TOPOLOGY OF SPATIAL TEXTURE
IN THE ACOUSMATIC MEDIUM

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List of Compositions

Compositions can be played from the application, Topology of Spatial Texture, which can be found on the USB memory stick. The audio files are also included on the attached DVD media. Please refer to the Appendix for instructions regarding the eight-channel configuration.

Elemental Chemistry	(2008-09)	13’48”	Stereo	[DVD 1]
Cataract	(2010)	13’31”	Eight channels	[DVD 1]
Latitudes	(2011)	13’45”	Eight channels	[DVD 1]
Catabolisms	(2011-12)	12’14”	Eight channels	[DVD 2]
Lucent Voids	(2012)	20’44”	Eight channels	[DVD 3]

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Declaration

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Erik Nyström

ABSTRACT

This research explores the dynamic fabric of experienced space in acousmatic music. The *topology of spatial texture* is a network of concepts treating music as a flexible, textural space, which deforms, shapes, and transforms in time. A comprehensive terminology is introduced, along with five fixed-media electroacoustic compositions, which exemplify a manifestation of spatial texture in composition and musical thinking.

The theory draws from research on the cross-modality of texture perception, philosophical discourse on embodied meaning, physics, psychology of visual art, and discourse on space in acousmatic music. Several different structural perspectives are discussed, which reveal how spatial texture incorporates lower sound-structural levels, materiality, states and processes, motion, global networks and terrains, and relationships between space and time. Emphasis is put on visual and physical connections with spatiality in the acousmatic experience: cogency in spatial structure and dynamics reinforces links among modalities.

The concepts and terminology are intended as a contribution to theory in the acousmatic medium, relevant to composition, analysis, and listening. The music represents an aesthetic orientation which emphasises materiality and morphology in texture, transformative processes, spatial design, and spatiotemporal polyvalence.

INTRODUCTION

This work takes a texture-oriented approach to the spatial arena available to the listener and composer in the acousmatic medium, aiming at an integrated conception of spatiotemporal structure.

A central theme is the role of spatial texture as a mutable source of sonic formations. This is relevant to how elementary properties form part of a *low-level topology*, discussed in chapter 2, and to the connection of motion with physical deformation (*deformotion*), spatial transformation (*transformotion*), and morphological shaping (*morphogenesis*), made in chapter 4. On the fringes of these forming processes, spatial textures have a more chaotic existence, where dissipative energy is engaged in an indeterministic, *entropic*, interaction among amorphous, qualitative states and eruptive, critical phases, or *thermal crises*. This is dealt with in chapter 3.

Polyvalence among the spatial roles of textures can be thought of as a complex of *foci* and *peripheries*: in chapter 5, a classification of textural species – *weave types* – is given, referring to the simultaneous distinction of *threads* guiding the listener's attention. Spatial texture has an imaginal, visual presence, which is manifest as *textons* – the 'visual atoms' of texture – introduced in chapter 2, and as a macroscopic *terrain* – a relief of spectral perspectives – discussed in chapter 6.

Throughout, the listener is the protagonist: the listener's orientation in space is a matter of vantage point and embodied imagination; the listener's mental image of the terrain incorporates a topology of spatial time and an experienced relationship between body, spatial metonyms for time, and spatial orientations. Chapter 1 introduces the spatial thinking in this work; chapter 7 takes the reader/listener on a journey through space-time in the *elastic present*.

The thesis is anchored in the folio of acousmatic compositions, from which analytical examples are drawn to illustrate theoretical concepts. The works – one in stereo and four in eight-channel format – are introduced in chapter 8, each individually exploring an aesthetic based on spatial texture.

The research is applicable to listening, structuring processes in composition, perspectives for analysis, and pedagogical practice. It is also a contribution to terminology related to circumspatial[1] structure, in dealing with dimensions, structural features and schemas, and how spectral relationships are manifest in spatial perspectives in the listener's surrounding environment. Multichannel formats – a technological prerequisite for composed circumspace – have fairly recently begun to see a wide application in composition, concerts and publications, although they are not a novelty to the acousmatic medium. Aesthetic interests are motivating more sophisticated technical methods for composing with these formats. In this respect, conditions are set for our approaches to spatiality and form to advance. This work aims – in both theory and practice – at an innovative approach to spatial discourse in the acousmatic medium.

[1] *Circumspace* is a term invented by Smalley to represent 'perspectives that encompass the listener' (Smalley 2007: 51). It is not bound to any specific technological formats.

1. LISTENING TO SPATIAL TEXTURE

Spatial texture arises in a complex of *spectral space*[2], *perspectival space*[3], and *source-bonded space*[4], and encompasses the structural range between the lower-level dynamics of what might be considered a single texture – usually perceived as a collective of spectromorphologies[5], or one spectromorphology with a micro-temporal surface complexion[6] – and higher-level relationships among several textures and other spectromorphologies in a more global view of the musical discourse.

The term appears in Smalley's article 'The Listening Imagination', where he writes that spatial texture has a role in the mediation of spectral texture, and 'concerns the topological content of the real/imagined space – its size, the relationships of the dimensions of sounds to their localisation, the density of distribution of sounds, the connectedness of the sounds in space (spatial continuity/contiguity), and actual spatial movement'.[7] This relates to how the perspective is articulated as sounds are spread over loudspeakers to create a coherent image, and how spectromorphologies – internally and as wholes – are manifest within this image. It is a question not only of composed structure, but also of concert diffusion, where the composed space(s) of a work must be negotiated with the acoustics of the performance space. In this context, spatial texture is not only relevant to what we normally think of as textural sounds, as it incorporates aspects of the entire spatial image. In Smalley's subsequent writing on *spatiomorphology,* spatial texture is described as being 'concerned with how the spatial perspective is revealed through

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[2] Smalley defines spectral space as 'the impression of space and spaciousness produced by the occupancy of, and motion within, the range of audible frequencies' (Smalley 2007: 56).

[3] Perspectival space is defined as 'the relations of spatial position, movement and scale among spectromorphologies, viewed from the listener's vantage point' (ibid.).

[4] Source-bonded space is defined as 'the spatial zone and mental image produced by, or inferred from, a sounding source and its cause (if there is one). The space carries with it an image of the activity that produces it' (ibid.).

[5] See Smalley (1997) for a comprehensive explanation of spectromorphology. In his words, 'the two parts of the term refer to the interaction between sound spectra (*spectro-*) and the ways they change and are shaped through time (*-morphology*)' (ibid.:107). When considering the lower-level constituents of spatial texture we are often dealing with sounds which are primitive, or obscured and confused by other activity. Nevertheless, they are both spectral and temporal – thus spectromorphological – and exist in the context of a larger textural spectromorphology.

[6] The difference between 'one' and 'many' spectromorphologies here is to do with the global coherence and density of the texture and is therefore not clear cut.

[7] Smalley 1996: 92-3.

time'.[8] *Contiguous* and *non-contiguous* space are described as two important conditions of internal structure in spatial texture:

> Space is contiguous when revealed, for example, in continuous motion through space (such as in a left-right gestural sweep), or when a spectromorphology occupies a spread setting (without spatial gaps). *Non-contiguous space* is revealed when spectromorphologies are presented in different locations such that two successive events are not considered near neighbours: there is no sense that a spectromorphology occupies or moves through adjoining sectors of space.[9]

Here, 'locations' appear to refer primarily to positioning within the stereo image. How 'the spatial perspective is revealed through time' is also likely to concern the perceived depth of the frontal image and spectral occupancy, since these are related. In view of Smalley's more recent vocabulary, introduced in 'Space-Form and the Acousmatic Image'[10], we can broadly say that this view of spatial texture is a matter of perspectival space – especially the landscaping of *panoramic space*[11] and *prospective space*[12], which also includes *distal space*[13] and *proximate space*[14].

In non-contiguous texture, the distribution of elements is an important factor, and here Smalley defines three styles: the presentation of spatially *isolated* morphologies, the interaction of panoramic *exchange patterns*, and the *scattering* of sound across spatial regions. The gaps in between the sounds are part of the texture and can allow space within a texture to embrace other spectromorphologies. Contiguous textures either articulate space through *spread settings*, covering an area, or *trajectories*, which cross space in *paths* and *velocities*, which may leave *residues* as they move.[15]

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[8] Smalley 1997: 124.

[9] Ibid.

[10] Smalley 2007.

[11] Panoramic space is defined as 'the breadth of prospective space extending to the limits of the listener's peripheral view' (ibid.: 55).

[12] Prospective space is 'the frontal image, which extends laterally to create panoramic space' (ibid.: 56).

[13] Distal space is 'the area of perspectival space farthest from the listener's vantage point in a particular listening context' (ibid.: 55).

[14] Proximate space is 'the area of perspectival space closest to the listener's vantage point in a particular listening context' (ibid.: 56).

[15] Smalley 1997: 124.

Smalley notes that contiguity can be relative to structural scale, so that a texture consisting of non-contiguously scattered spectromorphologies, existing within a relatively short time-span, can be perceived as contiguous if their behaviour continues over a longer time-span. This depends on the aggregation of local events being sufficiently dense temporally, and consistent in its behaviour. Thus, textures of agglomerated sounds do often cover spaces without gaps, although the low-level morphologies are separated enough for us to be aware of them.

One noteworthy element of the above discussion is the role of time: it acquires a spatial function. Trajectories leave continuous spatial contours behind in our listening imagery; densifying micro-temporal sounds agglutinate into spatial surfaces; temporal durations become spatial distances. This space-time intersection is a theme that will be developed further.

1.1 Perspectival, Spectral, and Source-Bonded Aspects of Space

The coming chapters takes the concept of spatial texture beyond its origins, developing it into a more comprehensive principle of musical process. This requires a broader understanding of its spatial manifestations and their coalescence. First, let us consider how the spectral and the perspectival coexist as two kinds of dimensional percepts[16], interlaced with images radiating from source-bonded contexts.

1.1.1 Perspectival Field

The *perspectival field* extends from the listener's vantage point and encompasses all subcategories of perspectival space, of which the most important are prospective space, panoramic space, *circumspace*[17], and *circumspectral space*[18]. The relativity to vantage point has two different manifestations. In the case of stereophonic, prospective and panoramic space, an ideal vantage point is often implied. This is not simply a convention, because – as in the case of a

[16] I discuss dimensions further in chapter 2.

[17] Circumspace is 'the extension of prospective and panoramic space so that sound can move around the listener and through or across egocentric space' (Smalley 2007: 55).

[18] Circumspectral space is 'the spatial distribution or splitting up of the spectral space of what is perceived as a coherent or unified spectromorphology' (ibid.).

painting[19] – a composed perspective is given within a panoramically limited aperture. Even where prospective perspectives are intentionally superimposed or distorted, there tends to be a vantage point, centred in front of the image, from which the composed relationships are best perceived. When viewed from other horizontal angles, the image on the whole is panoramically skewed, but its proximate and distal features do not change in relation to one another. When viewed from different distances, the image will be narrower or wider and more or less contiguous, but its internal composition has a uniform relationship to *egocentric space*[20]. Prospective space is observed rather than inhabited.

Circumspace is different, because listeners find themselves within the perspectival field, where regions have a stronger difference in presence and position in relation to egocentric space. The degree to which such perspectival modularity is pronounced is an aesthetic decision in composition. The circumspatial works composed in this project all have a given front and rear, thus assuming that the entire audience is facing in one direction, but other aspects of vantage point are treated in a more relative manner. If listeners are positioned further to the back, for example, they may be inhabiting different zones from those at the front: prospective space (which forms one part of the field) will be more distant, whilst other regions come closer. What appears as a panorama from the rear view, may come across as a *lateral space*[21] up front.

Even though listeners are unable to change positions in most listening situations, their attention is free to project across the field in any direction. And because perspectival orientation is fundamental to human reality, listeners are able to construct a global view of the field, or imagine how it could appear from other vantage points.[22] If the composed relationships of prospective space are analogous to pictorial representation, those of circumspace are more similar to architectural structures and designed landscapes: the relationships of the perspectival field are more radically affected by vantage point, yet – as in a building or a garden – the structure guides

[19] Smalley has drawn a parallel between acousmatic prospective images and perspectives in fifteenth and early sixteenth century paintings, pointing to similarities in implied vantage point (Smalley 2007: 50-51).

[20] Egocentric space is 'the personal space (within arm's reach) surrounding the listener' (ibid.: 55).

[21] Lateral space is 'the extension of panoramic space towards the rear of the listener' (ibid.).

[22] Alva Noë discusses how humans deal with perspectival orientation in *Action in Perception* (2004). One of his key points is that sensorimotor skills are essential to perception, and that these enable us to understand how perspectival deformations relate to actual shapes of objects. We have accumulated an intuition for spatial relationships through our ability to move our own bodies in relation to what we are perceiving (ibid.: 79-90).

the attention of its inhabitants/visitors through balance, emphasis, and points of attraction. These are higher-level structural concerns which we shall return to in chapter 6.

The contours of the perspectival field and its regions of activity is a matter of how spectral space is distributed and balanced to form a perspectival view. It is the scope of spectromorphology, and how spectromorphologies are manifest textural aggregations, that brings the perspectival field into existence.

1.1.2 Spectral Verticality

Relations in the audible frequency range create the upright dimension which is here termed *spectral verticality* – specifically referring to the dimensional aspect of spectral space. As with perspectival orientation, our understanding of verticality is embodied – verticality is not only a scale which textures populate; as listeners, we also find ourselves within a vertical context.

The perceptual correlation between frequency and vertical height has been verified experimentally and it is believed that it goes beyond metaphorical links or cultural conditioning.[23] Moreover, research has suggested that frequency has a stronger influence on perceived vertical orientation than the physical position of a sound source[24]– so long as it is not visually or contextually obvious where and what the sound source is[25] – and that verticality can be simulated through the processing of audio signals.[26] My own experience is that verticality manifests convincingly in composed spectral relationships: high-frequency textures, for instance, often

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23 The verticality experienced in frequencies was studied as early as 1930 by C. C. Pratt, and has become known as 'Pratt's effect'. He had subjects estimate the height of an occluded source producing sine tones, and found a direct correspondence between verticality and frequency (Pratt 1930). Roffler and Butler (1968b) affirmed the relationship in further experiments, and also found it occurring among congenitally blind persons – which suggests that it is not merely a visual influence – and young children who were unfamiliar with the conceptual and linguistic association between 'high' and 'low', and frequency. Pratt's effect has also been tested for un-pitched noise bands (Cabrera and Tilley 2003; Susnik et al. 2005) and complex harmonic sounds (Cabrera and Morimoto 2007), with similar results. For a summary of research on the subject, see Cabrera et al. 2005.

24 See Cabrera et al. (2005) and Roffler and Butler (1968b). Roffler and Butler (1968a) also found that frequencies above 7 kHz need to be present in a sound in order for any vertical localisation to take place. This is due to our dependence upon reflections of the pinna when binaural relationships are insufficient for determining source orientations.

25 In acousmatic listening it is of course, technologically speaking, contextually obvious that the sound sources are the loudspeakers. However, when spectral space is efficiently articulated, the presence of loudspeakers is usually not obvious in the phenomenal sound experience.

26 Susnik et al. (2005) found that up to 60 different elevations can be perceived in correspondence with spectral distributions and emphases. Bloom (1977) simulated filtering introduced by the pinna through acoustic analysis and sound processing.

create an impression of canopy extending well above listeners although presented through a horizontal array of loudspeakers. Spectral verticality, in itself, is therefore not directly dependent on vantage point, since the correlation between high-low and up-down remains the same no matter where we are and what direction we are facing. However, when the spectrum of a spatial texture extends into a perspectival field, and a vertical relief emerges along the horizontal dimensions, spectral space becomes different depending on the directed attention of its observer. In spatial texture, spectral verticality always has a perspectival distribution, and vice versa.

The perspectival field and the spectral verticality together form the condition for three-dimensional relationships in spatial texture. The compositions realised in this project often present images and environments which are distinctly perspectival in the sense that listeners may be able to experience their own physical presence and location in relation to features moving or set at varying distances and in different directions. But these situations are equally spectral, because no such spaces would be convincing unless they had a vertical dimension within which an extended and varying terrain is articulated. Dimensions and orientations become important in spatial texture, and therefore I find it difficult to imagine the vertical without the horizontal, or to picture environments, substances, or objects without orientational contexts.

1.1.3 Source-Bonding

Source-bonding is an integral aspect of most textural sounds, and invariably influences the spatial experience, as imagined spaces associated with potential source materials often appear in listeners' minds. For instance, reverberant properties in a texture may carry a subtle suggestion of a particular kind of enclosing room; a suggested physical substance, or references to biological life, may bring to mind an associated type of environmental context. Remote, conceptual references to potential sources can also occur even when we are faced with more artificial or abstract sound materials.

Source-bonded space affects the perspectival field, in that different materials and their associated spaces find their perspectival orientations and relationships in the music. Source-bonded space also relates to verticality: for example, spectromorphologies of large, heavy, source objects are often oriented to lower frequencies. But a non-spectral vertical source-context can be manifest as well – a high-altitude or submarine environment could be suggested because of familiar source-bonded textural features, but still have a full spectral verticality within. Spectral verticality affects source-bonded space in that frequency ranges and spectral behaviours may trigger associations with, or at least narrow down the plausible array of, possible sources. But the presence of source causality can also deflect the attention from spectral structure: when listeners become aware of very familiar phenomena, the anchorage in source-bonded contexts often becomes a stronger spatial cue than spectromorphology and spectral verticality.

1.2 Spatiality

The term *spatiality* emphasises qualitative impressions which summarise the spatial experience. We might have a sensation of *perspectival spatiality* when a complex perspectival field is present – if, for instance, the layout of zones and trajectories of motion have an emphasis on horizontal extension. Or, *spectral spatiality* may be emphasised in the presence of an elaborately developed spectrum: for example, how it is morphologically occupied; how textures are stratified[27]; how agility and malleability are manifest in spectral interiors. *Vertical spatiality* is a better term for describing the bodily feeling of a dramatically extended verticality, or adventurous journeys in spectral heights and depths through directional motion processes. *Source-bonded spatiality* applies more to imagined spatial origins than sound structures and shapes: we enter more familiar situations.

Spatiality involves a spectrum of different physical experiences associated with our bodily presence in the acousmatic sound world: we inhabit the musical space; it inhabits us. The dynamic between different facets of spatiality is integral to the metamorphoses of spatial texture.

