Texture and Entropic Processes in Electroacoustic Music

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Abstract

This paper investigates the aesthetic possibilities of textural processes as the root of organisation, causality and gesture in electroacoustic music. A general model for the qualification of textural properties is outlined, providing a foundation for elaborations concerning transformational and mutative, textural and gestural processes. In these explorations, metaphorical thinking is applied, inspired by contemporary natural science, rooted in thermodynamics, which has a wider relevance to the questions of organisation, causality and time in nature. The approach renders *entropy* (irregularities, disorder, unpredictability) the central subject, held here as a key influence on the emergence of temporal process and form out of textures. These processes are described as *dissipative structures* - an aesthetic concept based on the scientist Ilya Prigogine's work on self-organisation in nature (1984), which metaphorically matches well with the notion of texture as a self-propagating phenomenon (Smalley 1986).

The ideas presented here are a condensation of my MA dissertation, and are supported by excerpts from two compositions, *Multiverse* (2007-08) and *Far-from-equilibrium* (2008), which were realised as part of the research, supervised by Professor Denis Smalley at City University.

Texture and Entropic Processes in Electroacoustic Music

1. Introduction

In electroacoustic music, the term *texture* can be associated with spectromorphological phenomena that have the attributes of self-weaving, immersive sound canvases, which are often qualified by general characteristics and behaviours rather than distinct sequential organisation. Smalley has described the term in the following way:

> '*Texture* […] is concerned with internal behaviour patterning, energy directed inwards or reinjected, self-propagating; once instigated it is seemingly left to its own devices; instead of being provoked to act it merely continues behaving.' (1986, p. 82)

Texture is here described in contrast with *gesture*, which is thought of as a more initiative force, providing direction, causality and propulsion in music (ibid. pp. 81-84). Wishart has also elaborated on texture, drawing attention to the role of organisation and density in the textural listening percept:

> 'Textural perception […] only takes over when the succession of events is both random and dense, so we have no perceptual bearings for assigning sequential properties to the sound stream.' (1994, p. 66)

With this in mind texture can be regarded a multi-scale phenomenon, where the macroscopic appreciation of sound is closely connected to, and dependent on, low-level activity. This is relevant also for the attitude taken to texture traditionally, in the context of instrumental music, where the term is often used to describe 'the sound aspects of a musical structure' (Sadie and Tyrell 2001)[1], including timbral combinations and organisation of parts etc. Obviously, this perspective would be less adequate in electroacoustic music, where structure and sound are often synonymous, and dependence on finite structural units and combinatorial thinking is frequently avoided. Notwithstanding, the ideas presented in this paper also pertain to the notion of texture as a general description of sound characteristics on several levels within a piece, although a relativistic attitude has to be assumed.

The qualitative and often spatial nature of texture can create a sense of temporal suspension or non-directionality in music, and a permeating principle seems to be that the identity of a texture can rely upon and gravitate around conditions that are independent of beginnings and ends in the temporal flow[2]. These allow a certain freedom in a texture's existence as a perpetual instance of itself. But there are also situations where textural activity opens potentials for change, and such situations, where textural properties are highly dynamic, can produce a distinctly directional, propulsive and gestural flow of time. The significant aspect of the textural processes is that the resulting directionality has a kind of emergent causality, not unlike self-organised phenomena in nature.

2. Mutative relations between gesture and texture

The hierarchical distinction between gesture and texture is often relative to temporal scale, density and mode of organisation of events, and they are therefore often complementary aspects of the same morphology, or structural development. This collaborative relationship between gesture and texture can have fundamental consequences regarding time and form. If we imagine a continuum between immersive, temporal suspension and directional process, within which the music is balancing, it is arguable that the formal and textural character of a piece is highly dependent on the structural level or timescale within which gesture is emphasised. Pieces with a distinctly interactive gestural language on a local level can have a textural character on a more global level. Conversely, music with a macro-gestural kind of form can be textural on a local level. In either case, several levels of gesture and texture may exist in-between, allowing focal changes to keep the music engaging, through altering between time-scales. Furthermore, structural levels often support each other – for example, micro-level activity that is interesting in its own right, can also contribute to macro-level direction – this aspect is to be discussed further in regards to *dissipative structures*, a concept which explores the possibilities of mutative and transformational relationships within and between gesture and texture (see chapter 4).

