possible representations that the sound may provoke to the imagination: images, archetypes and thoughts. The "door sound" example supports this argument: a sound that comprises similar hue and degrees of saturation and brightness to those of the sound that comes from a closing door, may provoke the image or representation of an imaginary closing door. While investigating the textural value of a sound, the listener needs to be distanced from the physical properties of the stimulus in order to grasp its innermost character and interpret a meaningless acoustic signal into meaningful art[4]. Although the physical properties are stored in the memory base, the interaction with the sound, which I define as the creation of **mindscapes**, emerges from the deciphering of the attributes of textural value. The maypole of textural value provides a workable, though subjective, means of describing the texture of a sound. It is subjective because there are no numerical units to measure the saturation and brightness of a sound and therefore the scales of saturation and brightness have unjustifiable and blurred boundaries. Moreover, the more complex a sound or a group of sounds is, the more subjective the perception of its textural value becomes. However, a composer could use the maypole of textural value as a strategic map for shaping spectromorphologies. Let us examine more closely the map, illustrated in Figure 4, using three hypothetical examples that cover the three primary regions of the audible spectrum. Sound 1 is a monochromatic frequency (sine wave) within the medium primary region. It is situated on the

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[3] This paragraph assumes a chronological order in the process of perception. However, this order is based on my personal experience and is therefore subjective.

[4] This listening strategy is similar to *écoute réduite,* described by Schaeffer (1966).

circumference of the spectrum circle, and has maximum saturation and brightness (transparency). Sound 2 is located within the high primary region and carries a small number of partials. It is characterised by a high degree of saturation and brightness on condition that its partials do not cause influential masking effects. Sound 3 is a semi-complex sound located in the low region of the spectrum. Since it carries a large number of partials, its perception is influenced by internal masking effects and therefore is characterised by translucency. It is situated in the middle of the saturation scale because although some of its partials may be dominant, they cannot be perceived individually. Hue, saturation and brightness are projected above the spectrum circle in order to underline the fact that during the perception and comprehension of the textural value of a sound, the listener is distanced from the physical properties of the stimuli. The listener thus enters the realm of representationalism where mindscapes related to images, archetypes and thoughts are stored and emerge from the memory base.

1.7 Observations regarding the perception of textural value

The maypole of textural value can be useful for both composers and listeners because it offers a tool for the identification and description of a texture. It also provides a method for subjective analysis based on the following observations:

(i) The more transparent a sound, the more saturated it is.
(ii) A monochromatic hue has the maximum saturation and brightness for its spectral position.
(iii) All possible textures can be produced by combinations of the three attributes in proportion.
(iv) Two textures are equivalent when they have equal attributes. However, since we cannot specify numerically the saturation and brightness, this is an empirical comparison.

The great disadvantage of using the maypole of textural value lies in the fact that it does not include the temporal dimension. It treats the sound as a "visual" element, which is frozen in time and therefore stable for examination and comparison. Iannis Xenakis states that, in order to examine graded values, in our case the textural value of a sound, it is necessary to involve the temporal dimensions of *before* and *after* (Solomos, 2001:60). Only these dimensions will allow the observation of the ceaseless modifications of all the attributes in the passage of time. For example, in order to understand how a glissando moves within spectral space, we need to know the state *before* and *after* each spectral point of the glissando. For a description of textural value that involves the temporal dimension we need a much more complicated system than the diagram provided here. Still, such a description will only be comparative, since any involvement of the temporal dimension presupposes a subjective approach.

1.8 Summary

Throughout this paper, many arguments suggest analogies between visual and auditory perception. The differentiation between physical stimulus and perception and the distinction between meaningless and meaningful information have been emphasised. Perception has been described as the interactive relation between sensation of objects or events and their mental interpretation. In order to appreciate the music, the listener has to explore and eventually understand the meaningful information carried by the sounds, and apply representative relationships in order to understand the dynamic balance of the piece. It has also been argued that, due to the inadequacy of the memory base in acousmatic music, the listener unconsciously searches for representative relationships, or mindscapes, different from and unfamiliar to previous musical experience fields held in the memory base. The hypothesis developed is that the listener may understand and interact with musical events through the most common tool of perception found in memory base: light.

The concept of *textural value* was introduced in order to provide a context within which the totality of meaningless sensory data and meaningful understandings occur. The perceived textural value was defined by co-ordinates such as objective parameters (meaningless) and subjective attributes (meaningful), including *amplitude* and *frequency*, *hue*, *saturation* and *brightness.* A diagram, *the maypole of textural value,* provided a workable, though subjective, system for describing sounds, and could be used by composers as a strategic map for shaping spectromorphologies, and as an analytical tool for categorising sounds.

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