1.2.1 Interior, Exterior and Relational Spatiality

I have identified three basic schemas which are to be regarded as perceptual concepts not specific to spectral/vertical, perspectival, and source-bonded spatiality. The first two – *interior*

[27] Stratified spectra are discussed further in chapter 2, on the topic of distribution.

and *exterior* – belong together. Interior spatiality refers broadly to the 'inside' of texture, and the sense of containment invoked when textural spaces surround us as listeners, or where our attention is drawn into a textured space, although physically we do not inhabit it. Interiority is manifest in textures which have enough internal variety and complexity to give us an impression that sounds belong within a larger context, and in source-bonded suggestions of, for example, surrounding environments or enclosed acoustic spaces. *Exterior spatiality* implies a sense that only the surface of a texture is available for us to perceive: it has no depth or volume, and it is too dense or homogenous for us to be able to penetrate it and find a rich interior. Sparseness and homogeneity in the overall image can promote exteriority, as can the impression that sounds are out of place, not belonging together. Source-bonded exterior contexts can also be relevant.

The third schema – *relational spatiality* – incorporates the other two in that it concerns spatial situations that are primarily dependent upon relationships among textures rather than the textures themselves. All spatial textures possess some relational spatiality, since they are spread in the perspectival field. Relational spatiality can involve structures consisting of sounds of a primitive sonic nature, carrying little spectral or source-bonded spatiality on their own: rather, their relative placements in spectral and perspectival space is what creates a spatial relationship. Thus relational spatiality emphasises the voids among sounds, where some textures acquire a spatial role only because of what they are contrasted with. We generally find these situations on a higher structural level, where the superimposition of textural materials can create relations of interior and exterior spatiality – for example a reverberant acoustic interior covered by drier spectral texture, creating a translucent exterior, or artificial sounds contrasted with more source-bonded materials.

1.3 Materiality: Surfaces and Consistencies

The *materiality* of spatial texture may be seen as the window into our experiential bank of perceptual interactions with physical media, where we draw from multiple sensory modalities in the process of diagnosing the characteristics of sonic 'stuff'. Scientific research on texture perception has emphasised that our apprehension of surface qualities involves an interaction of haptics, vision and audition.[28] Indeed, in our general perceptual concept of texture – sonic, tactile or visual – many of our descriptive terms – for example rough-smooth, soft-hard – could be assessed using different modalities. We often think of texture first as material – from which spatial properties may arise. Mark Johnson says of our cross–modal concept of texture, that, 'like infants, we adults have a ROUGH-SMOOTH image schema, which we use as we anticipate a change in surface texture as we walk. For example, we can see where we will step from the rough carpet in the hallway onto the slippery tile of the bathroom, and we transfer this information from the visual to the somatomotor system so that our feet will not slip'.[29]

We may conceptualise textures in material adjectives such as *metallic*, *glassy*, *woody*, *stony*. As Klatzky and Lederman suggest, 'intuitively, we might think that a surface composed of punctate elements will look jittered, feel rough, and sound scratchy, whereas a glassy surface will look shiny, feel smooth, and emit little sound when touched. Our intuition tells us that the physical features of the surface are realized in different ways by the senses, yet reflect the common source'.[30] [31]

Acousmatic texture also conjures up such reactions, since we form an idea of what sort of materials we might be hearing from the acoustic behaviour of the interactions among surfaces and objects. Even if we know that an acousmatic texture has not originated in our acoustic reality, associations with vision and touch often have a role in the process of making sense of what we are hearing. We often think about, and describe, what we hear in terms and concepts that are equally fit for other modalities. As a listener, I often have the impression that I can imagine from hearing alone what the tactile and visual properties of an auditory texture could be. This is not necessarily a feat of fanciful imagination – although that has an important role in musical listening too – but also the result of a pragmatic instinct to understand what I perceive, using

[28] Lederman and Klatzky 2004; Klatzky and Lederman 2010.

[29] Johnson 2007: 143.

[30] Klatzky and Lederman 2010: 211.

[31] Experiments in texture perception have established that sense modalities influence one another – for example, touch perception of a texture can be affected by the sound of probing its surface (Guest et al. 2002; Jousmäki and Hari 1998; for a review see Klatzy and Lederman 2010). There are also indications that we choose from haptic, visual, or auditory modalities which sense to rely upon as most accurate in the diagnose of textured surfaces (Lederman 1978), or integrate two or more for a complete picture (Lederman et al. 2002; for a review see Lederman and Klatzky 2004). According to Klatzky and Lederman (2010) there is more research needed before the integration between auditory and haptic cues to roughness perception can be evidenced, but it is clear that an interaction is taking place.

what is available among my experiential resources.[32] But we should also be aware that there is a difference between strongly source-bonded materials, where we can tell that what we hear has originated in physical acoustic events, and more ambiguous or even artificial, synthetic materials, where we are only able to approximate general surface or consistency qualities and other source-bonded features.

An intuitive approach to materiality is to utilise the common reference frames that we possess for surfaces and substances: there are several binary continua which come with a cross-modal set of associations that seem appropriate to textured materials, such as rough–smooth, hard–soft, rigid–elastic, fluid–solid, porous–impermeable.[33] We are thus concerned with source-bonded features of texture, but not necessarily of the kind which lets us determine a physical source with certainty. Rather, it is the sort of source bonding that might lead us to contemplate the physicality and consistency of a texture as slimy, runny, sticky, lumpy, hard, soft, etc. Textural materiality does not necessarily belong to source objects as much as it is a transient quality with traces of physical media,[34] and inevitably suggests spatial properties such as magnitude, weight and elasticity. A spatial exposition of material properties also occurs as the ability of textures to be deformed are revealed through motion.

While on one immediate level we consider materiality to be surface properties of physical matter-oriented textures, we can extend the concept further towards underlying spatiotemporal properties of a work. Often, what is considered 'texture', in the spectromorphological repertory of acousmatic music is not sensibly described in terms of surface materiality since, for instance, it may be made up sonic artefacts of natural or cultural activity. Here 'texture' refers more to structural function and spatiality than it is indicative of material properties. Still, if spatial texture has a profound role in the structure of a work, a degree of underlying physicality may be revealed through the manner in which the space evolves and warps

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32 Research in ecological acoustics confirms that we can determine properties of objects with high accuracy, including geometric proportions and interactions among materials, from auditory perception of physical acoustic features alone (see Carello et al. 2005; Gaver 1993a, 1993b; Lakatos, et al. 1997; Warren and Verbrugge 1984).

33 In an experiment by Hollins et al. (2000), where subjects diagnosed tactile textured surfaces through multi-dimensional scaling, rough–smooth and hard–soft were found to be the most consistently applied adjective scales out of a selection also including sticky–slippery, warm–cool, and mouldable–springy.

34 We can relate materiality to the substance end of Smalley's object/substance indicative field, referring to the 'sense of '"thingness"' in sound (1996: 89). In his words, 'the substance end of the field emphasises malleability and fluidity and refers primarily to textural motion' (ibid.).

over longer durations. Space itself acquires texture, and its salient behaviour – identified in transitions, transformations, deformations etc. – can give us an indication of elasticity, viscosity, smoothness, and roughness in the fabric of space.

Thus, although materiality is a term more strongly referring to inorganic materials, I do not wish to impose restrictions here, especially since sounds in acousmatic music are often undergoing ambiguous processes where it is not clear 'what' they are. The acousmatic sound world thrives on this kind of hypothetical chemistry where several layers of reference are present in the same fabric. The two concepts of spatiality and materiality probe different aspects of texture, but yet cannot sensibly be divorced from each other.

1.4 Visual Thinking, Visual Listening

> The auditory world is like the visual world would be if all objects were very, very transparent and glowed in sputters and starts by their own light, as well as reflecting the light of their neighbors. This would be a hard world for the visual system to deal with.[35]

Albert Bregman makes this analogy to point out what he considers to be a significant difference between visual and auditory ecology: we generally use vision to determine the shapes of objects by means of light reflecting off surfaces, and we use audition to supplement this with information of energy produced (sound emitted) by objects.[36] Whether this division of perceptual labour is so clearcut could be disputable, since surfaces also reflect sound.[37] In the acousmatic condition, specially, we are in a particular state of sensory bias where we certainly pay attention to the subtleties of acoustic reflections among sounds to determine spatial properties such as surfaces, dimensions, and shapes of objects – and we are quite good at it – so perhaps we could say that audition has to do some of the work that vision would normally do. But the auditory world also stops being merely the world according to one of the senses and becomes a portal to a state of modal confusion, at the mercy of our imagination. The intentional deprivation of any visual evidence of causality behind sounds leaves room for listeners to engage in a greater

[35] Bregman 1990: 37.

[36] The existence, nature, and relationship of auditory versus visual objects is debated in cognitive science discourse – see, for example, Kubovy and Van Valkenburg (2001) for an opinion on the subject.

[37] Newell 2004; also see footnote 32.

exploration of visual imagery. Our images are not only those of objects emitting sound, however[38]: we may also allow *the sounds themselves* to acquire quasi-visual shapes, colours and spatial orientations, as if they were reflecting light. In fact, I would say Bregman's hypothetical statement, about a transparent visual world behaving like sound, is rather descriptive of what some acousmatic experiences are like. We do not literally see objects and events, but some sort of visual correlate often seems conjured up in our minds. Although our ordinary visual system would not be able cope with such transparency, our visual listening imagination seems more ready for it.

Imagery in acousmatic listening has received some attention in the literature. Smalley states in his writing on indicative listening relationships with sound that vision is an important part of our reference frame and that 'music, and electroacoustic music in particular, is not a purely auditory art but a more integrated, audio-visual art, albeit that the visual aspect is frequently invisible'.[39] In the approach taken in this thesis, structures – as we know them in our minds – are viewed as having a form of graphic spatiality because of their spatial articulation. This, however, appears to be an aspect of imagery that has received less attention in the discourse than gesture, utterance, sound-making activities, and extrinsic associations generally.[40] The use of imagination to complete the acousmatic experience has been discussed by Suk-Jun Kim, who says – citing Casey's view that 'we intend more than is given'[41] – that 'it is our intention to perceive things in their wholeness that initiates the process of imagining. Furthermore, we tend to

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[38] Wightman and Jenison (1995) defines auditory objects which do not refer to sources as 'abstract', but I hesitate to apply this to acousmatic music, where the aesthetic context could give any kind of sounds suggested origins and meanings.

[39] Smalley 1996: 90.

[40] Godøy has written about images associated with Schaefferian sonic objects – his discussion orbits around what he calls 'action imagery', concerning 'music-related actions as possible active ingredients in musical imagery', including bodily sound-making actions, tracing of shapes, and 'sound accompanying actions' (Godøy 2010: 60). He focuses on a timescale of sound objects of 0.5 to 5 seconds which he argues 'constitute the most significant timescale of music in relation to the study of sonic images' (ibid.: 54). The kind of visual imagery relevant to to my approach, however, is more graphic and spatially articulated and does not concern itself with temporally delineated objects as much as processes which stretch beyond the present – often a prolonged aggregation of smaller objects – and further, durations are of less interest than the spatial relationships which often are established among textural layers. Filimowicz and Stockholm (2010) have presented an approach to what they call the 'acoustic image' using the continuum of contrast and similarity, as well as referential sounds and their opposite 'abstraction', which involves sounds that draw attention to intrinsic features, and sounds that carry a very remote source-bonded physicality, but the discussion is not explicitly focused on correlates between spatial structure and vision. This is also the case with Barreiro (2010), who offers a review of listening approaches and how they relate to imagery in acousmatic music, focusing mainly on the role of extrinsic-intrinsic relationships, source-bonding, and gesture-related imagery; and with Miranda (2010), who offers a neuroscientific guide to musical listening and mental imagery.

[41] Casey 1976: 137.

move freely between what is perceived, which is given, and what is imagined, which is not given, so as to finally form an integrated whole'.[42] Bayle has described an aspect of the acousmatic experience as the 'image-of-sound', or 'i-sound' – 'an intermediate object which in a certain way includes appearance, where it can be followed and seen to work' – which arises in the process of 'listening without seeing'.[43]

In the book, *Visual Thinking,* art theorist and psychologist Rudolf Arnheim argues – following his assertion that perceiving and thinking are not isolated from each another – that 'vision is the primary medium of thought'.[44] I am not going to speculate on whether this is a universal truth and whether vision has a similar role in thinking for everyone – of course, musicians are generally good at using auditory imagination. But Arnheim also points out that 'in vision and hearing, shapes and colors, movements, sounds, are susceptible to definite and highly complex organization in space and time. These two senses are therefore the media *par excellence* for the exercise of intelligence'.[45] If vision and audition are converging in our understanding of space, and if vision has such an important role in thinking and imagination, then it seems reasonable to devote considerable attention to vision in a spatial art such as acousmatic music; structuring images through structuring sound.

For the purposes of the present discussion and much of the thinking throughout this thesis, I term the condition where graphic associations have an important role in the acousmatic experience *visual listening*. In doing this I want to concentrate primarily on a visual imaging concerning the spatial layout of textures, which often carry rather direct relationships between spectromorphologies and visual shapes. It is therefore not only a question of deducing plausible source-causes as if they existed behind the metaphorical acousmatic curtain, nor is it necessarily about transporting ourselves to, and imagining the view of another place in the real world. What we often face are the kind of sonic conditions that are more conducive to the attribution of visual properties to sounds themselves rather than their supposed sources. Thus, this visualisation is

[42] Kim, 2010: 47. Kim's "imaginal listening" approach involves imagery associated with body and place, paying attention mostly to source-bonded or extrinsic aspects of a sound-making human presence or the hypothetical place which listeners may deduce from present sounds. He does not discuss imagery in a more graphic, spatial sense, however.

[43] Bayle, 1989: 166.

[44] Arnheim 1969: 18.

[45] Ibid.

highly reliant on intrinsic spectromorphological features,[46] and the manner in which spectral and perspectival space are articulated generally, but also the physicality of textures.

Spatial articulation is spectrally inherent in the sound material, and a work composed in awareness of this is more likely also to attract a visual listening experience. Highly articulated spectral contouring imparts a certain integrity to textures in terms of how they are able to move vertically, which is also affected by internal spectral texture and density, suggesting weight and, by implication, agility and affordances. The emphasis on spectral shape, motion, and relative stratification in the overall structure can give us the impression that sounds are substances in their own right, rather than the acoustic artefact of an event or object.[47] The concurrent extension of textures in the perspectival field also influences the emergence of image- and landscape-oriented percepts. The balance of contouring and spectral dispersal enables clear foci and peripheries, or figure and ground. Contrasts in materiality, spatial orientations and internal spectra among textures make images more spectral also in a visual sense, as a form of colour palette becomes accessible. This requires a degree of structural definition where spectral verticality and perspectival field are integrated, allowing us to perceive relationships among processes clearly – especially relevant in circumspatial composition, where a three-dimensional experience has greater potential for articulation.

Kubovy and Van Valkenburg argue that 'auditory localization is in the service of visual localization'[48], which would suggest that we seek visual correlates with spatial hearing.[49] If spatial exactitude belongs more to the visual than to the auditory world, then perhaps we also rely on vision to a great extent when imagining spaces, since this would be the sense with which we verify spatial structure.[50] Spatial textures often have a spatiotemporal behaviour that sounds of

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[46] Smalley 1997.

[47] This condition is similar to what Khosravi (2012) refers to as 'autonomous spectromorphological entities'. His entities, however, are not the same as my *entitative state*, introduced here in chapter three, and also discussed in Nyström (2011).

[48] Kubovy and Van Valkenburg 2001: 99.

[49] However, they also take their argument as far as saying that 'space is not central to the formation of auditory objects' (ibid.): they state that spectral contours are what demarcates sounds from one another, as auditory objects with edges enabling figure and ground segregation, but do not consider this to be spatial information.

[50] Handel (2006: 23) explains that the spatial resolution (referring to sound source localisation; not space-form) of audition is significantly lower than that of vision, due to the significantly lower frequencies and greater size of wavelengths in mechanical pressure sound waves compared with electromagnetic waves of light, and due to the greater quantity of spatial sensors in the eye (120 million) compared with the 2000 hair cells in the ear.

the real word normally do not possess. Our visual world is more familiar with elastic, growing, reshaping forms which occupy areas rather than points in space. Spectromorphologies which not only have spectral contours, but also extend in perspectival space, become more like three-dimensional visual forms, with width, height, and depth. In addition to the temporal shaping of spectra, spatial textures acquire a purely spatial, non-temporal, approximation of shape, more similar to that of visual objects whose outlines are not articulated along the axis of time: textures have spectral and perspectival contours, sizes, and scales, which are not necessarily directly tied to temporally-evolving aspects of sound, such as motion and growth.[51]

Thus an acousmatic image with a logic that is as visual as it is auditory – considering centres and peripheries, horizontal and vertical balances, and respecting the listener's orientation – more readily attracts a graphic companion in the sound experience. If I have a sense of orientation in the sound world, and feel as if I could turn my head or look in a direction in order to focus on sounds, then it also seems natural to see the sounds in my mind.

Extrinsic associations of the more hypothetical kind, where materiality and spatial behaviours suggest a plausible physicality in textures, also have an important role in visual listening. Smalley gives an example of degrees of uncertainty in extrinsic-intrinsic threads, when he writes that 'there is quite a difference in identification level between a statement which says of a texture, "It is stones falling", a second which says, "It sounds like stones falling", and a third which says, "It sounds as if it's behaving like falling stones"'.[52] The more obscure condition of the last statement suggests that there is a physical coherence in the sound, although it is not necessarily familiar. So, as listeners, we synthesise hypothetical objects, materials, and life-forms with our imagination, actively decorating the unfolding acousmatic world.

All these factors together bring the texture itself into a closer relation to the listener, allowing it to plant itself in the listening space with a more convincingly realistic, although often unreal, presence: the listener acquires a sense of embodied participation, orientation and placement within the composed space. The graphic analogue, first prompted by acousmatic abstraction, becomes more literal: we forget the veil and it turns into a wallpaper, horizon or

[51] This is discussed further in chapter 2 (section 2.7) where a distinction between *instantaneous* and *evolutive* structures is made.

[52] Smalley 1997: 110.

stratosphere, as we are more prepared to believe that what we hear and 'see' is there, although we may not know *what* it is. And, despite the ambiguities, the familiar world of source-causes does not appear to have anything to reveal, holding nothing visual that could enhance our knowledge of the nature and causality behind what we are hearing.[53]

Although devoting so much attention to the visual aspect of listening might seem idealistic, if we dismiss this as a particularly eccentric or specialised response, I believe that there is relevance in this approach, so long as it is acknowledged that it would be absurd to think that one could expect listeners to adopt a particular listening mode prior to hearing a work, not allowing them to form a relationship of their own with the music. It is of course a voluntary listening behaviour that comes naturally only if the music actively lures listeners in that direction. The works presented in this project were all realised with an attitude engaged in visual exploration of spatial texture, and it has been satisfying to hear many listeners, at concerts and listening sessions, give accounts of graphic associations in their experience. The visual listening attitude is embedded in many of the concepts introduced in this thesis: the compositions should fulfil their role as a locus in the convergence of the ideas presented.