3. General Parameters of Texture

I suggest, here, a set of parameters, which could be applied to several attributes of texture in a variety of contexts (see figure 1). They represent a flexible framework and method for understanding textural motion, qualities, structures and identities, applicable on any structural levels.

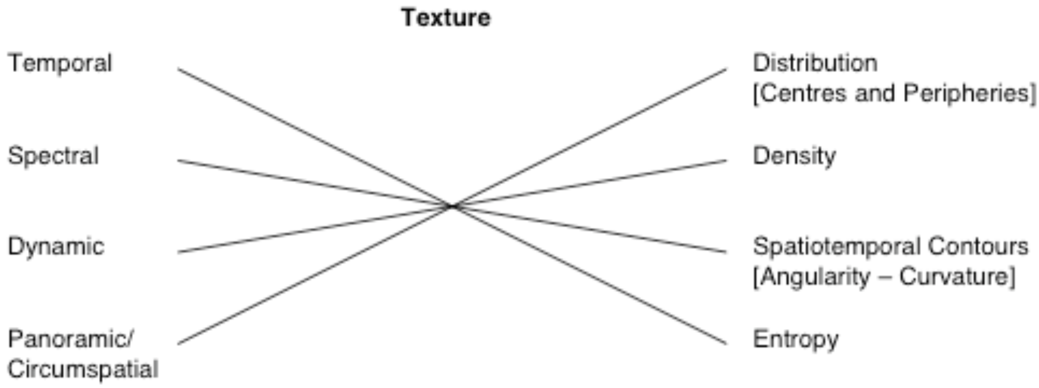

Figure 1. General parameters of texture

The use of the term "parameter" does not imply the existence of a finite quantitative architecture behind all possible textures, but rather a reduced, *qualitative* vocabulary with multiple applications. This can be combined with a more referential descriptive language. The terminology and concepts of the model are indebted to already existing approaches to composition and analysis, the most conspicuous reference point being that of Xenakis' stochastic music, which can be seen as a framework of methods for organising texture statistically. The *density*, *distribution* and *entropy* of events are indeed cornerstones in this approach (1992, pp. 1-79, pp. 289-293)[3]. The general parameters of texture are not, however, mathematical or algorithmic, and as such, they also overlap with Smalley's *spectromorphology*, which contains a rich taxonomy of sound shapes and continua of close relation (1997, pp. 107-126)[4]. The non-mathematical application and development of Xenakian concepts, particularly entropy, is to a degree influenced by Pape's approaches to composition and form, which are largely based on perceptive continua between 'order and disorder'. Pape has applied this idea in, for example, *Le Fleuve du Désir IV* (1994-2002), where he models a sonic evolution out of transitions between more or less turbulent states, inspired by motion in natural fluids. He also places importance in change contours, associating continuity and discontinuity with degrees of disorder (2002, p. 20). In the model presented here, however, *contours* do not imply such a relationship. There are also parallels to the two principal properties that Wishart attributes to texture, *field* and *density*, where field describes 'a grouping of different values which persists through time' – the kind of generalised salience that is a typical feature of texture and can be associated with distribution in the present model. This is pertinent to both spectral and temporal features which permeate a texture. Wishart's notion of textural *density* is restricted to the time-dimension (1994, p. 68).

The basic hypothesis here is that every texture has distributions, densities, contours and entropies. Theoretically speaking, these qualifications could assess a texture as if were an infinite instance of abstract sound matter without context. A musical scenario, however, is transient, and other factors come into play, which seek to reveal hierarchies, relationships and causes. Among these parameters, entropy is the one that puts time, evolution, organisation and causality into the context.

Taking a closer look at figure 1, the *temporal*, *spectral*, *dynamic* and *panoramic/circumspatial* categories on the left side of the diagram interlink so that any can be influenced by another. The word *dynamic* in this context is synonymous with loudness or intensity and the *panoramic/circumspatial* parameter puts, in a technical sense, any of the other parameters into a stereo or multichannel array of loudspeakers, enabling textures that are spread panoramically or circumspatially. The parameters on the left are always put into the context of distributions, densities, spatiotemporal contours and entropies on the right, and thus we find multiple ways of describing spectra, dynamics, temporal fluctuations and evolutions, as well as the emergence of spatial forms.

3.1 Distribution [Centres and Peripheries]

Distribution describes the areas and centres of temporal, spectral, dynamic or panoramic/circumspatial sound activity within a texture. The periphery is the furthest that a textural property spreads in any dimension.

Temporal distribution concerns the ways in which events are spread in time (including rhythmic organisation).

Spectral distribution concerns the frequency-domain spread and energy centres of a textural property.

Dynamic distribution concerns the relative loudness of activity in textural properties.

Panoramic/circumspatial distribution has an important influence on spatial form in textures. In combination with spectra, simultaneous panoramic-spectral forms, such as diagonals, are possible, which may be more or less regular depending on entropy. Panoramic distributions of temporal densities can also affect width in the stereo image. Further, circumspectral distributions and densities have an effect on volume and spatial interior (Smalley 2007, p. 51).

3.2 Density

The compactness of sound mass can be assessed within the peripheries of the distributions above. Density concerns both high-level form considerations, and the perception of density in the consistency of sound due to micro structural relationships.

Temporal density concerns the average quantity of events, or activity, over time and can be associated with the *attack – effluvium continuum.* (Smalley 1986, p. 72)

Spectral density refers to the average quantity and loudness of spectral activity within given (spectral) peripheries. The distribution and density in this domain can have effects on considerations regarding proximate and distal, spatial depth and *spectral space* (Smalley 1997, p. 121, 2007, pp. 44-48).

Dynamic density is the average quantity of activity at a certain loudness. I find that a constant loudness of events, reinforces the experience of compactness and opacity in texture. Conversely, events distributed across a wide dynamic range can give us a sensation of fragility, lightness or mobility.

Panoramic/circumspatial density has a strong influence on prospective and panoramic peripheries as great densities of energy in this domain can give us a sense of spatial confinement as opposed to scale.

3.3 Spatiotemporal Contours [Angularity and Curvature]

The continuum between *angularity* and *curvature* can describe the temporal evolution of any other parameter, but also spatial shapes which do not require trajectories through time in order to be established, such as previously mentioned panoramic/spectral diagonals, which could have, for example, bowed or linear contours. A simple example of such a contour could be a harmonic spectrum where partials are linearly distributed spectrally and panoramically, so that a spectral line emerges from low left to high right. In temporal evolution, *curvature* denotes a gradual interpolation, whereas *angular* contours are abruptly switching between states.

3.4 Entropy

The question of textural organisation can seem paradoxical since, as Wishart notes, the textural percept may be dependent precisely on randomness, or the lack of perceived organisation at some degree (1994, p. 68). Textural organisation is a listening process that interpolates between levels of structure, and our sense of order can be related to consistencies in densities, distributions and contours, which statistically describe the collective behaviour of apparently disorganised micro-events. Thus, the 'sonorities of the second, third or higher order' (Xenakis 1992, p. 47), may appear – a kind of emergent meta-organisation, which can seem disorganised internally, although this does not necessarily imply disorder (Di Scipio 2001, p. 72). In order to avoid confusion, I use the term *entropy,* for discussing the degrees of randomness, irregularity and unpredictability within textural properties collectively. Conceptually, the use is similar to that of Xenakis, who defined entropy as a parameter for 'the degree of order or disorder in a group of elements', in his Markovian stochastic music, as applied in, for example, *Analogique A+B* (1959) and *Syrmos* (1959), (1992, p. 61, p. 79-109).

The concept of entropy is found in various scientific disciplines, most notably thermodynamics and information theory, and can be thought of as a measurement of possibility. Coveny and Highfield offer the following description:

> 'Entropy was so named by Clausius from the Greek words *en* (in), and *trope* (turning), with the intention of representing the 'transformation content' or 'capacity for change'. It is undoubtedly the most important concept in thermodynamics, and furnishes an explicit arrow of time: increasing entropy coincides with time's forward movement.' (1991, p. 151)

Entropy is related to complexity, as high entropies imply low information redundancy. As a degree of information and change potential, entropy can be viewed as an important factor in the perception of sound, where in high degrees of entropy, we are no longer able to compute the causal relationships between sound events, within their own structural scale. A sensory overload that may follow with degrees of entropy in micro-structural properties of textures, or low-level gestural activity, can contribute to higher-level textural form. Entropy can also be descriptive of deliberate states of 'incoherence', e.g. chaotic situations, where hierarchies are obscure and the music seems to take several disparate, or no, directions at a given point in time.