1.5 On the Role of Composition Formats

Although formats are not the principal subject of this research, they cannot be ignored. Of the five compositions submitted with this thesis, *Cataract*, *Latitudes*, *Catabolisms*, and *Lucent Voids* are composed for eight-channel loudspeaker reproduction, while *Elemental Chemistry* was composed for stereo and later adapted for wave field synthesis.[54] The eight-loudspeaker configuration used is the commonly found format of four left-right pairs approximating a horizontal circle or oval surrounding the audience.[55] This format seems apt to the research

[53] Ultimately, the term 'acousmatic' comes into a critical perspective if the veil is no longer the ideal metaphor for the listening condition, but that is a discussion of greater scope than permitted in this thesis.

[54] The Game of Life Foundation in the Netherlands, kindly offered me a short residency to work with their wave field synthesis system, then installed in Leiden, in January 2011. Wave field synthesis is a technological paradigm for spatial sound distribution where wavefronts are synthesised to produce virtual sound sources in the free field. This theoretically enables accurate source localisation from multiple vantage points, thus reducing the perspectival fragility of conventional stereophonic and multichannel distribution techniques (Spors et al. 2008; Theile 2004; Wittek 2007).

[55] An additional subwoofer (or several, depending on the size of concert space) is necessary for full spectral depth, although not separately composed for.

subject, first because it has enough spatial resolution and coverage for exploration of extended spatial structures in composition, and second because it has evolved to become a relatively standard configuration in electroacoustic composition and concert presentation.[56] This, I hope, gives the research general validity, and allows for the music to be performed without extraordinary technological requirements.[57]

Although a circumspatial field is emphasised in the theory, many of the concepts – for example, entropic processes, the motion typology, and weave types – are also applicable in stereo in that they emphasise an inherent spectral spatiality in texture, which does not necessarily require lateral or circumspatial distributions in order to be composed and perceived – but the reader would then have to subtract those aspects that go beyond the front-oriented prospective image. For composition, I expect that at least six channels would be necessary for full manifestations of the structures presented here. In concert diffusion, of both stereo and multichannel pieces, extended loudspeaker arrays can be used to enhance and emphasise composed spatial relationships and processes.[58] Multichannel works are less dependent upon such enhancements in diffusion since a more extended spatial texture has been composed already.

Composition for more than eight channels can increase the spatial resolution and be of benefit to some of the structural concepts presented here, for example with dedicated material for

[56] In conventional diffusion systems and multichannel composition formats, much of the spatial layout is dependent on images and positions resulting from inter-aural psychoacoustic factors (Everest 2001), which have a sensitive dependence on the listener’s position in relation to the system (Kendall, 2010b). Wave field synthesis has offered an alternative where sounds ostensibly can be given physical positions in the listening space, and be perceived from different listening positions (Spors et al. 2008; Theile 2004; Wittek 2007). However, I have learned from concert experiences and from composing with such a system that they are not flawless either, since their accuracy is highly subject to the size and character of the acoustic space and the loudspeaker array; and there are also distortion artefacts introduced by phase relationships when sounds are put in motion. Nevertheless, there is certainly potential for complex spatial texture applications in this paradigm, including, for example, zoning enabled by placing textures in different areas of the listening space with greater accuracy, and the exploration of relative magnitudes made possible by peripheral textures being given greater physical dimensions, encircling other smaller textural zones.

[57] Certainly configurations that have more channels allocated to the front of the audience would enable a more complex prospective image, but my compositions have used the equally surrounding array because of the desire to explore the entire circumspatial field, without needing impractical numbers of channels.

[58] This means cloning composed channels onto extra speakers outside or above the eight-channel ‘circle’, to be mixed in performance. Suspended loudspeakers can to a limited extent emphasise verticality, but also improve the impression of contiguity in texture spread across the audience space. Multiple stereo-pairs in varying distances and widths on stage in front of the audience, as common in concert setups, can work well in emphasising the frontal panoramic image and varying distances implied in the composed space of the work. For a recent overview of multichannel composition and diffusion practices, see Wilson and Harrison (2010). In other writing, Harrison has also asserted the importance of spatially conscious concert presentation as a natural extension of compositional practice (1999, 2000).

loudspeakers at different distances and elevations.[59] This would primarily be in favour of articulating zones and scale in the perspectival field. As noted in section 1.1, verticality seems to be more dependent on spectral structures than on physical source-locations: vertically distributed loudspeakers have less effect on perceived verticality than a spectrally composed texture. Wave field synthesis can also be a fruitful format, especially for composing terrain, where an extended, complex, perspectival field can be of interest.

[59] Jonty Harrison's work *BEASTiary*, premiered on the BEAST system in Birmingham in December 2012, is an example of this. In the piece, which utilises more than 70 channels for different loudspeakers surrounding the audience (including elevated ones), one can hear a perspectival field of textural zones and behavioural spaces with different localities and sizes.

2. LOW-LEVEL TOPOLOGY

> Imagine a surface made of thin easily stretchable rubber. Bend, stretch, twist, and deform this surface any way you like. ... As you deform the surface, it will change in many ways, but some aspects of its nature will stay the same. ... The aspect of the surface's nature that is unaffected by deformation is called the topology of the surface.[60]

Topology concerns the essential structural connections present in texture. These remain despite processes of motion and reshaping, and topology is therefore essential to textural flexibility. Indeed, topological structures can be present on all levels in a work, but in this chapter we are discussing the 'first order' of texture, the level at which textural sub-streams initially group into one spatial texture which we may think of as the atomic space-time fabric of an acousmatic work – hence topology of the lower level.

On a lower structural level, spatial texture can form a kind of plastic, gravitational adhesive of acousmatic space, generating and moving many of the larger forms within its structures. In what follows, we shall see how texture produces space through the propagation of two kinds of elementary morphologies, *textons* and *filaments. Propagation modes* are identified as the low-level axes of spatiotemporal structure in spatial texture. The spectral and perspectival distributions of propagating streams are then described, after which all aspects are connected into what is termed the *low-level topology* of spatial texture**.**

2.1 Surface Texture

Density in texture, both temporal and spectral, has important spatial implications which must be considered if we are to understand its different structural manifestations. As a starting point, an idealised, high-density, opaque texture may be considered as a situation where internal structure is not perceived. This is an idealised form of *surface texture* – continuous in time, contiguous in perspectival space, and fused or dense in spectral space. It is textural in that the saturation gives an impression that internal activity may be there, although it may not be clearly accessible to perception. Surface texture is thus a case of exterior spatiality, encompassing both

[60] Weeks 2002: 26.

noise- and resonance-oriented textures to the extent that a holistic percept overrides constituent features. *Spectral density* which 'can be imagined as a fog, curtain or wall of broader or narrower spread which allows sounds to penetrate or not'[61], is an important factor in surface textures, having distinct implications for presence and layering in both perspectival and spectral space.

However, in a musical context, this kind of dense homogeneity is variable, meaning that also textures with distinct granularity introduced by particles, or roughness in dense spectral collections of partials, possess surface properties and an exterior spatiality. This indicates a relationship between surface texture and materiality, since materials are often associated with textural surface properties. It is when textures are loosened up, displaying a collection of constituents of more complex characters and spatial relationships, that an interior can emerge. This happens first through the separation among components in the *spectral* and *temporal discontinua* (see figure 1). Textures often exist in an ambiguous interim between interiority and exteriority, and may, in this respect, fluctuate in relation to context; they are scalar phenomena, particularly when the process of revealing, or covering up of, interior structure is emphasised in composition.

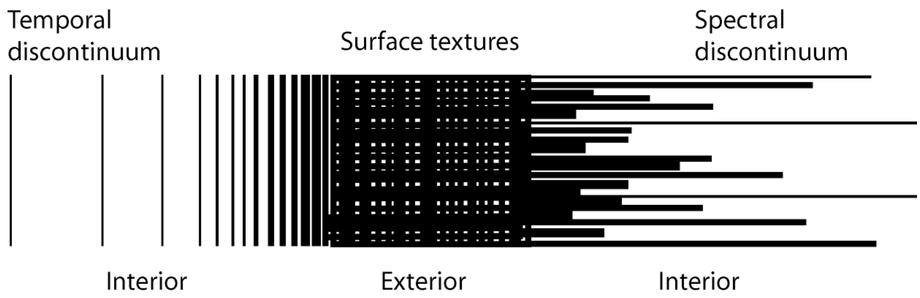

Figure 1: Surface texture and the temporal and spectral discontinua.

Within the temporal and spectral discontinua, two general types of elementary morphologies reside: *textons,* which depend on both temporal and spectral segmentation; and *filaments,* which are time-continuous and thus primarily spectrally segmented. The discontinua have a bearing on perspectival space, whose contiguity is dependent upon the alignment and fusion caused by spectral and temporal features in texture. In other words, non-contiguous

[61] Smalley 1997: 121.

elements in perspectival space cannot be perceived unless there is first a temporal or spectral segregation.[62]

2.2 Textons[63]

Bregman's discussion of textured sounds in *Auditory Scene Analysis*[64] includes an interesting parallel to neuroscientist and experimental psychologist Béla Julesz' research on textures in visual perception. Julesz showed that preattentive neurological processing[65] can immediately distinguish macroscopic texture gradients based on conspicuous features among individual elements, which he termed *textons*.[66] His postulate was that the preattentive system 'knows *where* texton gradients occur, but is unaware of *what* these textons are'[67], so that the visual system is able instantaneously to scan an area and separate macroscopic regions of textural difference based on local 'gross properties such as width, length, and orientation'[68]; dynamic visual textures also include motion and flicker as texton properties.

He argued that it was the density and orientation of texton features that causes preattentive texture segmentation, and that we therefore do not easily segregate regions of texture containing different elements with varied constellations of the same numbers of lines and terminators. (See figure 2). Further, it is only through attentive vision[69], that we are able to define, for example, shapes of blobs and differences in the composition of line segments.

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62 This is obvious to the acousmatic composer, but the role of spectral and temporal factors in segregation of auditory information is also evidenced in Bregman (1990).

63 Textons, propagation and distributions are also discussed in Nyström (2011) The present chapter is more comprehensive, however.

64 Bregman 1990: 116–22.

65 Julesz describes preattentive vision in the following way: 'a system that is parallel (independent of number of elements), acting almost instantaneously, without scrutiny, and covering a large visual field, as in texture discrimination' (1986: 245).

66 Kandel and Wurtz 2000: 502–4; Julesz and Schumer 1981.

67 Julesz 1986: 245.

68 Ibid.: 246.

69 Julesz describes attentive vision in the following way: 'Serial search (scrutiny) by a small aperture of focal attention in steps lasting 15 - 20 ms each (much faster than eye-movement scanning), as in form perception. Only in this attentional aperture is it consciously known what the textons are' (ibid.).

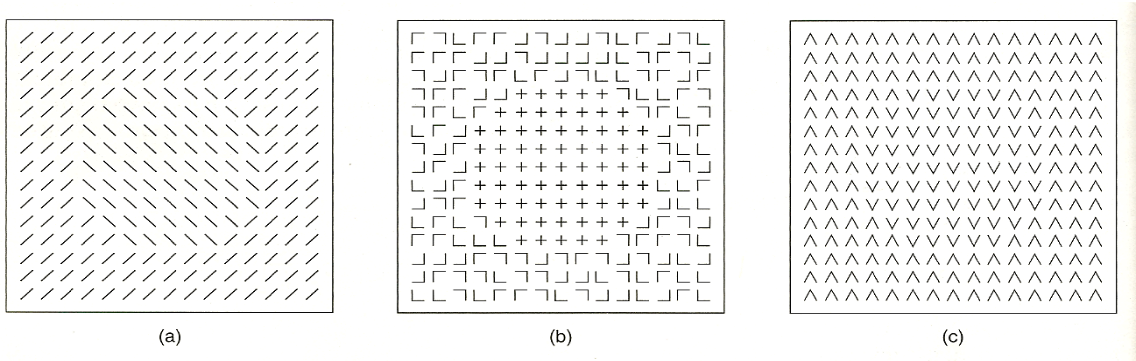

Figure 2. Texton features and texture segregation: (a) illustrates difference in texton orientation, (b) illustrates difference in line crossings between Ls and +s, and (c) illustrates that no preattentive segregation occurs if texton angles and lines remain identical (Image: Goldstein, 1996).

Long before presenting the theory of textons, Julesz had also made some experiments concerning discrimination between auditory textures, using statistics of randomly generated melodic patterns. Although it has not since been proven that auditory textons exist[70], Bregman sees a hypothetical connection between Julesz' textons and the idea of acoustic *grains*, as would be applicable to distributions and densities of granular textures in the time domain. He speculates that our perceptual system might organise certain auditory information based on groupings of grain features over time, but asserts that more research is needed to verify this hypothesis.

2.2.1 Acousmatic Atoms

I have adopted the term *textons* for describing some of the low-level features of spatial texture, partly because it is an apt word, but also because the role of textons in visual textures is somewhat analogous to low-level textural properties apprehended through visual listening. The idea of textons being the 'atoms' that appear in our vision before we have formed an idea of *what* we are seeing, seems relevant to acousmatic listening, where spaces can present us with an abundance of activity which on one level appears as a textured image with grainy, or pointillistic, local features, in a more abstract sense, whilst on another level we are also able to associate the features with hypothetical source-causes. Thus, textons have their strongest presence in

[70] Julesz: 1995.

conditions of visual listening, as a convergence of textural structure in auditory and visual domains.

In musical listening we are of course interested in properties that do require attentive listening, and therefore textons in spatial texture should not be seen as a lawful means of texture segregation: listeners might choose how to group and segregate textures depending on the context. Although the question of *how* our perceptual mechanisms discriminate textures can be relevant, our primary interest is to describe phenomena of spatial texture emergence as they can be consciously perceived, rather than account scientifically for the conditions that enable them.[71] In visual texture there is an intuitive aspect in textonal granularity in that one can apprehend spatial depth and relief in a textural image due to the relative properties and orientations among smaller elements. I see this as comparable to the appearance of spatial textures in acousmatic music, relevant to the spatial patterning of textural 'images'. Since spatial textures exist in the flow of time, global tendencies among textons, influencing the elastic shaping of textural forms become important in creating spatiotemporal topologies.

We need to be able to describe the 'perceptual atoms' in both spatial and temporal terms here, partly because auditory shapes are time-dependent, but also because audition does not have as much capacity for simultaneous spatial detail as vision does: multiple sounds occurring in different positions of space simultaneously do not easily segregate into a field of textons in the same manner that a visual texture can present us with an area of non-temporal detail instantaneously. Instead, acousmatic textons are a phenomenon of spatiotemporal granularity with perspectival locations, spectral distributions and temporal aggregations. Time has a spatial role in the formation of spatial textures.

There are three fundamental assumptions underlying the role of textons in spatial texture. First, *textons cannot exist without texture*. There is an obvious necessity for textons to appear in plural so that they collectively exhibit the emergent property of texture. Second, *textons are the lowest-level perceived spectral and temporal features of spatial textures*. Thus textons represent

[71] The scientific origins of Julesz' research in visual texture segregation treats problems of psychological or neural processes of perception; other applications of textons concern computational analysis and synthesis of texture (Forsyth and Ponce 2003; Zhu et al. 2005; Wang and Zhu 2004). Insofar as it is possible, I avoid discussing processes that we are unaware of while perceiving music. Further, while there are analogies between auditory and visual processing in the role of preattentive interpretation of information in perceptual organisation (Bregman 1990; Handel 2006; Sussman et al. 2007), this is not an emphasised aspect in the acousmatic conception of textons.

the first order of micro-sonic[72] specks that give time-aggregate texture its surface or interior spatial quality. Textons are both spatial and temporal 'atoms' in that they are the smallest perceived integrals of the temporal continuum and the spatial extent of texture. Textons may thus range from impulses to grains of longer duration, with minor spectromorphological properties of their own. Third, *textons are spectromorphologically intrinsic features*, meaning that the textonal aspect of texture exists alongside source-bonded diagnoses (as visual textons also do). Since acousmatic textures often have ambiguous source-bonded relationships, textonal features easily amalgamate with source-related associations, as if we were seeing a visual coloration of the sounds of objects.

2.2.2 Texton Shapes and Properties

A field of spatial granularity is articulated in the aggregate complexions of textons, through their locations in perspectival space, and vertical distribution in spectral space. Although texton properties constitute texture and influence textures' macroscopic properties, a reverse relationship also exists, where our apprehension of the low-level features is affected by the density and behaviour of the mass.[73] Transformative processes and internal complexity often bring out dynamic qualities or differences among textons. Intrinsic low-level features can form *texton shapes*, although these are not necessarily of great complexity. *Temporal definition* is determined by the continuum between *sharpness* and *graduation*, referring to the dynamic spectromorphological contours, which can have bearings on the perceived spatial proximity and distance of textures. Textons may range from an attack portion alone, of infinite sharpness, to slightly longer durations which could have a combination of sharpness and graduation, for example, as attack-decay spectromorphologies. If textons have brief *elongation* in time, they can

[72] In Curtis Roads' view, microsound 'extends from the threshold of timbre perception (several hundred microseconds) up to the duration of short sound objects (~100 ms)' (Roads 2001: 20–1). Pasoulas has contested this definition on the grounds that microsounds are not only distinguished by duration: how they become part of a larger mass because of their lack of individual identity is also relevant (Pasoulas 2010: 70–3). My view is that this first level is relative to the textural context, which is why I avoid a metric description of temporal properties.

[73] This is discussed further in the chapter 3, under the topic of inductive processes and qualitative textural states (section 3.2).

have *spectral orientations*, which can manifest as small glissandi,[74] or more complex variations. Together with temporal properties, the *spectral definition* of textons further serves to articulate a texture's transparency and presence in perspectival and spectral space; of course there is not much time within the duration of textons to articulate spectra, but in mass, this does make a difference.

The spectral elevation of textons can influence their perceived sizes, in that there are limits to the possibilities of textonal similarity in different regions of spectral space, not least since the spectrum of audible frequencies in itself has inherent timbral qualities. Sounds in the high-frequency range tend to seem thinner or smaller than those in the lower range[75], and this can translate into differences in spatial size as well, leading to the separation of textures. Further, since sharp attacks have a tendency to produce higher-frequency content, shape is also related to spectral elevation.