3.5 A Verification of the General Parameters

In the attempt to validate the general parameters as descriptive of textural interactions, we can look at the opening section of my piece *Far-from-equilibrium* (2008) (sound example 1). Here, form and gesture are moulded out of a textural process, which develops from spectral peripheries, gradually filling the spectrum. In the upper part of the spectrum a granular noise-texture is present, whereas simultaneously, a scratching, rumbling texture develops from the low midrange towards the bass-end, gradually exhibiting more gestural characteristics. Initially, we can say that the overall spectral distribution is gradually expanding from the peripheries of the spectrum, while a gyrating mulch of more bass- and midrange-oriented granular textures emerge, and around 1'40", the macro-spectral distribution stabilises with the appearance of a steady sub-bass drone. This allows for new, more gestural, material to emerge in the spectral centre (figure 2). All along this opening, we hear that the global spectrum is getting denser, but there is also an increase in density of textural layers within the macro-texture. One can also note that there are some fluctuations in spectral density (between lower density resonance and higher density noise) present in the chaotic, gestural squelches that emerge inside the granular textures at around 2'04", creating a sense of internal, spatial depth. At this stage there is an increase in temporal density of change.

The opening has panoramic fluctuations in temporal densities, which cause dilations and contractions in the stereo image. There are also panoramic-spectral diagonals, whose angles are gradually shifting as the filtering of noise alters between left and right. The spectral density fluctuations of the gestural squelches, mentioned above, (from 2'04") also have panoramic altering distributions, which add a sense of body to the texture.

The fluctuations of macro-spectral and dynamic distributions, and the temporal densities of grains in the higher (spectrally) noise-texture have curved contours, while the internal micro-dynamics have distinctly angular impulse characteristics. The emerging gestures at 2'04" also have mostly curved, spectral contours, although some angularity is also present due to momentary increases in temporal density.

The entropic aspects of this musical passage can be assessed in various ways. On a local scale, there are entropic fluctuations in temporal distributions of grains (interpolations between stochastic and metric iterations), and, since there is a dominance of noise, there is a high spectral entropy. On the macro scale, the very first 15 seconds could perhaps be heard as a process of leaving a state of equilibrium, with high entropy and unclear sense of direction. However, as the texture gradually begins to move towards greater densities, a direction emerges and thus, we can say that the entropy decreases. However, there is also a simultaneous *production* of entropy, taking place on another level, as there are more and more textures appearing, resulting in a greater complexity of interactions and increased turbulence. This provides a logical precedence for the stability that follows in the bass drone, but it also creates an excess of energy, which in turn is dissipated through the coming gestures (also turbulent). Ultimately, this results in the transformation at 2'39, leading to a new section which has a more sporadic, "cacophonous" landscape dominated by gestural morphologies that have distinctly fluctuating properties in terms of internal spectral and temporal densities and distributions, and generally, unpredictable contours. The entropic spectral and temporal distributions of these gestures cause a dense macro-texture. Generally, we can see how the decrease in entropy on one level often coincides with a production of entropy on another.