Textons group or segregate through similarity of features, spectral proximity or distance due to global spectral stratification, common microtemporal perturbations, as well as imposed spectral contours, and global coordination in tendencies such as motion directionality and growth processes.[76] All these aspects are essential to low-level topology. The accumulated history of behaviour in a texture influences our knowledge of its nature: for example, when textons are gradually elevated or reshaped over a period of time, different phases in their spatial appearance are connected.

Ex 1, which is extracted from *Cataract* at 6'45", illustrates an environment where textons are grouped into textures, depending upon morphological similarities, perspectival localities, spectral elevation, and temporal patterning.

[74] This could be achieved through glisson-synthesis, a technique developed by Curtis Roads, where granular textures are created by masses of grains with individual spectral trajectories (Roads 2001: 121–5).

[75] Stephen Handel makes a division into two pitch regions, where pure tones in frequencies above 6000 Hz sound thinner, and below this limit sound fuller (Handel 2006: 179).

[76] Principles of auditory stream segregation and integration (Bregman 1990) are embedded in this, although it should be noted that the meaning of 'spatial' in auditory science is not necessarily translatable to space-form (particularly since the spectral domain is not considered spatial).

2.3 Filaments

Continuous, temporally smooth components of textures emerging in the spectral discontinuum are termed *filaments*.[77] *Finite* and *infinite* filaments constitute two general types, which affect the nature of filament propagation and the way they articulate space. Finite filaments are such that they are generated and/or terminated in durations that are shorter than the global duration of the texture itself, and appear in streams or clusters. Conversely, filaments which last about as long as the texture itself are considered infinite.

Shapes and properties of filaments are different from those of textons; filaments are better thought of as strands of sound where beginnings and ends are less important than their propagation behaviour. Further, filaments can be less of a mass-phenomenon than textons: not many are needed for a spacious spectral texture to emerge. Distinct features of filaments are their spectral stasis or orientation, and their role in deeper, resonant textures which project into distal areas of perspectival space. In contrast to textons, filaments do not articulate exact points in space: they are more about smearing the spatial continuum in time, and contouring motion trajectories and peripheries. A form of second-order filaments occasionally emerges in my compositions; these are beads of textons which become continuous strands in spectral space.

Ex 2 from the opening of *Elemental Chemistry* illustrates filaments in a fluctuating textural interaction, against a resonant and noisy background. A more steady behaviour is illustrated in ex 3, taken from 2’44” in *Latitudes*, where filaments oscillate in different speeds in the mid and higher-mid spectral ranges.[78]

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[77] My application of the term is similar to Trevor Wishart’s. He discusses ‘filament structures’ in relation to Xenakis’ mass-glissandi and arborescence textures (Wishart 1996: 70). He also indicates the potential held within irregularly evolving filament structures and the relation to Schaeffer’s notion of eccentric sounds (Chion 2009: 146-153).

[78] The auditory spectrum is asymmetrical in that low frequencies are spatially different from high frequencies: the voluminous acoustic resonance of low frequencies blurs details but also gives them an impression of being larger. As this is reinforced by gravitational associations with spectral properties, the implied weight of frequencies also indicates spatial magnitude. This means that both textons and filaments tend to be more oriented towards the mid and higher ranges of the auditory spectrum, where spatiotemporal definition is greater, but also where agility, mobility, lightness, and smallness – giving these morphologies dynamic presence in texture – is greater.

2.4 Textural Propagation

The structured process through which textons and filaments generate space in time is here termed *propagation,* following the idea that texture often implies a self-causal process, sustained by itself and fed by its own seeds. This internal renewal and growth is manifest as textons clone and mutate over time, and filaments spin an acousmatic fabric.

Propagation animates the image in streams that appear as textural substrata – the axes of continuation and transformation. These can be seen as an essential behaviour or modulation governing the production of texture, and their fundamental global principles are *entropy*, *contours* and *density*. Entropy (discussed further in chapter 3) relates to the irregularity of the propagation stream, while density refers to the packing of events in time – also with effect on spectral density, and perspectival contiguity. Contours describe the *angularity* or *curvature* of change in propagation. *Propagation modes* exemplify some archetypal manifestations of low-level textural structure.

The textonal modes defined are illustrated in figure 3 (p. 43), representing the modulation of two arbitrary spatial properties in time. Together, the varying properties result in a propagation animated in spectral and perspectival space. Propagations in which textons hardly change are considered *fixed*. *Intermittent* propagations appear in the form of interrupted trains of textons, which may have regular or irregular intervals, and can appear in more or less coherent streams with iterations recurring in a particular region, or appearing in different places each time. Propagations can also be *switching* abruptly between states, or change smoothly or slowly over time in a *gradual* fashion. The *oscillating* mode is regular, or varying steadily over time, while the *fluctuating* propagation implies irregular variation. *Angularity* and *curvature* are two important criteria that influence the manner in which propagation varies: for example, an oscillation can switch between states in angular fashion, or have more curvilinear interpolations. *Patterned* propagation implies some degree of repetition, or at least fractured repetition, in the occurrence of textons with different properties. *Scattered* propagation implies a degree of randomness so that texton properties differ in terms of locality, elevation or shape, but without obvious patterning. This is a generalised category, which can be further nuanced by considering characteristics relating to statistical distributions and entropy – the overall range of possible states within the scattering. Another important factor is the degree of periodicity of texton propagations, affecting the pitch-noise continuum in high densities, and regulating rhythmic pulse at lower rates.

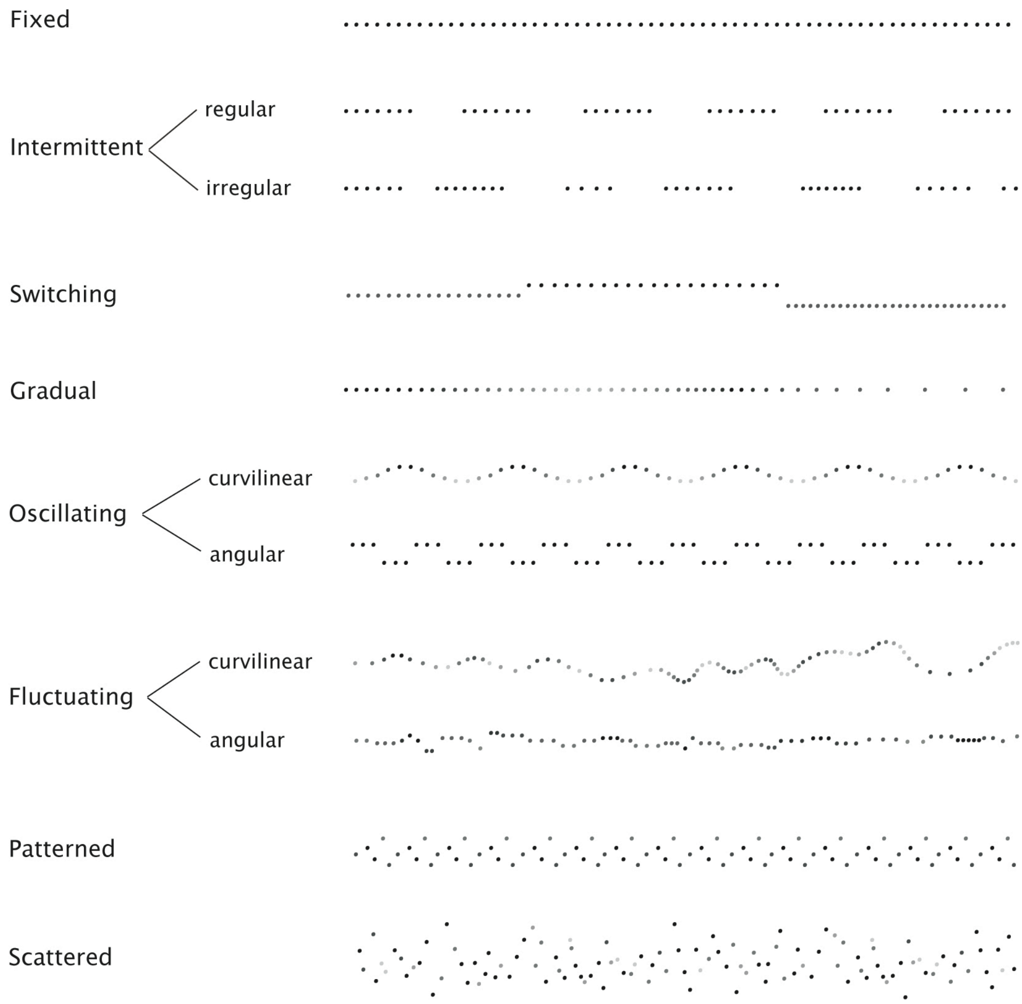

Figure 3. Texton propagation modes.

Propagation of filaments – illustrated in figure 4 (p. 44) – is quite different in that it is not necessarily a process of producing new sounds, but rather, of prolonging and shaping. Their temporal propagation properties are ultimately at the service of spectral texture. Typical modes are *fixed, gradual, oscillating* and *fluctuating,* primarily applicable to infinite filaments, but may also occur as a stream of finites. *Scattered* and *patterned* modes apply to finite filaments only. Note that finite filaments can propagate on two levels – internally, as each filament is shaped over time; and globally, as their succession is manifest over time.

There is no implication that all textural propagation falls unambiguously into one of these categories; on the contrary, they often happen together. A propagation stream may, for example, oscillate in dynamic intensity, while simultaneously have a fixed spectral elevation; or fixed and switching propagation could alternate.

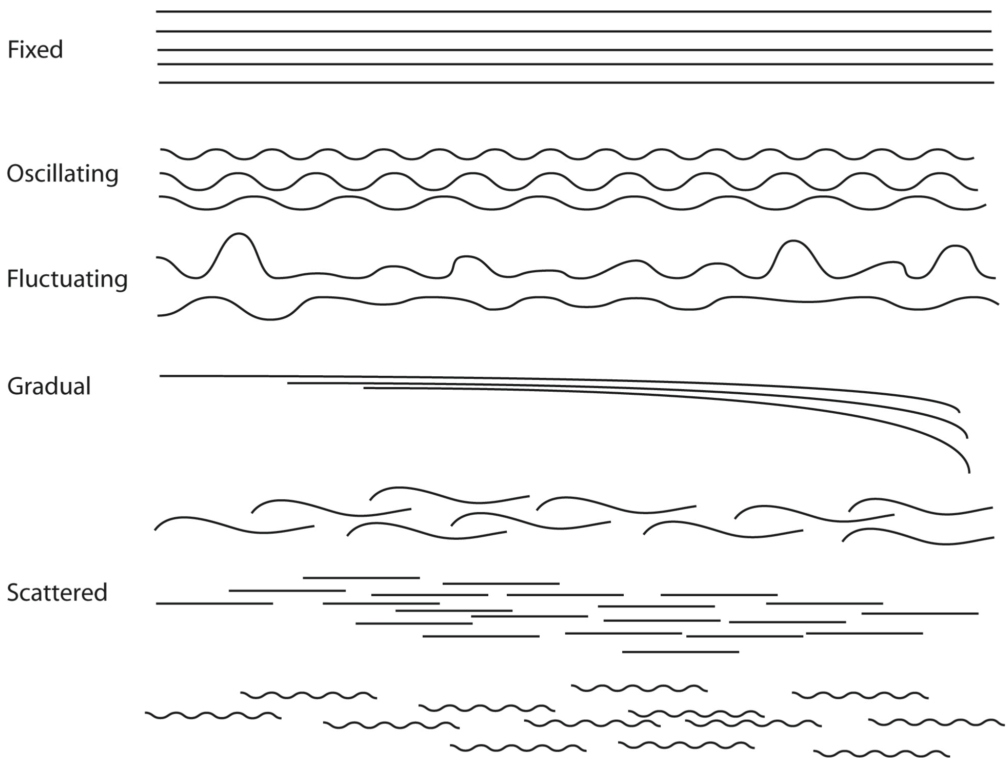

Figure 4: Filament propagation modes.

Thus far, propagation has been presented as general functions that govern a hypothetical infinitum of textons or filaments. While this is useful as an identification of structure in a more abstract sense, it is not an exhaustive elucidation of the manifestations of propagation in the acousmatic musical scenario. Apart from processes of global tendencies as propagation evolves over longer durations, there are other kinds of structures~~,~~ where propagation is nested within, and occurs among, figures – *figured propagation* – and textural fragments – *fragmented propagation.* These structures are important as they draw the listening attention towards a lower level, where greater heterogeneity among textons and filaments may be manifest.

2.5 Dimensions of Spatial Texture

Before discussing distributions in the next section, we shall for a moment leave the atomic realm and return to the structural dimensions of spatial texture. As illustrated in figure 5, the totality of the perspectival field comprises the dimensions of *latitude* and *longitude*, which relate to the terrain of spatial texture, described in chapter 6. This is not a grid, as in geographic representations, but rather a percept of distances and orientations – an inferred structure of balance. Latitude is the sideways dimension, comprising the width of panoramic and/or lateral space. Longitude represents the extension from frontal, distal space to the rear of circumspace, along which several latitudes may appear as lateral or panoramic layers articulating degrees of distance in front, or presences on the sides, of the listener. While, of course, exact degrees of latitude or longitude are not possible to perceive, a comparable sense of extension from one musical passage to another is; likewise, we can perceive relative dimensions appearing within the same texture, thus creating a perspectival field. The perceived centre of the perspectival field is dependent upon the listener's vantage point, but also influenced by what the listener deduces from knowledge of what the 'objective' centre of the listening context is. Peripheries may extend well beyond the loudspeaker arrangement depending on the textural material – they represent the furthest edge of the image.

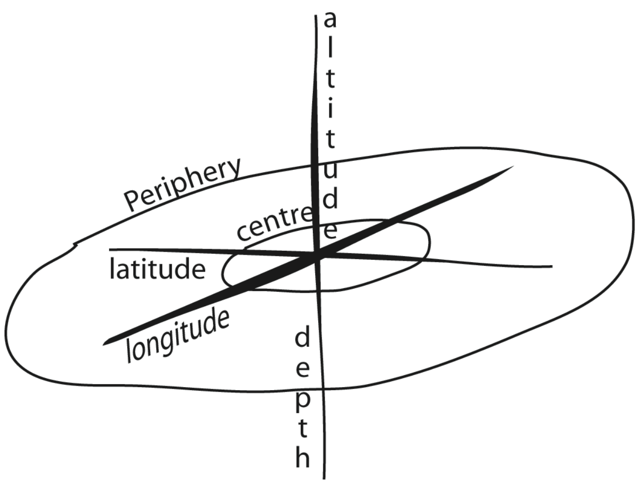

Figure 5: Dimensions of spatial texture.

The full extent of spectral verticality reaches from the lower extremities of *depth*, which is perceived as if existing below the listener, to higher *altitudes*, extending to areas perceived as above. It is in the nature of perspectival field and spectral verticality that they both rely on the accumulation of experience throughout a work, and the structural loci and relationships that are established within this process. In the overall topology of a musical work, space is elastic: the presence of, and relationships among, dimensions are a matter of context-dependent, relational spatiality, and should therefore not be thought of as a fixed geometry.

2.6 Distributions

Distributions position propagation streams in the spectral verticality and in the perspectival field. The diagram in figure 6 shows the distribution types at the top. Spectral verticality and perspectival field are to be seen as two different dimensional aspects of spatial texture distribution.

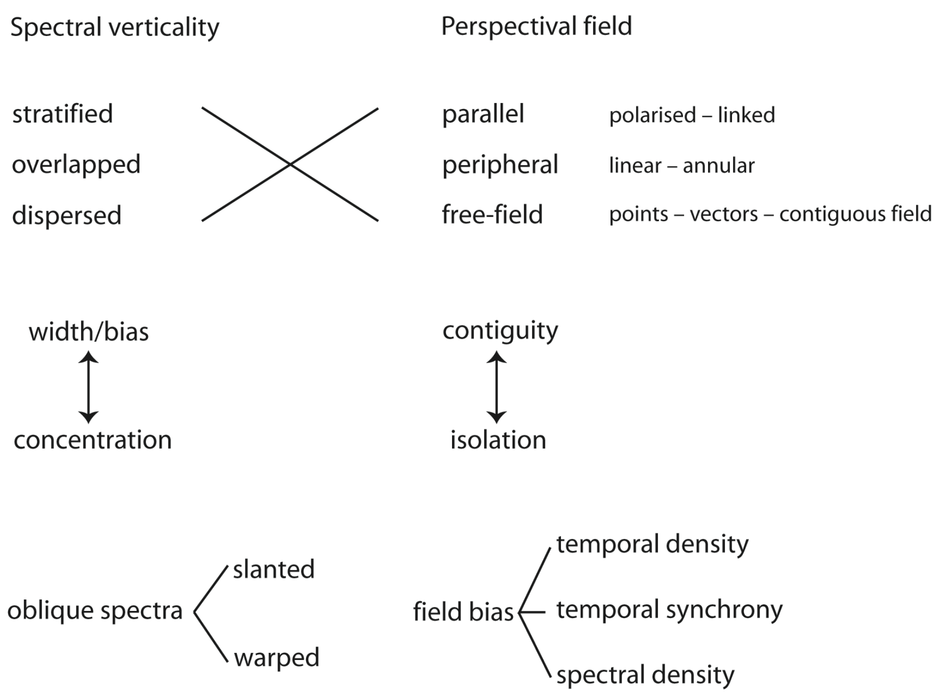

Figure 6: Distributions.

In spectral verticality, *stratified* distribution means that propagation streams are grouped into one or several spectrally limited bands. *Overlapped* distributions can, for example, involve spectrally fluctuating propagations which intertwine. Scattered or patterned propagations, or dense noisy propagations with wider bandwidth than strata form *dispersed* distributions – thus, wider vertical fields or clouds are created. The *width/bias–concentration* continuum concerns the spread of the spectral distribution. In stratified distribution this can also apply to the relative distance between multiple strata. Distributions may also have a vertical bias which could mean, for instance, that higher strata are wider or louder than lower.

Three distribution types are given for the manner in which propagation streams are arranged in the perspectival field: *parallel*, *peripheral*, and *free-field*. *Parallels* are lateral or panoramic pairs of propagation streams. The *polarised–linked* continuum depends on the degree of similarity between the propagations: they are polarised if distinct spectral and temporal differences set them apart, but form a lateral link if they are similar in spectrum, density and synchrony. Where several parallel distributions are present, they can be placed at different latitudinal positions (along the longitude), creating a spatial texture that extends over an area in the perspectival field. The parallels can be further separated through relative spectral stratification. And if the parallels are linked, stratified latitudes appear, where, for instance, the front of the perspectival field is lower and the rear is higher.

Peripheral distributions are located along the edges of circumspace, and can be circumspectral. The *linear-annular* continuum concerns the extension of the periphery: a linear periphery could, for example, extend in a part of prospective space, whilst an annular periphery encircles the whole of circumspace. In *free-field* distributions propagation streams enter the more centre-oriented parts of the perspectival field. *Points* concern textons dispersed individually across the field, whilst *vectors* are propagations which move freely in beads. In the former case, zones or latitudes can be created, depending on where the points are positioned. Spectrally, these arrangements can form, for example, stratified peripheries, dispersed free-field points, or overlapping free-field vectors. *Contiguous field* represents a spread texture with no gaps. The *contiguity–isolation* continuum generally concerns whether the perspectival field is joined up or more segmented.

Oblique spectra (on the lower left of the diagram) are formed when simultaneous propagation streams are differently distributed vertically in the same perspectival distribution so that a global contour emerges. Stratified latitudes can form a *slanted spectrum,* if the front is lower than the rear, or vice versa. Linked parallel distributions can also be slanted, if propagation streams have different stratification between left and right. When an annular distribution differs spectrally along the circumspatial periphery – in an irregular manner – a *warped* spectrum emerges.

Another principle by which perspectival distributions are deformed is *field bias* (on the lower right of the diagram). Here, the relative density and synchronicity among different streams attract the overall field in different orientations as sound accumulates in different areas. Propagation density and synchrony are the key factors here: temporal density causes bias, but is also affected by synchrony – periodic texton propagations often seem denser to the ear than aperiodic ones. Greater temporal densities and differences in texton properties also cause spectral density biases. The relative packing of filament propagations can also cause spectral density bias.

Depending on noise and resonance properties among textons and filaments, and on width or concentration of strata, distributions can acquire different roles in the overall image. For example, dispersed peripheries may extend into distal regions while textonal strata come forward in the image; filament textures often naturally end up in the background if stratified noisy or textonal material is also present.

Ex 4 is an extract of some of the textonal activity in ex 1, showing more clearly how textures may be distributed relatively, and how together they contribute to a diverse sound environment. Each texture has a point distribution in spectral and perspectival space, but they also inhabit zones which are brought to attention because of the relations among propagation patterns highlighting different areas over time.

Ex 5 illustrates spectrally stratified parallels. Opening as a graduated noise morphology, a texture quickly spreads across the perspectival field, establishing parallel pairs of propagating textons in different latitudes. Thus, a spectrally slanting longitude is formed, where the front is highest and the rear lowest – this relationship is gradually reversed towards the end of the example, where the rear rises above the front. This is a type of spatial texture that appears frequently in *Catabolisms*. Ex 6 is excerpted from its mixed context in this work (at 2’39”), so that we can hear how stratification works as a spatial structuring concept: streams are introduced with brief quasi-gestural coagulations of noise, each placed in different spectral altitudes and perspectival latitudes.

Peripheries, strata and vectors are illustrated in ex 7, an excerpt from 8’34” into *Latitudes*. First we hear how textons accumulate and move along the circumspatial peripheries. After 0’18”, strata gradually emerge – these have dynamic modulations which vary in speed across different latitudes. We can also hear how filament propagation streams break up into squelchy texton propagations, chaotically moving in free-field vectors around the perspectival field.

2.7 Instantaneous and Evolutive Structures

Distributions, in most cases, concern the arrangement of multiple simultaneous propagation streams – for example, parallel panoramic distributions or spectrally stratified propagation streams. Such structures are *instantaneous*, if they exist simultaneously in a moment or during a musical passage, so that a spatial texture is formed of several subordinate propagations working at once. Although the texture is deforming over time, at any moment it also has a non-temporal spatial shape where distributed propagation streams contribute to a structure that is spectrally different in different areas of perspectival space at once. If we, hypothetically, were to slice a moment out of the temporal flow, a spatial, shape would be present, as if freezing a moving image.[79] For example, stratified or laterally slanted latitudes can create an instantaneous oblique spectrum. Instantaneous structures have an appearance akin to visual space, where objects do not require temporal motion and transformation to be articulated to our perception. They are therefore essential to spatial texture and represent an addition to the conception of time-dependent sonic shapes. The idea is similar to what Xenakis refers to as outside-time structures:

> In the snapshot, the spatial relations of the entities, the forms that their contiguities assume, the structures, are essentially outside time (hors-temps). The flux of time does not intervene in any way. That is exactly what happens with the traces that the phenomenal entities have left in our memory. Their geographical map is outside time.[80]

'The traces of phenomenal entities' and 'the geographical map' are relevant to the discussions of chapter 6 and 7. For now, it will suffice to define *evolutive structures* as those where time acquires a spatial dimension in the process of shaping sound. Thus, they cannot exist without

[79] This idea is similar to what Xenakis describes as 'screens': slices of time containing distributions of grains, somewhat like a sonic storyboard which acquire a temporal evolution as screens are successively interpolated over time (Xenakis 1992: 50–63). His perspective, however, considers a compositional technique, while mine is a way of describing a perceptual phenomenon.

[80] Xenakis 1992: 264.

motion. If, for example, strata are not present simultaneously, but appear and disappear in different altitudes over time, their distribution is evolutive. The spatial texture in question is formed by a distribution that needed time to evolve, and the totality of its constituent structures are never simultaneously present. Point distributions and vectors, whose structural nature are dependent on temporal progression rather than simultaneity are thus intrinsically evolutive. Other distributions could happen under either condition – for example, a peripheral distribution could occupy all areas of circumspace at once, but could also be outlined in evolutive fashion in a circular motion through gradual propagation. The distinction, however, is dependent on temporal context. Together, instantaneous and evolutive structures are the basic space-time relationships in spatial texture.

2.8 Connected Low-Level Topology

Propagations, distributions, and properties of textons and filaments are placed in a continuum of flexible connections, allowing both instantaneous and evolutive shaping of spatial texture. Yet they maintain an essential topological structure, which is temporally nonlinear.[81] The four main aspects – *texture warp*, *integration*, *surface texture–interior texture*, and *resolution* – are indicated in the diagram in figure 7 (p. 51), and represent the salient features of a textural topology in the temporal process of deformation.

Texture warp occurs when propagation and distribution are engaged in the stretching and bending of the spatial fabric, as they are engaged in temporal processes. Alterations in propagation influence the elasticity of texture, in how textons contract and dilate in time. As distributions are variable in time, they warp texture through contracting and dilating strata and parallels, through deforming peripheries, or through variable densities among points and vectors. Both oblique spectra and field biases can create instantaneous warp, whereas evolutive warp occurs naturally through the shaping of all topological features over time.

[81] Low-level topology can be related to what Jonathan Kramer considers to be nonlinear aspects of music. His typology refers to time, where nonlinearity is '*the determination of some characteristic(s) of music in accordance with implications that arise from principles or tendencies governing an entire piece or section*.' (Kramer 1988: 20; author's italics): topology, as a temporally nonlinear structure, is understood from 'cumulative listening' (as Kramer puts it) to the behaviour of texture. In my view, however, this may also include directional – 'linear', in Kramer's terms – motion processes that reveal the malleability in texture.

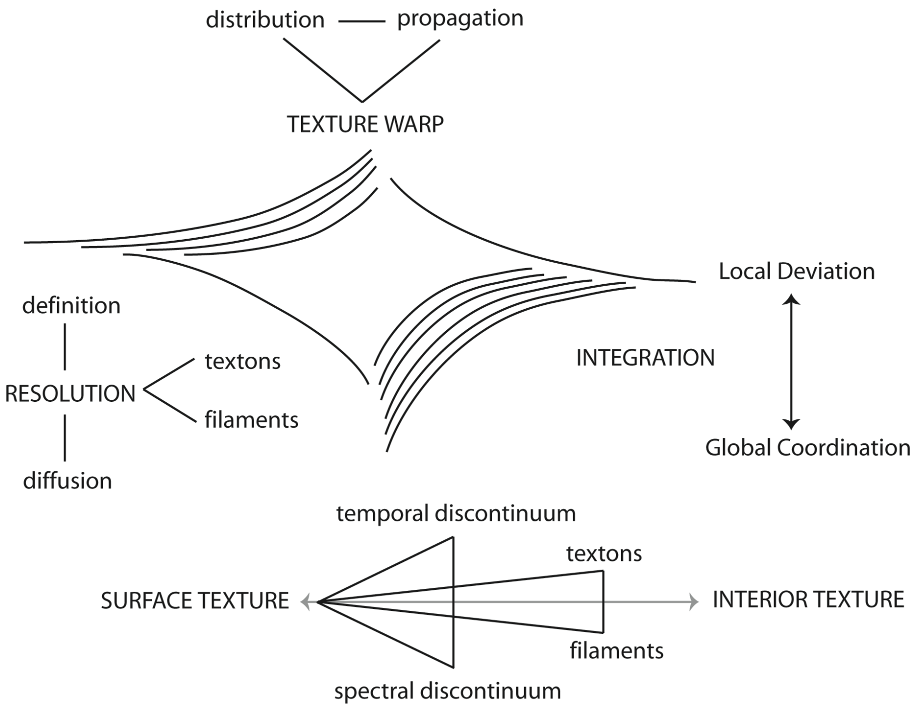

Figure 7: Low-level topology.

Integration concerns the degree to which the spatial distribution of streams form a whole as opposed to being segregated into individual areas of space. As all other topological aspects, this continuum is subject to temporal alteration, meaning that textures can integrate and segment recursively in an organic process, as *local deviation* and *global coordination* work against each another. Differences in propagation or texton properties among streams will draw attention to local areas of the texture, whilst global properties affecting all streams will serve to integrate the texture. Global coordination factors concern similarities rather than differences, so can also concern propagation and texton properties. Further, motion and collective tendencies, which are introduced in chapter 4, have effects on integration. If *perturbation*, a form of microtemporal motion, is imposed upon on all streams it will cause a global integration in the texture, perceptually bringing the texture together spatially. *Motion directionality* can impose spectral and perspectival tendencies on the whole texture, counteracting local eccentricities. *Densification*, referring to processes such as *agglomeration* and *accretion,* tends to integrate texture through forming an impenetrable surface.

The continuum between surface and interior texture, at the bottom of the diagram, is related to the separation occurring in the spectral and temporal discontinua, and the articulation of textons and filaments in the structure. Note that interior also needs a degree of local complexity to establish – homogeneous texton or filament textures often remain surface-oriented.

Resolution, on the left of the diagram, concerns the spatial clarity of the texture, and is a matter of how clear the *definition* of its activity is. Texton properties – especially temporal definition – affect this, as do the spectral gaps and relative propagation modes among filaments: spectral and temporal separation increases definition. *Diffusion* relates to spectral density and blurred or smeared features.

The following examples show a few different textures that have been extracted from their contexts in order for their topological flexibility to be revealed. First, in ex 8, we have a thin stratified textural cloud whose surface alters between granularity and more continuous noise. The texture occupies the entirety of peripheral circumspace at any point of its duration and its perspectival motion is due to warping and biasing through altering spectral contours, and spectral and temporal density in different parts of this periphery. A dense, oblique spectrum in the front is first emphasised – low on the left and high on the right – which after a few seconds begins to put textons in relief. Then the temporal density of these increases in the rear so that the texture is biased in that direction, and this tendency of biased density continues along the right periphery towards the front before it disperses with decreasing density. Over the course of this example we hear a warping topology which shows different degrees of texton definition, and an altering spectral bias towards different areas of perspectival space. A global coordination occurs in the temporal shaping of the texture, and in the fluttering amplitude modulations appearing occasionally, which apply to all parts of the texture and make the peripheries appear more integrated.

Ex 9, is extracted from *Catabolisms* (at about 8’50”) and shows a textonal texture that is shaped through spectral contouring and temporal density. In the beginning the propagation is fairly synchronous, creating a pulsed texture, but as the density increases, an unstable, almost vocal-like, timbre emerges. At 0’30” the texture changes quite radically again, as it is oriented towards the lower regions of spectral space – its materiality changes, becoming more lumpy, rocky, or woody in quality. The topology exhibits a structural malleability allowing for continuous textural transformation. It is the global coordination that causes the essential sonic alterations, and it is the local deviation that keeps the texture spread in different areas of the perspectival field at once.

Ex 10 shows a topology occurring in *Lucent Voids* (at 7'17"), which has both noisy material and textons emerging inside. We can hear it deforming spectrally in different parts of perspectival space as it extends towards the rear latitudes. It is not only distributions that contribute to the flexibility here, but also the change of surface texture. A topology typical of *Latitudes* appears in ex 11. The texture has wobbly perturbations on different variable stratified latitudes, and can transform its interior between resonance, noise, and textons.

3. MORPHOLOGY OF THE AMORPHOUS: ENTROPY AND TEXTURAL STATES

> Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line. ... The existence of these patterns challenges us … to investigate the morphology of the "amorphous".[82]

We perceive materiality in texture as general physical conditions inferred from our perception of the global context. Low-level organisation often eludes our attention, and the degree of persisting variability tells us something about the constant features of textures. It is not only the sonic structure that presents such variability, but a degree of randomness is often also an implied property of energy dissipation in supposed source-causes, such as objects falling against surfaces, micro-explosions in burning materials, or boiling fluids. This indeterminate aspect of texture draws our attention to materiality and spatiality rather than patterning: there is a variability in the structure, suggesting that the low-level activity has a certain freedom to move without altering what we perceive as constant in a texture. In this chapter we reverse the perspective of the previous; seeing the local through the global, first exploring the concept of *entropy*, and then continuing with *inductive processes* and *qualitative states*.

3.1 Entropy

In entropic textures, irregularity is an essential aspect of organisation. Irregular and ambiguous forms among textural masses often have an important role in structure, and can be manifest as a seemingly self-regulating flow of energy in the interaction among textural topologies. As Leonard B. Meyer has emphasised, 'the lack of distinct, tangible shapes and of well-articulated modes of progression is capable of arousing powerful desires for, and expectations of, clarification and improvement'.[83]

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[82] Mandelbrot 1982: 1.

[83] Meyer 1956: 160.

With these considerations we can begin to explore a 'morphology of the amorphous', outlining an application and definition of the concept of *entropy* in acousmatic music.[84] Mathematician Benoit Mandelbrot suggested with the question 'how long is the coast of Britain?' that the magnitude of a spatial dimension is dependent on the scale of measurement – the more local irregularities are incorporated, the greater the length – although the macroscopic form remains similar.[85] The *fractal dimension*, as Mandelbrot termed this relationship, increases spatial variation, yet concurs with a global consistency of shape. Although it is not my purpose to apply fractal geometry to musical composition or analysis here[86], it is worth noting that Mandelbrot's interest was largely oriented towards textural forms, and that the gist of his thinking has some relevance to the points I make in this chapter. We can say, for instance, that a global trajectory of ascending textural motion presents one spatial dimension, but that a simultaneous, irregular, local motion behaviour introduces another. This is something that happens within a texture's general behaviour: a persistent variance of propagation gives the texture another layer of spatiality and materiality aside from the directed temporal process, imparting surface complexion to an otherwise 'pure' spatial shape.

Arnheim relates the property of generality to texture in both visual arts and music:

> We may define texture as the result of what happens when the level of perceptual comprehension shifts from the scrutiny of individual structural relationships within their total context to that of over-all structural constants.[87]

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[84] I am aware that entropy is a concept that has already had considerable popularity in cross-disciplinary applications, not only in the arts, but also in fields such as politics (e.g. Bycon 1999, 2005), social economics (Swanson et al. 1997), and cognitive science (Swenson and Turvey 1991; Swenson 1998); and in views on evolution among some physicists (e.g. Wicken, 1998) in debate with Darwinian biologists. Corning and Kline writes that ''entropy' may fairly be called one of the great buzzwords of twentieth-century science. The very abstractness and obscurity of the term evokes in laymen an aura of mystery and arcane knowledge. But more important, the scientific `law' that is associated with the concept (the Second Law of Thermodynamics) has long been treated with special reverence as one of the fundamental principles of the natural world. Indeed, entropy has often been portrayed as a dark force which somehow governs the fate of our species and dooms our progeny to oblivion in the eventual "heat death" of the universe' (1998: 274). Although I may be one of these laymen, I maintain that entropy is relevant to my subject, but will try to avoid portraying it as a universal force (apocalyptic or otherwise).

[85] Mandelbrot 1977: 25-33.

[86] Fractal analysis has received some attention in musical discourse. Su and Wu have argued that fractal analysis is an 'innovative means to disclose the intrinsic property of music' (2006: 194), and Hsü and Hsü (1990, 1991) have made fractal reductions of works by Mozart and Bach, to reveal scale-independent structures on the basis of the same analogy that I made between musical shape and the measuring of a coastline in different resolutions. I am doubtful, however, that these mathematical approaches to analysis reveal anything that composers, musicologists, and listeners are not aware of already. Eldenius (1998) has also demonstrated fractal approaches to computer music composition.

[87] Arnheim 1966a: 172.

He relates this quality to the style of painting that may be exemplified in the work of artists such as Jackson Pollock and Mark Tobey, where the quantity of, and disparateness among, elements is such that their local features become complexions. Arnheim writes that 'more comprehensive shapes' are prevented, and 'a common denominator of textural qualities such as prickliness, softness, excitation, viscosity, mechanical hardness, or organic flexibility emerges from the inspection of the whole. All movements, also, are compensated so that nothing "happens," except for a kind of molecular milling everywhere'.[88]

The Oxford Dictionary of English[89], defines *entropy* as 'a thermodynamic quantity representing the unavailability for a system's thermal energy for conversion into mechanical work, often interpreted as the degree of disorder or randomness in the system'. Thus, we can think of it as non-engaged energy, equalised within the boundaries of a system, or dissipating as it is converted from one form into another. Entropy increases with a tendency towards equilibrium – a process tending towards the simplest macroscopic order, enabled by the utmost fragmentation among its constituent structures. The term was coined by the German physicist and mathematician Rudolf Clausius in the 19th Century, as a magnitude for '*transformation content'*. He invented the word *entropy* from the Greek word *τροπή (tropē)* – transformation – with the intention of finding a term with as close a relation to '*energy'* as the concept itself: thus, *en-* (inside) plus *tropē* (transformation).[90] This definition is of a phenomenological nature, stating, in accordance with thermodynamic laws, that the entropy of a closed system is constant or increases, which means, for example, that heat spontaneously flows in direction from hot to cold in order to establish equilibrium. Clausius' theory, intended for development of steam engines, also carried universal implications: he postulated that the 'entropy of the universe tends to a maximum'.[91] Physicist Ludwig Boltzmann subsequently defined entropy statistically, as a quantity of microstates probable in a system. Thus, high entropy suggests that there are countless

[88] Arnheim 1966a: 172.