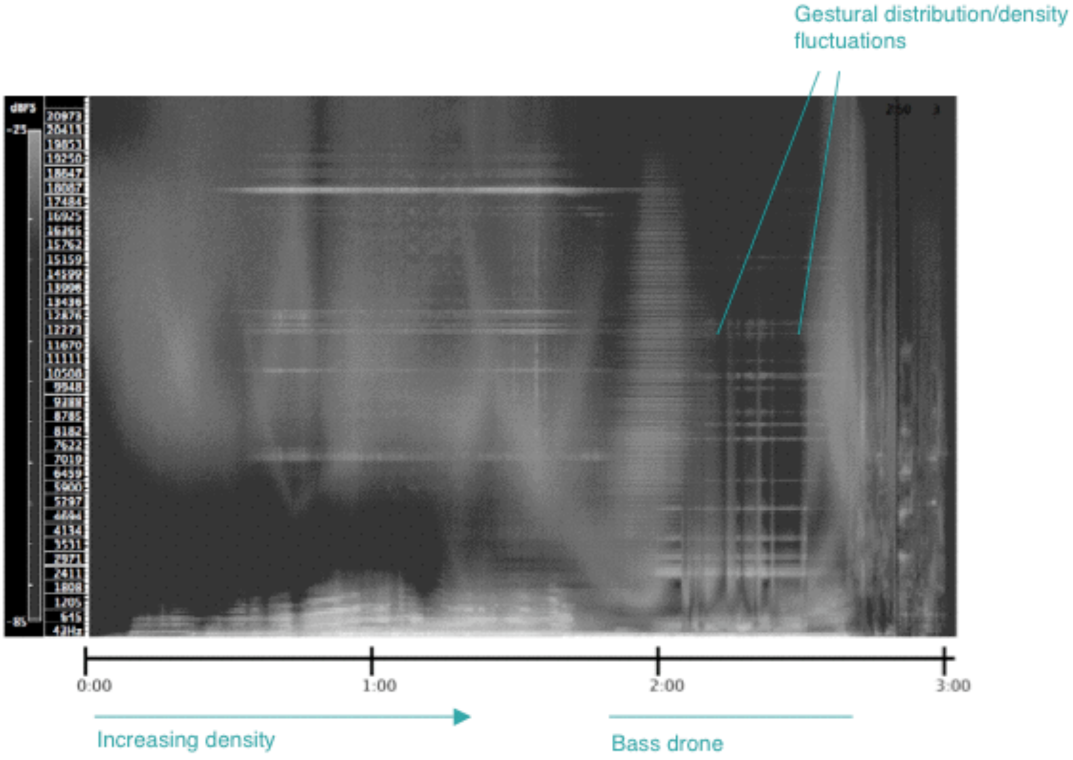

Figure 2. Spectrogram of the first three minutes of *Far-from-equilibrium*. The white smudges show spectral distributions and densities.

4. Entropic Processes / Dissipative Structures

I shall here incorporate the concept of *dissipative structures*, as adopted from the scientist Ilya Prigogine's work in physics and chemistry (1984). The purpose is to describe textural interactions which result from entropic processes, where multiplicity enables transformational potential, analogous to the flux of energy and matter between thermodynamic systems[5]. I find commonalities between the interactive capacities and ambiguities emerging within and between textures on multiple levels of structure in music, and the growth and organisation of dynamic, organic systems in nature[6]. I also find the idea of natural production of life relevant to the notion of texture as a self-propagating phenomenon. In the present context, the concept of *energy*, is something I associate with change and motion of textural properties, whereas *matter*, can be thought of as *identity*, referring to that which constitutes the wholeness of a texture, dependent on any properties describable with the general parameters.

In thermodynamics, a distinction is made between *equilibrium* dynamics, which effectively, are only possible in *isolated* systems, and *non-equilibrium* dynamics, which pertain to *closed* and *open* systems (see figure 3). These different kinds of systems can be thought of as containers, which are distinguished by degrees of exposure to the external world, as manifested in the exchange of energy (e.g. heat) and/or matter (e.g. water) with other systems and its surroundings.

An isolated system in equilibrium has a maximum degree of entropy – a uniform state of randomness in all microscopic particles, with no tendencies in energy flow. Non-equilibrium systems are more difficult to measure as they are affected by the entropies of their surroundings (Coveny and Highfield 1991, pp. 152-162). Living organisms are examples of non-equilibrium systems, whose exchanges of matter and energy with other systems cause larger, eco-systems. Non-equilibrium systems can be subdivided into *near-equilibrium* and *far-from-equilibrium* systems. The former behave in a linear manner, meaning that the result of activity is the sum of the performance of the parts. A system far from equilibrium is unstable and non-linear; the increasing entropy of the system is not synonymous with a trajectory towards a pre-determinable state – on the contrary, it feeds new processes, which can cause the emergence of novel organisation and qualitative transformations (Prigogine and Stengers 1984, pp. 140-141).

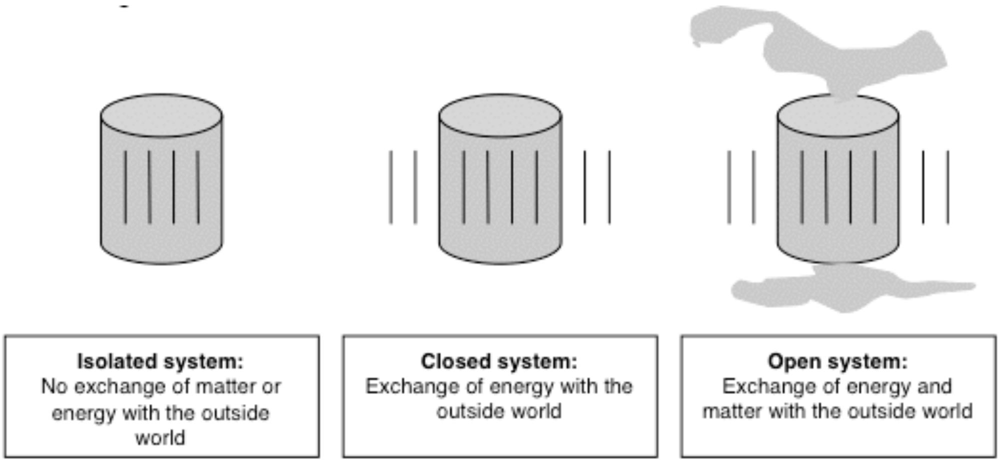

Figure 3. Isolated, closed and open systems.