[89] The Oxford Dictionary of English 2010.

[90] Clausius 1867: 357.

[91] Ibid.: 365.

different arrangements that atoms or molecules could have within a given macroscopic condition.[92]

Although the concept doubtlessly raises problems when applied to aesthetics, since the artistic scope of noncomplex homogeneity is limited, I find that processes 'in transformation' – as suggested in the word '*entropy*' – invites a musical application since it relates to time and change. This is not a novel idea, but something that was also recognised by Xenakis, who applied the concept in his stochastic music.[93] As a model for textural design, stochastic music enabled the global structuring of micro-events by statistical functions, shaping texture by means of guiding tendencies of relative indeterminacy over time. Xenakis assigned the parameter of entropy to the variability, or disorder, allowed in the stochastic functions, or the probable states that any sound event in a texture may have within the mass.[94]

Entropy, for Xenakis, is related to 'richness' in sound, and, in agreement with the physicists, he associated an increase of unpredictability with capacity for transformation.[95] This highly macroscopic orientation is, of course, only a part of the spectrum of textural possibilities, since organisation, heterogeneity and patterning fluctuate in the musical experience. Horacio Vaggione has argued this point in his critique of the strictly stochastic models of Xenakis' early works, writing that,

> Xenakis eliminated theoretically the possibility of a truly polyphonic, multilayered discourse, restraining himself to a kind of homophony (his "clouds" or uniform textures). Manipulating sound events as statistical "populations", Xenakis negates the singularity of these events, retaining only their external, one-sided aspect of elements governed by a global law, and hence devoid of any intrinsic formal property.[96]

The essence of Vaggione's argument – that musical articulation should happen on all structural levels, and that a global generalisation of texture is inadequate as a model throughout musical

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[92] Ball 2009a*:* 107.

[93] In *Formalized Music* (1992), Xenakis also uses the term ataxy in the same context, and seemingly with the same meaning; it is not clear, however, why he uses both terms.

[94] Ibid.: 43-78.

[95] In *Formalized Music*, he even goes as far as saying that 'in fact, sonic discourse is nothing but a perpetual fluctuation of entropy in all its forms' (ibid.: 76) although he also admits that, 'human sensitivity does not necessarily follow the variation in entropy. ... It is rather a succession or a protocol of straints and relaxations of every degree that often excites the listener in a direction contrary to that of entropy' (ibid.)

[96] Vaggione 1993: 98.

discourse – is of course perfectly sensible. But we must also acknowledge that a degree of global generality is usually present in texture, and that degrees of diffuseness or disorderliness can have a value in spatial terms. Moreover, the dissipation of energy associated with many textural materials, is essential to the physicality of spatial articulation. Such textures, whose value is more related to material and spatial qualities than to organisation, however, need to have a role in a musical context: entropy can be developed as an aesthetic principle specific to textural processes, as long as it is treated with an appropriate view of its structural purpose.

3.1.1 The Anabolic Tendency and the Catabolic Effect

In his essay *Entropy and Art* from 1971, Rudolf Arnheim exposes the physicists' view of entropy to a humanistic perspective, and argues that the thermodynamic view of the universe is contrary to our human experience of it: structurally, thermal equilibrium is not disorderly, but rather 'the simplest possible level of order because it is the most elementary structural scheme that can be subjected to ordering'[97] – 'equilibrium is the very opposite of disorder',[98] which 'is not the absence of all order but rather the clash of uncoordinated orders'.[99] In addition to this, he argues, it is clear to see that the universe is not simply choosing degradation of structure as its most probable path to equilibrium. On the contrary, nature and culture have a tendency to order themselves, and their very existence is dependent upon organisation, both functional and aesthetic. His discussion – which reflects on the trends towards exploring indeterminacy, and extremities of simplicity and complexity, in various artistic disciplines during the mid-twentieth century – asserts that structural complexity is as much a necessity in art as it is a condition of life in general. In any ordered phenomenon, he argues, this is manifest in what may be thought of as the *anabolic tendency* – a 'shape-building cosmic principle', resulting in the 'creation of the structural theme, which establishes "what the thing is about", be it a crystal or a solar system, a society or a machine, a statement of thoughts or a work of art'.[100] This process is subjected to

[97] Arnheim 1971: 50.

[98] Ibid.: 25.

[99] Arnheim 1966b: 125.

[100] Arnheim 1971: 49.

another tendency of tension reduction, striving for equilibrium and the simplest possible order. This can be a matter of finding an ideal balance within given constraints, but it can also be manifest in the *catabolic effect* – a structural degradation towards uniformity, resulting from the removal of constraints, and 'comprising all sorts of agents and events that act in an unpredictable, disorderly fashion and have in common the fact that they all grind things into pieces'.[101] The tendency towards equilibrial balance, and the catabolic effect, are both to be associated with the universal increase of entropy. Arnheim illustrates the relationship in the diagram in figure 8.

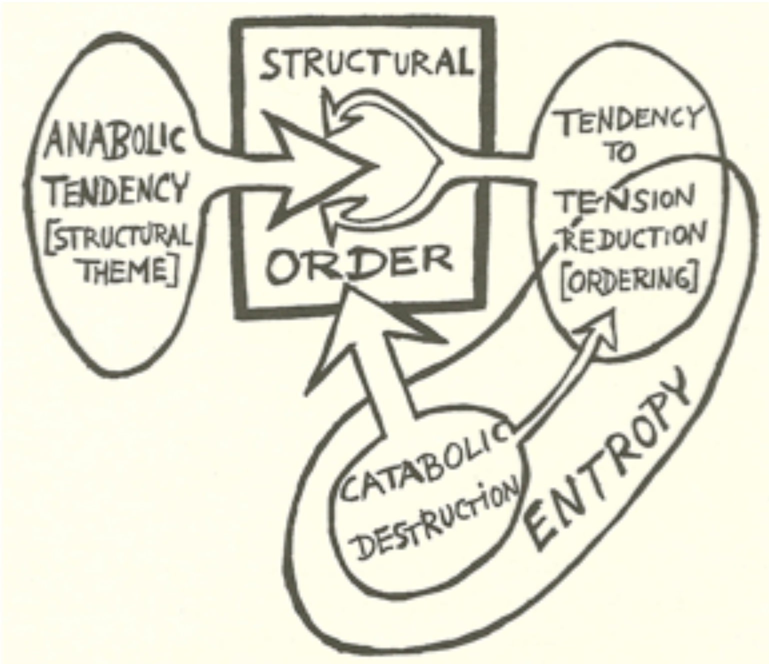

Figure 8: Structural order. Arnheim's illustration of forces relevant to order (image: Arnheim, 1971).

Thus, it is the maintenance, or building, of complex structure within constraints preventing equilibrium, that constitutes order in art. Ultimately, Arnheim considers entropy to be a rather insignificant concept, in that it is a mathematical measurement rather than a lawful force. Whether entropy is a force or not, both anabolic and catabolic processes are relevant to spatial texture. When transported into the time dimension, these processes can be balanced in the progress of a work: the structural order of a temporal process remains indeterminate until it is completed.

[101] Arnheim 1971: 28.

This idea is in some ways concurrent with the developments in the scientific view on thermodynamics during the latter half of the twentieth century, with emerging disciplines such as *physics of nonequilibrium processes*[102], following early discoveries such as the self-oscillating chemical reactions demonstrated by Belusov and Zhabotinsky in the 1950s, where chemical mixtures spontaneously organise themselves into patterns, rather than homogenise.[103] Physicist Ilya Prigogine has asserted that, although universal entropy is increasing, this trend is coupled with a multitude of processes which, instead of displaying a stable tendency towards thermal equilibrium, display non-equilibrial behaviours essential to the chemical, biological, and physical processes that make life possible.[104] Thermodynamic systems in nature (humans, animals, plants, etc) are open, meaning that they exchange matter and energy with their environment. Their own striving towards creation and maintenance of structure causes energy dissipation, increasing the entropy of their environment. Thus, interactions in states near and far from equilibrium, give rise to complex organisation and deterministic chaos, a ‘bizarre form of order’.[105] Vortex formation is a classic example, where the pressure of fluid flow within constraints causes turbulence, from which vortical patterns emerge.

3.1.2 Defining the Entropic in Spatial Texture

My application of entropy to acousmatic music abandons quantitative thinking for an approach applicable to sound experience. The adjective, *entropic,* is favoured over the noun, to indicate a descriptive emphasis. The following definition is proposed:

Entropic – (of texture, process, spectromorphology, form) having an inherent quality of irregularity in spatial structure, temporal structure, and motion, often manifest in loose

[102] Prigogine 1997.

[103] Ball 2009a: 110-111.

[104] Prigogine devoted much of his career to the issue of time in physics. The instability among systems in nature is, in his view, evidence of time’s arrow. He was influential in the paradigmatic shift towards indeterministic views on physics – contrasting with classical models – during the twentieth century (Prigogine 1997, 2003).

[105] Coveney and Highfield 1991: 37.

organisation or ambivalent behaviour, and resulting in a percept where low-level structure is less prominent than general macroscopic features.

Entropic conditions have ramifications for several aspects of texture, including the following:

Dissipation. Textures often suggest a dissipation of energy, as motion animates their interior, or enables growth. In this view, the textural surface is a source-bonded byproduct of interacting forces; we can think of, for example, the sound of friction in elastic or rigid materials, or the collision of particles against surfaces. We are able to perceive physicality in such textures because we are familiar with the behaviour of materials and forces.[106] The principle of entropic processes builds on the structural role of dissipating energy, whether it is simply dispersed, or it affords the formation and organisation of new morphologies.

Fusion of spatiality and materiality. A texture's spatiality can be emphasised if attention is taken away from low-level organisation. This is closely dependent upon material associations emerging in a dissipative behaviour.

Duration. The exact temporal organisation of an entropic textural interior is often ignored due to perceptual limitations of attending to dense, lower-level structures, or simply an overall lack of patterning that evades low-level interest. Aki Pasoulas writes, in his study of timescales in electroacoustic music, that in certain micro-macro relationships 'we estimate durations of longer intervals that are constituted by a conglomeration of the short changes occurring at the micro level'[107]: our apprehension of duration can be affected by entropic structures, so that time passes slowly or imperceptibly, since we have no means of marking its progress through regular change.

Spectral diffusion. The variability in spectral distribution can cause textural gauzes or clouds to be formed, which layer against, or block, other activity. Thus, varying spectral entropy can modulate our spatial focus of proximity and distance in perspectival space.

Catabolism. Entropic, granular textures often suggest processes of degradation due to their fragmented nature, and are catabolic in nature.

[106] Klatzky and Lederman 2010.

[107] Pasoulas 2010: 77.

Disorder. I have elsewhere written of entropy as ‘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’.[108] This is not unlike Arnheim’s definition of *disorder* as ‘the clash of uncoordinated orders’, and can include multifocal[109] situations where no certain foreground compels our focal attention, challenging us to grasp for structures in the pursuit of crystallising our experience. The effect of this is both spatial and temporal; when spectral and perspectival space are articulated with overwhelming density in a collision of structures, our attention may be switching among different layers, zones, and streams of activity at any given moment; there can also be an impression of loose temporal synchronicity among events.

Deformation. Irregular behaviours among textured spectromorphologies introduce an ambivalence which challenges their stability. As they are subjected to a critical exploration of endurability, materiality, spatiality, and internal structure in sound by exposure to deformations through motion, we learn about the constants in their materiality.[110]

Physicality. Dissipative behaviour in texture is suggestive of the physical dissipation of energy typical of auditory textures where the collision of objects with surfaces and eruptive processes are often evoked.

3.1.3 Thermal Crises: Aesthetic Potentials of the Entropic Continuum

> Some of the greatest music is great precisely because the composer has not feared to let his music tremble on the brink of chaos, thus inspiring the listener’s awe, apprehension, and anxiety and, at the same time, exciting his emotions and his intellect.[111]

While Arnheim considers the catabolic effect to be an interfering anomaly, or an eventual decay taking hold when order has lost its relevance, I am suggesting that in music it can be married to the anabolic tendency, since structure is a process occurring over time, thus

[108] Nyström 2009: 49.

[109] *Multifocal weave* is a type of relation among foci and peripheries, discussed in chapter 5.

[110] Deformation is dealt with further in chapter 4.

[111] Meyer 1956: 161.

indeterministic to the listener. Ultimately, we are concerned with anabolic processes, in that we seek meaningful experiences, but catabolic phases can have a purposeful part in this. The anabolic and the catabolic can be placed in an *entropic continuum* through which texture modulates over time on any level, ranging from maximum causal directness at low levels of entropy – where all energy is efficiently carried forward – through an intermediate stage of increasing complexity and heterogeneity, which finally cancels itself out in the uniform atomisation that results from an hypothetical entropic equilibrium (see figure 9).

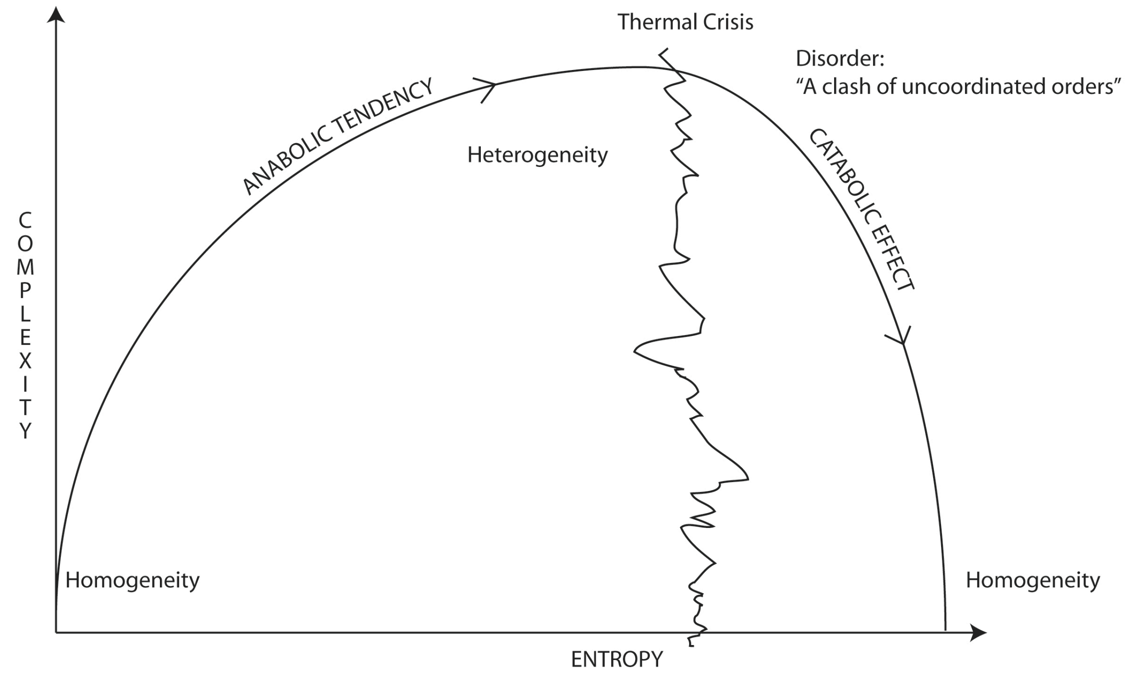

Figure 9: The entropic continuum.

Either extremity constitutes a primitive form of order, which could be illustrated with the deterministic propagation of a sine wave at one end, and the homogenous texture of white noise on the other. In his discussion on musical texture, Meyer emphasises the counterbalance between homogeneity and heterogeneity in musical form:

> Because ... the apprehension of shape is in part dependent upon the existence of a balanced relationship between uniformity and differentiation, the impression of shape can be weakened by the exaggeration or intensification of either force within the context of a given musical work. Shape may, from

> this point of view, be regarded as a kind of stylistic "mean" lying between the extremes of chaotic overdifferentiation and primordial homogeneity.[112]

The *thermal crisis* represents a critical threshold of instability, where structural tension approaches the unmanageable. Beyond this critical phase, complexity becomes disorder – as in Arnheim's 'clash of uncoordinated orders' – and then gradually pulverises into equilibrium. Intermediate degrees affect the certainty with which we parse the listening experience. As Stephen Handel states, 'it is along the continuum between chaos and randomness to order and structure that our perceptual world forms',[113] and indeed, the entropic process occurs in our active listening behaviour. High structural complexity in music grants the listener a greater license to shape the experience, in that there is an abundance of relationships to connect, and structures may appear ambiguous or unpredictable. The establishing of order in a system may need reconfiguration if change and growth of its boundaries are taking place. Arnheim gives the growth of organisms as an example, where changing complexity requires new anatomic arrangements.[114] Phases of relative disorder, or confusion, may occur at such stages, and this is precisely where the thermal crises appear.

3.1.4 Entropic Processes

> We can say that matter at equilibrium is "blind", but far from equilibrium it begins to "see." We have observed that at near equilibrium, dissipation associated with entropy production is at a minimum. Far from equilibrium, it is just the opposite. New processes set in and increase the production of entropy.[115]

The entropic continuum creates a discourse where the complex interaction among textural topologies becomes the causal impetus of the music. Keeping music away from equilibrium, this process occurs among several textures simultaneously in a natural tension between creation and decay. To the ear, the navigation from catabolic or disordered states towards complex structures, can seem motivated by the process itself, perhaps complying with one of

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[112] Meyer 1956: 161.

[113] Handel 2006: 3.

[114] Arnheim 1971: 26.

[115] Prigogine 1997: 67.

Ashby's definitions of a 'self-organising' system: 'it changes from "parts separated" to "parts joined"'[116]. A musical process in the entropic continuum is not merely unfolding, but rather, it forms itself as it progresses.

In a dynamic structure, spatial textures are *dissipative*: rather than existing in isolation, their motion radiates energy which allow textures to influence one another. It is only when no energy is transferred that the music reaches a state of catabolic inertia. Two types of entropic processes are distinguished: *equilibrial* and *non-equilibrial*. In straightforward terms, equilibrial processes tend towards uniformity whereas non-equilibrial processes tend towards complexity.

In equilibrial processes textures tend towards homogenisation with their sound environment and have the following characteristics:

(a) **The atomisation of texture; homogeneity.** A process which leads to global uniformity as low-level complexity cancels itself out.

(b) **Global dissipation of energy.** Textural processes which may have been differentiated or kept in tension are dispersed into a mass. This can occur though a gradual relaxing of structural tension, or be the result of more or less savage events whereby the dissipation may take some time to disperse its energy.

(c) **Irregularity** is manifest in spectral and/or temporal organisation.

Although complete textural equilibration would lead to inertia, the homogenisation of texture can be a phase where more fine-grained masses acquire a peripheral role, making space for new processes to surface. Equilibrial processes can thus bring order towards a more global level, guiding our attention away from the local activity which is becoming increasingly uninteresting. As Bergson puts it, 'disorder is simply the order we are not looking for. You cannot suppress one order even by thought, without causing another to spring up'.[117]

In contrast, non-equilibrial processes hover around the cusp of the thermal crisis, maintaining tension in a critical state of turbulence. They have the following characteristics:

(a) Heterogeneity is maintained or tends to increase. A multiplicity of textures and morphologies prevails.

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[116] Ashby 1962: 266.

[117] Bergson 1992: 98.

(b) **Dissipative processes are kept in tension.** Turbulent energy does not equilibrate, but spawns new processes and produces form rather than destroys it.

(c) **Low-level patterning and articulation increases.** Textures are less statistical as spectromorphological singularities appear within them.

In non-equilibrial processes, constraints are maintained or reshaped, rather than disintegrating. The thermal crisis spawns new anabolic processes, preventing the catabolic effect from running its full course. Equilibrial and non-equilibrial processes often occur simultaneously on different structural levels. If local equilibrial processes among individual textures are influential rather than isolated in the global network, dissipative behaviour causes structure. Catabolism can therefore be a phase in the anabolic trend: creation and decay are both inevitable products of time's arrow.

3.1.5 Orbital and Entropic States

In cases where the energetic flux of the global weave of a musical passage stabilizes, an *equilibrial state* is reached. Structurally, these can preserve or prolong the experience of a particular spatial environment, without moving forward in time. The temporal nature of the equilibrial behaviour will be relative to the duration of the state: allusions to gestural contours could be present, but the significance of any energetic interaction would be absorbed by the global equilibrium.

Motion can in some situations be locked into cyclical, repeated trajectories or patterns, creating a stationary macroscopic textural state, which although equilibrial, is not entropic, since relatively ordered patterns are maintained. I use the term *orbital* to describe states that exhibit these characteristics. This does not necessarily imply that perspectival or spectral orbits are literally occurring, but rather that there is a general presence of local recursion within the texture. Often, multiple, simultaneous, internally synchronized 'orbits' create a complex orbital texture, where rhythmic phasing can occur among the recurrent motions. Complete or relative periodicity is an important condition for orbital states.

If, on the other hand, trajectories, spatial articulations and contours are loose and irregular, an *entropic state* is present. Entropic states do not necessarily imply textural dissolution, but can also be a generally meandering activity, or shapelessness, being maintained over time.

3.1.6 Entropic Processes in *Catabolisms*

Catabolisms is a work exploring entropic processes, and its form can be viewed as being centred around outbreaks of thermal crises and the prevention of equilibrium. Much of the texture of the work is catabolic in nature, but it is engaged by anabolic forces, preventing the structure from disintegrating. The thermal crises form climactic phases where textural build-up of tension causes dissipating eruptions. We can identify several places where the music enters these critical stages – some of them remain fairly controlled, whilst others have a more dramatic effect on the discourse.

One of the earlier thermal crises occurs at 3’08” to about 4’00” – resulting in a catabolic equilibration ending at 5’13”. Ex 12**,** starting at 2’57”, shows a part of this process. The texture builds up in a complex anabolic structure, and reaches a crisis at 0’11”. The aftermath tends towards homogeneity, as the texture enters a catabolic process after about 0’40”, pulverising at 1’26”.

One of the major crises occurs at about 7’43” to 8’38” where cascading and elastic morphologies are interacting in increasing turbulence. The dissipation of the thermal crisis is more devastating here, although eventually interrupted by an implosion at 8’38”. Ex 13 begins at 7’43” – the climax is between the bass attack at 0’41” and the implosion occurring at around 0’55”.

The final crises occur subsequently, at 9’02” to 9’16” and at the cascades at 10’12”. Also here, catabolism is largely prevented through disruptive processes, maintaining some energy for the work to continue. At the very end of the piece the music finally disintegrates into an entropic equilibrium, where, however, we do not reach a crisis: it is as if the music capitulates, having no strength to maintain its structure against the pending fate of corrosion. Thus the catabolic effect concludes a process that up until that point has been able to sustain an anabolic tendency.

3.2 Inductive Processes: Qualitative States and Phases

We have seen how entropic processes can have a generalising effect on materiality and spatiality in texture, but we also need to ask what some of the qualitative effects could be – and how the micro-level is influenced by the macro-level. *Inductive processes* refer to the phenomenon of qualities being transported between wholes and parts, with emphasis on the idea that texture is not strictly a linear bottom-up structure that can be predicted as a mere summary of its constituents. Thus, the global behaviour of an aggregate, in terms of distributions, densities, contours and entropies may influence the role and character of elementary morphologies.

Inductive processes result in *qualitative states* and *phases*, which are all source-bonded to the degree that they refer to physical phenomena. In spatial texture, a state implies that the propagation remains within certain conditions for some time. Phases refer to textures passing through different qualities briefly – this often applies to situations where the ambiguities of multiple textures in interaction result in qualities varying from one moment to another.

I underline that these states are open to interpretation, and represent impressions which can coincide with a multitude of different spectromorphological conditions. The following sections indicate some common or comprehensible conditions where states appear, although a work might find its own ways into these phenomena.

3.2.1 Projective State

Propagations which are fixed, or modulate in a highly stable manner, often seem to extend space through mere longevity. To describe this phenomenon I use the word *projection*, as an interpretation of Edgard Varèse's words:

> …sound projection – that feeling that sound is leaving us with no hope of being reflected back, a feeling akin to that aroused by beams of light sent forth by a powerful searchlight.[118]

[118] Varèse 1967: 197.

This is a state of low entropy, where energy is focused; the association with light alludes to a sonic presence rather like radiation in a vacuum. In projective states the temporal dimension is absorbed in the extension of space, and in the case of textonal textures, textons are frozen in regular iterations, as if in a perpetuated instance. There are several conditions which may lead to projective states, but a key factor is the sense of infinity, which is manifested in spectral fixity, or uni-directionality. A typical projective state is the stabilised, hypnotic drone of static filaments, or of textons fused in a continuum, only appearing in vestiges as a surface roughness or fluctuation. Another example is the propagation of temporally contiguous or semi-contiguous iterated textons, where resonant features focus the projection. When projective states have spectral directionality, it is in the form of prolonged glissandi, and if there is perspectival motion, textons or filaments project so that stable vectors emerge. A boundless prospective space often emerges in projective states, as if sound extends infinitely in front of the listener. Projections can begin to glow steadily in distal space, or forcefully penetrate the sonic fabric, like high-energy rays or projectiles. Projective states suggest spatial extension, and thus relates to *projective space* (see chapter 6) and *projective time* (see chapter 7).

A projective state is illustrated in ex 14 from *Cataract* at 5’36”, where sound projects through vertically, as infinite, diverging glissandi, causing a confused rotation. The opening of the same work is also characterised by a state of layering projections, both in the form of sustained filaments and in the form of iterating textons; ex 15, beginning at 1’09” illustrates this: iterations of textons accumulate as spectrally fixed projections.

3.2.2 Entitative State

In some situations, the stream of textons synthesises into a motion trajectory, suggesting the presence of a self-propelled entity. While projective states are like blind arrows pointing into space, *entitative states* give the impression of living forms mapping out texture as they travel across spatial territories. Entitative streams of textons can erratically jitter around, in fluctuating propagation modes, or swarm in more directed, symmetrical trajectories through the perspectival field. Thus they often evoke reference to water- or air-borne animals in flock-motion. The motion may occur in temporally dense propagation streams, or as apparent motion trajectories among non-contiguous textons, which cohere over time so that an impression of living behaviour and integrity emerges. In very dense entitative states, where several propagation streams are at work, we may not perceive the individual entities as much as we get a sense that the texture motion is caused by internal activity of living morphologies. Filaments can also form entitative states, when behaving autonomously so that spectromorphological articulation follows perspectival paths.

In ex 16, from *Latitudes* at 5’35”, we hear how resonant granular beads in fluctuant propagation propel themselves around circumspace. In *Elemental Chemistry*, at 5’14” – ex 17 – we have an example of filaments in a mosquito-like entitative state, orienting themselves among a texture of frog- and cricket-like intermittent texton propagations.

3.2.3 Coagulated State

In coagulated states, texture is near solidification and textons clot into a thick magma or form a thin crust. In the case of high-density patterned propagations we can get a sense that texture solidifies in brittle crystals. Densification is the primary condition for coagulation to take place, yet granularity often remains, suggesting a rough surface, or lumps in a slow-moving mass. Coagulation can reach non-textonal continua if the context of a given passage makes us aware of the densification process.

An example of coagulation occurs towards the end of *Lucent Voids* – ex 18, beginning at 18’43” – where layers of textons accrete into a continuous substance over the course of 30 to 40 seconds.

3.2.4 Vaporous and Gaseous States

Vaporous and gaseous states are closely related and both highly remote from textonal activity. There can, however, be a context of agglomeration of textons associated with the texture, or conversely textons might emerge in a condensation process towards fluidity, or as a dilution of a gaseous substance. Vaporous states can manifest as smooth, noise-textures, and are often in transitory relation with fluid or coagulated states. Gaseous states are spectrally less dense, and diffusely resonant or transparent, so that an almost invisible texture is created. Aside from the source-bonded spaces associated with vaporous and gaseous textures, spectral space and perspectival space are also articulated, where strata in the higher spectral regions might strengthen the impression of air-borne substances or cloud-formations.

Elemental Chemistry reaches a vaporous state near the end, where an impulse texture densifies into a continuous state reminiscent of a cloud of droplets, before it catabolises into primitive textons. The process can be heard in ex 19, beginning at 12’50”.

3.2.5 Fluid State

If textons are slightly elongated, and propagate in spectrally scattered mode, densification will often lead towards a state of semi-continuous fluidity. Here, the spectral variation prevents coagulation, and a lighter, more mobile texture is perceived. Fluid state often implies an immersive wash of texture, and texton shapes are often induced from the macroscopic impression of source-bonded phenomena such as liquid droplets. Textonal fluid states are often associated with turbulent flow, and boiling or pouring liquids. It is also possible for fluidity to emerge in thicker, noise-textures, where the macroscopic spectral and perspectival properties imply fluid motion. Fluid states can of course also appear in continuant, filament textures; for example, in sinuous motion among resonances in a spectral fabric.

A merging of fluid and gaseous phases can be heard in ex 20 from *Cataract* at 7’08”: the texture reaches a bubbly, fluid stage, which is then absorbed into a larger gaseous atmosphere.

3.3 Summary

If we consider the indeterminate nature of a transient experience such as music, it seems reasonable to allow a *process* of organisation to take place. This process, in itself, is the musical adventure. The topics of order, disorder, and complexity in music are of greater magnitude than their presence in this discussion, but I have taken a viewpoint specific to textural processes, for which a set of principles has been presented. Thus, some textural conditions are here defined as *entropic,* as they possess an inherent irregularity. The *entropic continuum* encompasses both the *anabolic*, shape-building, tendency and the *catabolic* effect of decomposition. As textural processes oscillate along this range, they may enter a *thermal crisis* – a threshold of uncertainty and instability which can result in transitional phases and eruptions. *Equilibrial processes* strive toward homogeneity and catabolism, while *non-equilibrial processes* strive towards heterogeneity and complexity. Ultimately, musical structure strives towards organisation: entropic processes are about stages of reconfiguration in music, transitions between homogeneity and heterogeneity, the varying degree of clarity in densification processes, and ambiguities in spectral and temporal organisation. Thus the meaning of the word *entropy – in transformation –* seems apt to the musical interests explored here.

Two types of *equilibrial states* are introduced – *orbital* and *entropic state*. The former is a recursive condition, while the latter is a chaotic equilibrium. Further, there are five *qualitative states* which result from *inductive processes*, where the global conditions of texture influence the properties of textons and filaments; these states all carry references to physical phenomena.

4. MOTION AND CRITICAL FORMING PROCESSES

Motion is ubiquitous to any conception of spatiality, materiality, and morphology in music, and apparent also in textural processes – often manifest on multiple levels simultaneously. Discourse in textural music is largely related to how motion enables spatial deformations, transformation, and larger-scale spectromorphology.

The motion typology presented here has two parts – one concerning *general motion principles*, and the other, *special motion types*. The former classifies the fundamental concepts of spatial texture motion, while the latter points to some more specialised situations that might be considered idiosyncratic to motion in spatial texture. Finally, we investigate *deformotion, morphogenesis* and *transformotion* – three *critical forming processes* that potentially subsume all aspects of motion within particular phases of change and shaping.

4.1 A 'Diagram of Forces' – Motion, Materiality and Morphology

> The form ... of any portion of matter, whether it be living or dead, and the changes of form which are apparent in its movements and in its growth, may in all cases alike be described as due to action of force. In short, the form of an object is a 'diagram of forces', in this sense, at least, that from it we can judge or deduce the forces that are acting or acted upon it: in this strict and particular sense, it is a diagram – in the case of a solid, of the forces which *have* been impressed upon it when its conformation was produced, together with those which enable it to retain conformation; in the case of a liquid (or of a gas) of the forces which are for the moment acting on it to restrain or balance its own inherent mobility.[119]

As D'Arcy Thompson elaborates in *On Growth and Form* – a study of the physical and mathematical properties of morphology in nature – motion has its traces in all shapes we encounter. While solid forms may be considered as 'frozen' motion, however, musical morphology is motion itself. We could say that the forms we encounter in texture appear as contours manifest in memory, as spatial forms in our imagination. While in the solid physical shape motion is inferred in the perceptual fact, in the musical shape the process is the reverse:

[119] Thompson 1961: 11.

motion is the experiential 'medium', and spectromorphology its noetic product. In Arnheim's words,

> Nature is alive to our eyes partly because its shapes are fossils of the events that gave rise to them. The past history is not merely inferred intellectually from clues, but directly experienced as forces and tensions present and active in visible shape.[120]

Not only is shape articulated through motion, but also textural materiality. We become aware of properties such as weight, agility, viscosity, solidity, fluidity, through perceiving spectral motion in texture. Integral to the material nature of a texture, these factors are revealed as textures that are shaped and reshaped in space. The appraisal of spatial texture from its motion has an inherent relation to our participation as listeners; physicality is an important influence on our proprioceptive responses to, and visualisation of, sound. We would not be able to understand sound, space and motion if we did not have embodied experiential concepts with which we perceive. Mark Johnson suggests three main motion schemas that influence our conception of motion in music. I discuss Johnson's view on musical motion further in chapter 7 (with some critique), but shall for now apply these schemas independently. In his view, at least the following three experiential concepts are imperative to our understanding of motion[121]:

1) our perception of objects moving;
2) the movement of our own bodies;
3) our felt awareness of our bodies being moved by forces.

His point is that we understand motion because we have experienced it. We know what kinds of physical forces are able to move us because we are capable of inference on the basis of experience; we know how various physical properties of objects interact with forces; and we know how we are able move in various circumstances. This knowledge is pre-reflective and inherent in our understanding of the world, and in Johnson's view, we use it to metaphorically construct spatial conceptions of phenomena such as time and music. In acousmatic music, the

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120 Arnheim 1974: 417.

121 Johnson 2007: 247.

motion perceived as spectral, perspectival, and source-bonded also engage senses such as vision and touch. My view is that textural material and forms that have a less direct association with familiar real-world phenomena also trigger such percepts: listeners seek ways to understand through metaphorical processing.

Thus, in the present context, the first principle above relates to associations with moving objects that texture might evoke; the second, to our sense of orientating ourselves through time and space, although it must also be extended to our perception of manipulating and touching objects; the third is relevant to our feeling of being carried by textural forces. The moving of ourselves and the interaction with physical objects relates to tactile, visual and auditory percepts of manipulating objects in order to determine their physical properties. Textural qualities and materials, and their motion, may prompt associations with interactive responses. This is related to materiality and capacities for deformation and transformation, inferred in motion: both tactile and auditory texture perception are closely related to the perception of probing surfaces in order to establish their physical properties in relation to moving forces, and to other objects and materials.[122] Accumulated multimodal experience of physical manifestations of motion and deformation is integral to the understanding of material properties such as elasticity, fluidity, or rigidity, which in turn may suggest more specific types of physical materials (for example, plastic, rubber, metal, glass, wood, rock etc.).

These principles also give us ideas of spatial scale and magnification. For example, a texture whose materiality we associate with very fine surface qualities and small objects can come across as highly magnified in acousmatic listening, perhaps giving us an impression of being transported to a micro-spatial reality or scale. Similarly, acoustically abnormal temporal contours and gravitational implications of textural motion can suggest a scale far beyond the human, while a more familiar behaviour can situate motion in our own scale, perhaps giving the music a more human temperament. A piece of music derives much of its personality from the manner in which it moves.

[122] Klatzky and Lederman 2010.

4.2 Motion Focal Schemas

Motion has a very broad range of manifestations in spatial texture – from minute fluctuations to larger spectral trajectories, and multidirectional growth processes – but when appreciated through concentrated listening, it is difficult to differentiate between what is actually moving and what causes motion. In the case of textonal textures, it is the continual string or aggregate sequence of textons being produced that exhibits motion due to the relative spectral and perspectival differences generated over time.[123] These structures are relevant to the way our focal attention is oriented to motion on various levels in texture.

The two *focal schemas*, *exterior* and *interior* relate to the equivalent spatiality schemas, and refer to structural levels and spatiality of motion; in many situations, both are present, and the listener's level of focus will depend not only on the musical context but also on attentiveness: the aural scanning of a texture can be a matter of listening choice.

The four criteria for motion focal schemas, as seen in figure 10 (p. 77), are *motion articulation, acoustic source-bonded factors*, *density* and *interior variety.* Motion articulation resides in a continuum between the *local* and the *global*, where the former implies that activity within the texture is motive, whereas the latter extreme applies to motion that affects the texture on a whole. Thus the articulation of shape takes place in different degrees of detail. This is further dependent on aspects of *temporal scale*, *spectral articulation* and *perspectival articulation*.

Textural interior draws attention if its activity is highly articulated in patterning and shaping on a lower temporal scale, guiding attention away from growth or directionality evolving over longer durations: it is often a case of feeling submerged in a process of whose global form we have little grasp. But interiority can also be perceived over longer durations if *spectral articulation* presents structural complexity. A rich spectral texture, for example, where filaments are slowly moving in different spectral regions, could give us a sense of being situated within, or of having a prospective view of the interior of a resonant space. Moreover, prospective layering and circumspatial perspectival articulation increases the likeliness of our appreciating interiors.