Coveny and Highfield (1991, p. 168) describe the terms *dissipative structures* and *self-organisation*, as introduced by Prigogine:

> 'The new states which arise far from equilibrium can possess an extraordinary degree of order where trillions of molecules coordinate their actions in time and space. Prigogine coined the term dissipative structures to describe them, since they result from the exchange of matter and energy between system and environment, together with the production of entropy (dissipation) by the system. The complex and mutually dependent processes leading to the formation of these structures are collectively called self-organisation.'

One can see an analogy between *dissipative structures* and interactions among musical morphologies, structures and processes, which coincide with, or cause, the production of entropy. These not only cause change and transformations over time, but also fluctuating sound structures with multiple functions, such as gesture-textures. The transformational nature of dissipative structures, producing novel events and forms in the listening experience, can result in a highly directional sense of time, despite the often immersive and temporally suspended character of textural processes.

A dissipative texture can be one that turns into, or simultaneously is, a gesture, or vice versa, but it can also be an entire architecture of interactions. The key aspects are the ambiguities of identity, textural segregation, and syntheses, which arise with increasing entropy. We can then view textures as systems, which may be *isolated*, *closed* or *open*, as illustrated in figure 4. In an idealised view, an *isolated* texture remains independent of its context. If its internal activity fluctuates, this is not due to being provoked by other structural forces, and accordingly, it does not affect other events either. These textures can exist as autonomous backdrops in a musical scenario or, as strangely conspicuous "out-of-place" streams in the foreground. A *closed* texture, in contrast, is dissipative in terms of spatiotemporal contours, meaning that it can have causal relationships with other structural forces, e.g. its contours could be temporally synchronised with other textures or gestures. Also significant, is that a closed texture can undergo conversions between gestural and textural functions in structural interaction, but it does not transform significantly, or synthesise with other elements. An *open* texture is a highly dissipative structure, which can exchange both contours and identity with surrounding structures, but also spontaneously produce transformations, as if new systems where growing from its inside. The exchange of identity means either that there is a merging of several structural elements, e.g. where a texture mutates with another, into a new texture, whose identity overrides that of the initial parts, or that internal entropic processes cause bifurcations into new streams, which may generate further mutations.

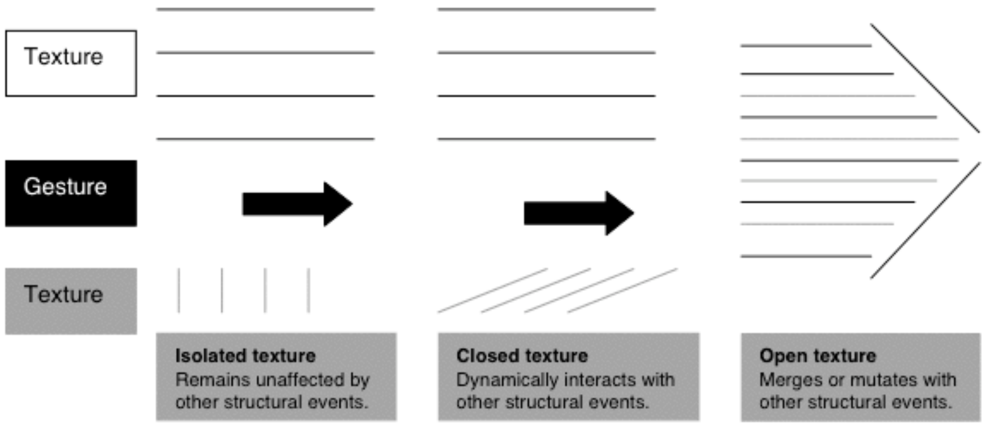

Figure 4. Isolated, closed and open textures. The angle of the grey lines of the bottom row of textures illustrates the interactive capacities of each type.

Isolated, closed and open textures are important structural features in my piece *Multiverse* (2007-08), where their simultaneities are intended to add a sense of scale, both in space and time. The layering of textures, as if they were parallel systems, can result in situations where time may stand still on one level, but move ahead on another, and spaces emerge due to contrasts of material.

An example of this is the section beginning at 4' 55'' (illustrated in figure 5), which starts with a percussive, string-like, harmonic gesture (sound example 2). This opens an initially stationary scene, whose backdrop is an isolated texture, characterised by a limited noise band, distributed in the high-mid part of the spectrum, and iterative, insect-like, scratches of varying grain densities. This texture remains unchanged when the next percussive event occurs at 5'09" – a gestural strike, which dissipates into a slowly convolving, granular texture with fluctuating temporal densities and spectral distributions, consisting of several new, interacting, internal textures. The bubbling, fluid and the siren-like textures in the background I consider as closed, since they move dynamically with the rest of the music, but remain segregated. The grain-streams and waves of noise in the forefront, however, are open since we are not always sure how many streams we are really confronted with, and they tend to merge into a single texture, as the entropy of the noise fluctuations allows for syntheses to take place. The section ends with an implosion at around 5'59", but simultaneously another texture emerges, quickly transforming from a faint, high frequency resonance, into a sporadic flock of randomly pitched, metallic, percussive, strikes, which decrease in density and magnify into gestures. This is an open, textural dissipation; the texture is pushed out of its resonant state into a transformation, which produces new events, proceeding in new collaborations.

On the macro-scale, this section can be regarded as having an open, dissipative texture, which moves from gesture, through texture, and then back to gesture. On a level below, isolated, closed and open textures co-exist, creating spatio-temporal contrasts and internal gestures. At a given instant, each texture may have its own system with its internal fluctuations in entropy, density, distribution and contours, before dissipating into a different mode of organisation.

The dissipation concept is also applicable to gestures. When highly causal, gesturally dominated, structures increase in complexity and density, a textural percept takes over, as we are no longer able to determine where or why a chain of events started or is likely to end; the entropy increases and the gestures dissipate, causing a higher order texture to emerge. We can also find dissipations in the opposite direction, when gestures acquire textured surfaces or interiors.

Returning to the aforementioned opening passage of *Far-from-equilibrium*, where textures amalgamate and form gestures, which in turn breed new textures internally, we can perhaps hear the evolution and growth of a dissipative system. Thus, the entropic processes allow for multiple organisational possibilities through irregular or unpredictable processes, where energy is balanced in-between spectromorphologies, causing new events emerge.

5. Causality

While dissipative structures describe the effect entropic processes have on dynamic evolution in texture, *causality* is a more profound issue, where entropy is considered on a more contextual level. We consider here the source, from which energy is, or was, injected, making a distinction between *external* and *internal* causality.

External causality implies that one event is caused by another, which often is a case of being triggered by gesture. Instances of this could be sequential cause and effect relationships or referential, source-bonded causality, in which case, an obvious cause can be regarded as external even if it is of textural character (Smalley 1997, pp. 110-111).

Internal causality implies that a phenomenon is caused by itself, suggesting an intrinsically self-propagating, dissipative system, of more environmental character. Being more associated with texture, internal causality can describe the multitude of causal interactions of audible and inaudible events, waves and particles in an acoustic scenario, or the non-sequential organisational principles behind a texture. Gestures can also have an internal cause, if they occur through dissipative processes.

The internal – external continuum can be obscure and is often dependent on scale and context. This can be a useful ambiguity in electroacoustic music.

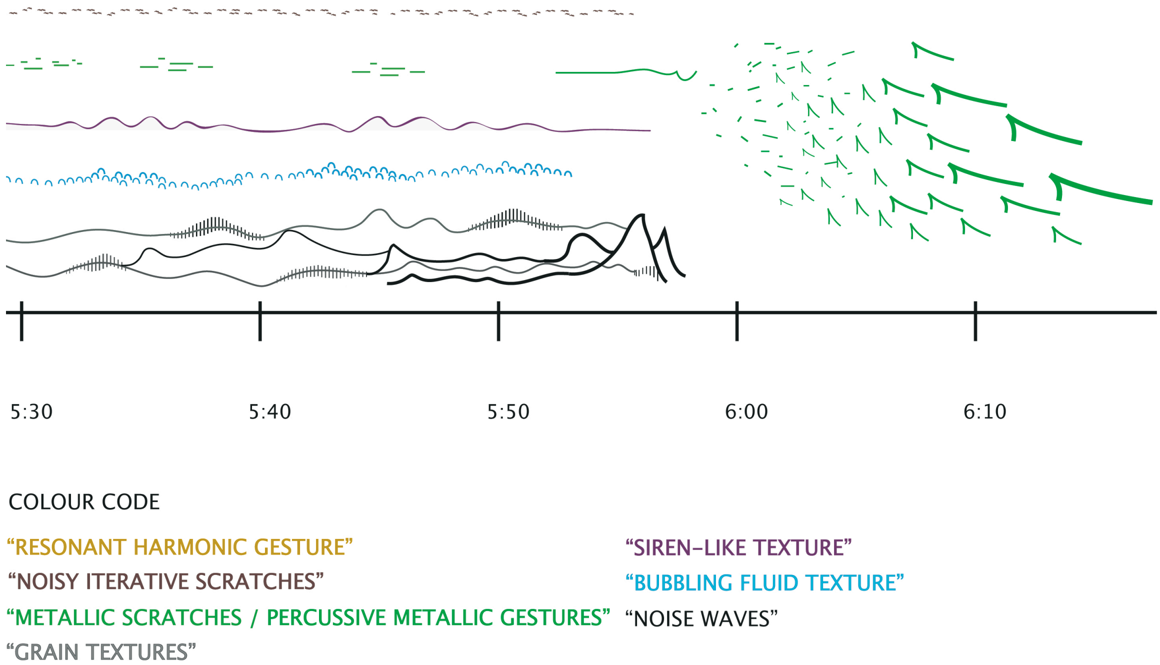

Figure 5. Rough graphic texture-transcription of a passage from *Multiverse,* 4'55" – 6'14". The differently coloured trajectories correspond to textures described in the text.

6. Conclusion

The essential objective behind the discussion of these concepts, is to take advantage of the aesthetic implications of the notion of far-from-equilibrium structures in music. The hypothesis outlined here began as an assemblage of already existing ideas which I have found relevant to texture, but I think the project has also created a useful musical framework, which connects time and space in texture, and can be used both in a more technical composition context, and as an abstract listening strategy. As such, I find that these ideas have provided some creative analytical perspectives.

The concepts draw attention to processes of growth and change in music, perhaps with a notion of "coherence" and form that emphasises possibilities rather than certitudes. I am interested in the potentials of an approach which focuses on fluctuations, and what it can offer an aesthetic that associates musical novelty and complexity with sonic vitality, rather than superficiality. The evolving forms that I link with entropic processes often have an organic character, which seems to carry unexpected events and directions through the listening experience in a functional way. Complexity is therefore married with a sort of simplicity, the kind of simplicity analogous to the idea of sound existing for its own sake.

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Sound Examples

Sound example 1: Far-from-equilibrium, (2008), 0’00’’ - 3’00’’

Sound example 2: Multiverse, (2007-08), 4’55’’ - 6’14’’

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[1] In accordance with the referencing instructions of The New Grove Dictionary of Music and Musicians, the editors have been credited, as no individual contributor is specified in the article.

[2] This can be loosely paralleled to Kramer’s notion of *non-linear* musical time (1988, p. 20). Although he refers to an instrumental music context, the idea of temporal non-linearity, as an emphasis on “principles or tendencies” in form, has some commonalities with this discussion.

[3] Di Scipio has written extensively about the composition approaches in Xenakis’ electroacoustic music (1998) and also made some interesting, critical assessments concerning the success of the stochastic models as algorithmic devices for sound composition (2001).

[4] For example, *texture motion* (ibid. p. 117), and *spectral density* (ibid. p. 121).

[5] The notion of sound structures behaving as systems, is in part informed by Di Scipio’s approaches to computer composition, where a “self-observing” audible eco-system with the capability of “continual exchange with the surroundings and its own history”, is designed algorithmically (Di Scipio, 2002, p. 25). These systems interact with the acoustic performance environment and are able to self-organise through feedback structures. Such technical strategies are obviously not implied in my approach, which is more metaphorical and focuses on perceived morphological interactions.

[6] Criton (2005, p. 372) has drawn some pertinent parallels between the music of Vaggione and the scientific paradigm of complexity, also pointing out the analogies between dissipative structures and sound in contemporary music aesthetics.