[123] Johnson makes a similar point in regards to notes in tonal music – each one alone does not move, but a sequence manifests as movement (this, of course, does not consider the spectromorphological motion inside the 'note'). He suggests that the emerging motion of a sequence is a result of metaphoric processing (2007: 245-46).

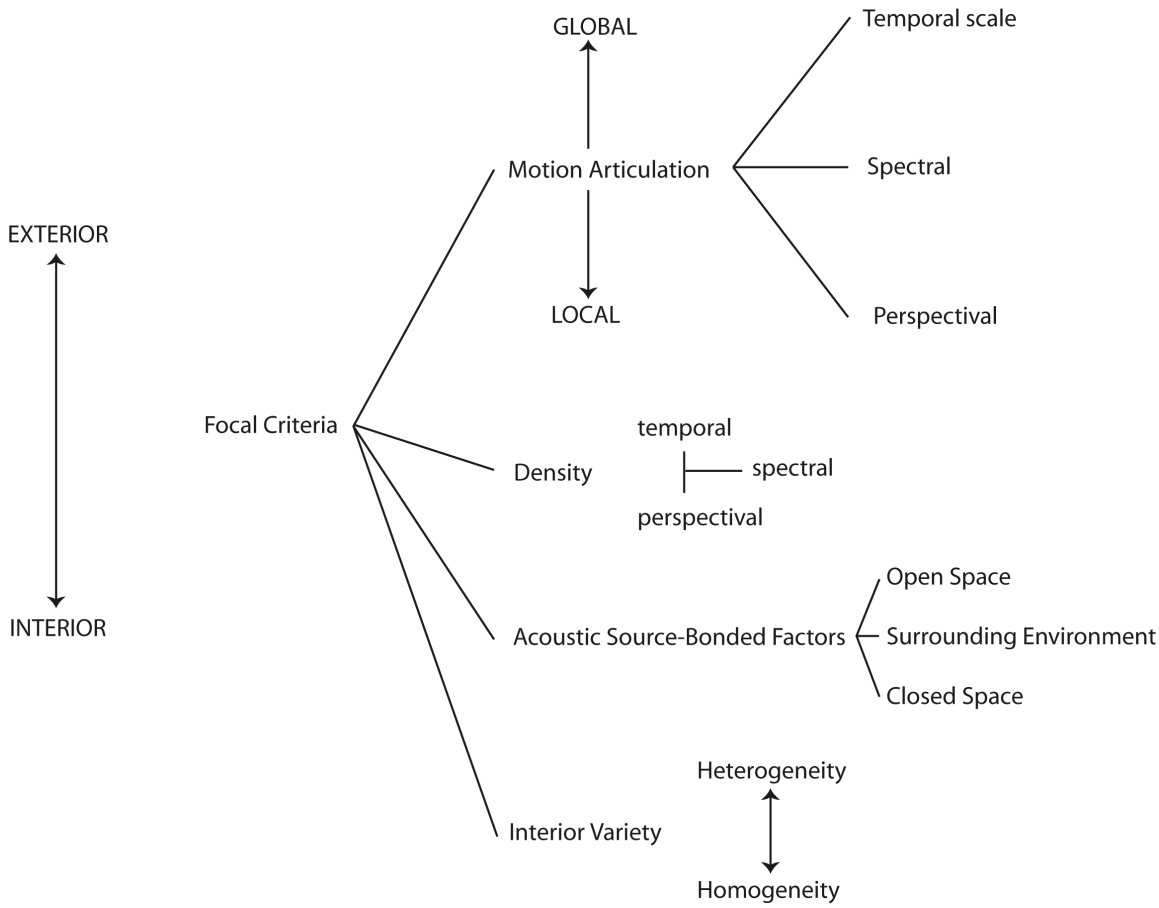

Figure 10: Motion focal schemas.

The outlines of motion articulation – spectral contours and general tendencies of growth in textural mass – are more typically articulated through exterior motion over greater stretches of space and time. However, there may also be situations where micro-activity simmers at the surface of a dense texture. Exterior motion can impart spectral and dynamic shape to aggregates of textons and filaments distributed rather uniformly across perspectival space.

Density is associated with growth processes, and its effect on focal aspects of motion is not unambiguous. Temporal, spectral and perspectival density work together here; a dense circumspatial and circumspectral environment puts us in its interior, but an opaque spectral texture with great degree of perspectival contiguity takes on a blocking function more associated with exteriority.

Acoustic source-bonded conditions – although not necessarily directly linked to motion — situate motion in a context: a reverberant acoustic – a *closed space* – can influence the sense of interiority, as can a rich *surrounding/immersive environment*, where acoustics are also present although they do not suggest a closing structure in the same sense. Open spaces may give us an 'outdoor' impression, or often something more akin to a cosmic background against which textures orbit: such conditions may influence exteriority to a greater degree. Finally, the interior variety in the textural makeup is relevant, since we are more likely to scan past a texture as an exterior surface if it is homogenous, while heterogeneity – spectromorphological variety – will more likely arrest our attentive ears and imagination.

4.3 General Motion Principles

Four general principles of motion are defined: *directionality*, *growth*, *perturbation,* and *spectral contours.* These, in turn, collaborate in the special motion types explained later.

4.3.1 Directionality

Most obviously manifest on higher structural levels, directionality emphasises orientation and paths; the motion of sound from one place to another. As the diagram in figure 11 (p. 79) indicates, vertical directions, obviously, either ascend or descend. Directions in the perspectival field project across the dimensions of latitude and longitude, in angles crossing the field in diagonals, or curves skirting the edges of the field. Longitude is often associated with *approach* and *recession* in prospective space, implications of *transverse trajectories* between front to rear, usually in higher altitudes – thus also a spectral phenomenon – and peripheral longitudinal trajectories. Transverse trajectories also apply to panoramic motion in the stereo aperture and any paths crossing sectors of circumspace.

But vertical and perspectival directions rarely happen without a mutual influence or collaboration. Ascending textures, even those with a frontal bias, often acquire an impression of being above listeners when entering higher altitudes, as they leave the perspectival image and become part of a canopy or an airborne stratum drifting above. Similarly, when textures enter the depth of spectral space, they often appear to be below us rather than within our image. This also means that transverse trajectories in the perspectival field are never quite convincing unless they have a presence in the spectral altitudes through which they are connected. Here, spectral elevation and distribution of a texture also affords agility of perspectival motion: we may expect aggregates of textons distributed over high frequencies to achieve entitative, fluid, or gaseous states due to mobility and gravitational lightness implied by their spectral spatiality and spectromorphology. If spectral and perspectival trajectories are more distinctly connected, *oblique directionality* emerges; for example, latitudinal or longitudinal motion may simultaneously ascend or descend.

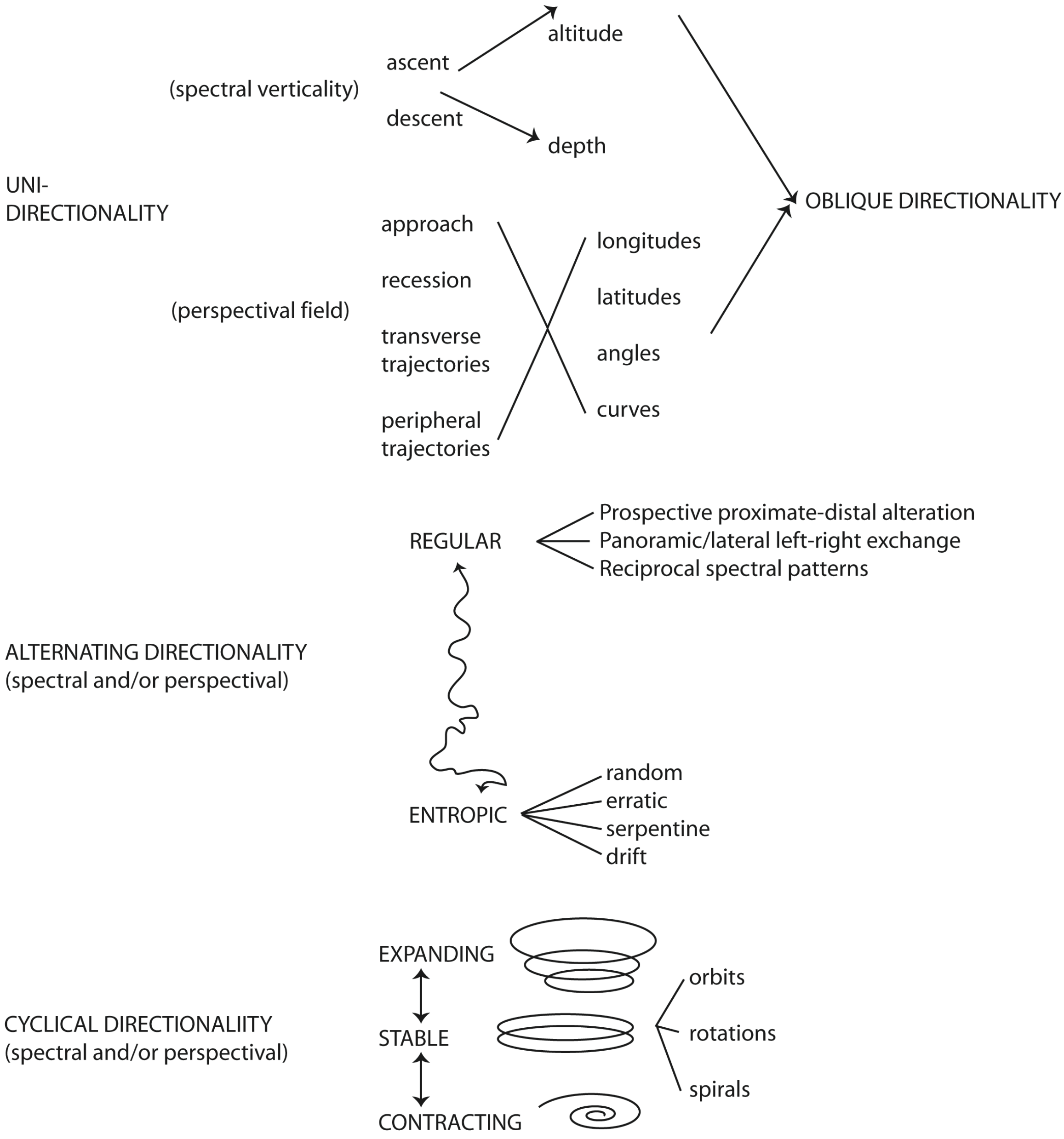

Figure 11: Motion directionality.

Alternating directionality applies to regular or irregular (entropic) reciprocity or ambivalence in directionality, applicable to either or both vertical and perspectival motion. A texture may, for example, undulate between locations in panoramic, or proximate and distal space, concurrently with alternating changes in spectral direction. Irregular and asymmetrical tendencies appear as types of *entropic* motion, where *random* alteration is a global diagnosis of general confusion in textural interior; *erratic* describes abrupt irregularity which has some trace of structure; *serpentine* motion is sinuous but irregular, or at least variable; *drift is* a more sedate, diffuse, or aimless flow, of textural mass[124].

Cyclical directionality can expand and contract over multiple revolutions, or remain stable; *rotation* implies that textural anatomy or textures themselves seem to cycle within or around themselves; *orbits* refer to larger-scale motion where textures move in trajectories surrounding, or in relation to, other spectromorphologies; *spiral* direction is an oblique phenomenon, where expansion or contraction could take place in latitude or longitude with ascending or descending spectral directionality.[125]

4.3.2 Growth

The expansion or contraction occurring with motion in multiple directions simultaneously implies a dynamic treatment of density and magnitude. Three main classes of growth are defined, reflecting aspects that may coexist. The distinction between growth and directionality is not always unambiguous; for example, a texture in proximate space becoming louder and spectrally more extended may be perceived as growing as well as moving closer. In the latter case we might assume that it retains its size and shape, and all we hear is spatial movement rather than a process of growth.

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[124] Drift also appears in Smalley's seven motion characteristics (1997: 117).

[125] Rotation and spiral also appears under the cyclic/centric category in Smalley's motion and growth processes (ibid.: 116).

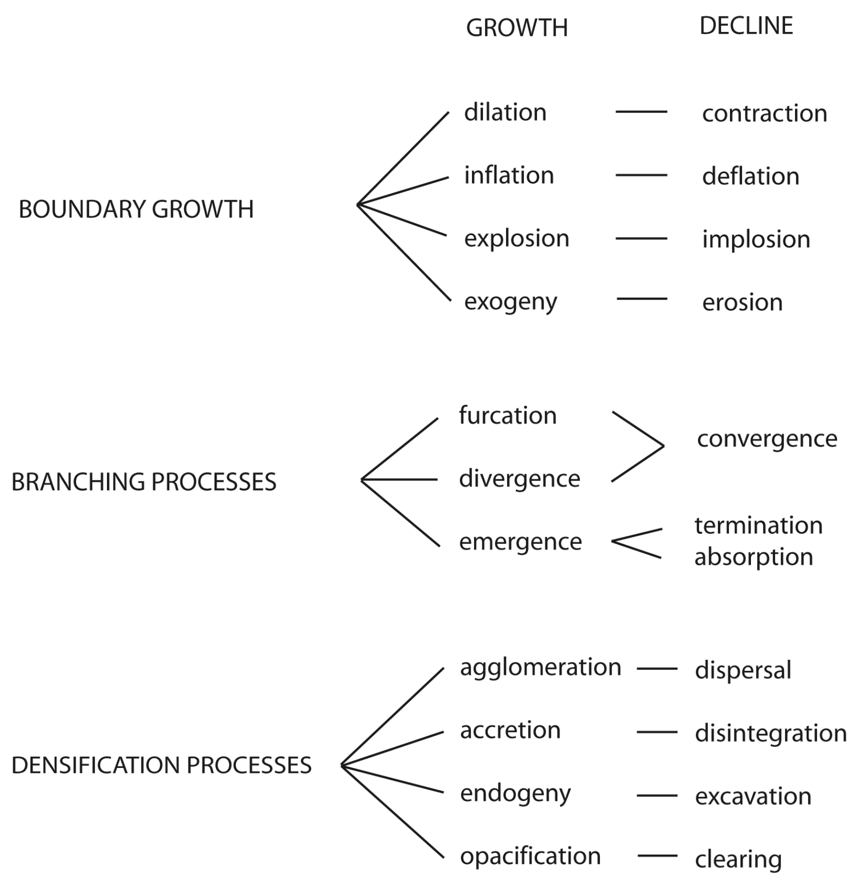

Figure 12: Growth processes.

The diagram in figure 12 elucidates the relevant growth processes and their related opposites (*decline*). Growth of textural peripheries is classified as *boundary growth,* where *dilation* implies that perspectival and/or spectral boundaries are simply widening without an implication of an interior force as cause. Examples of this could be an impression of gradual increase in circumspace due to the introduction of circumspectral resonances, or a widening vertical balance of high and low peripheries in spectral space. *Inflation*, although manifest in textural boundaries, suggests a widening due to the texture being pervaded by interior pressure, or that the interaction among textures has a mutually repelling effect, suggesting that space itself is inflating as textures push one another apart. Inflation is pertinent to certain qualitative characteristics such as gaseous and vaporous states, and a textural plasticity allowing a balloon-like swelling, or elastic tension. *Explosion* is, in principle, similar to inflation, but happens more rapidly, and may further feature a shattering of textural substance as a result of the force-cause. *Exogeny* is a term adopted from Smalley's motion and growth processes,[126] implying additive

[126] Smalley 1997: 115–6.

growth – in other words, morphologies multiplying on the exterior surface of a texture. The inverse boundary processes, where textural magnitude decreases, are *contraction*, where boundaries are attracted towards a centre; *deflation*, where a suggested interior force is losing pressure; and *implosion*, suggesting a violent collapse, or a backdraft, siphoning the texture away into a void.

Branching processes concern propagation streams multiplying into spectral strata, or segmenting due to individuation of their respective makeup, giving them differing material character. The three types differ in the manner that branching is introduced within the texture. *Divergence* suggests that one or a few propagation streams deviate from an existing texture, while *furcation* is a process where a textural stem multiplies into branches in several directions. *Emergence* is a less literal form of branching, where layers appear gradually without obviously originating in a stem, but yet maintain a kind of common ancestry amongst themselves. Inversely, these processes can be manifest as *convergence* – the merging of branches – *termination* – the ending of branches, and the *absorption* of branches into new textural formations.

Densification processes emulsify the textural interior by packing textons together in time, or increasing spectral density and perspectival contiguity of textons or filaments. *Agglomeration*[127] and *accretion* describe the gradual congregation of dispersed morphologies into a more congealed mass. The latter is the more radical of the two, implying that some sort of gravitational, attracting process is at work, where a thick and almost coagulated substance is being achieved in a process beginning in low-density propagation. Related processes of decline are *dispersal* and *disintegration. Endogeny*[128] is the process of filling a more or less hollow interior, the inverse of which is *excavation*. *Opacification* is a spectral densification process implying a filling of spectral space which may result in the blocking of other activity.

All growth processes imply both interior and exterior motion. Densification is often an interior process tending towards exteriority, since it results in a less detailed view, while branching processes often result in more complex interior motion, as multiple strands, decorating the spatial image, are drawn out of a texture. Boundary growth is of course exterior in essence, but its character remains dependent upon the implications of interior force.

[127] Adopted from Smalley (1997: 115–6).

[128] Smalley 1997: 115–6.

Ex 21 features a dilation of circumspatial peripheries, occurring in *Latitudes* at 2’00”. The excerpt begins with a lightly fluctuating resonant texture of limited spatial volume. The following descending cascades, however, introduce a diffusely resonant periphery in the lower-mid spectral region – entering between 0’20” and 0’30” – which gives an impression that a slowly-moving sea of sound has been opened underneath the mid range. Inflations occur in *Catabolisms*, and ex 22**,** from 0’09” is an example of this: a smooth noise-based texture rises above the entropic texture in the lower-mid spectral region, expands laterally and spectrally – as if blown up – and then recedes in a deflation. In ex 23 a texture has been extracted from its context in a section of *Lucent Voids*, in order to clearly illustrate furcation. It opens with a stream of frog-like iterations in a reverberant distal front, from which another stream emerges, orienting itself upwards in spectral space and in closer proximity, from which yet another emerges, reaching even higher and closer, and so on – until a bustling environment of semi-rhythmic interaction is established. The full context can be heard in ex 24**,** where the process has an obscured place in the front to begin with. Another kind of furcation can be heard in the polyphonic growth of inharmonic pitch-like material in ex 25, starting at 15’50” into *Lucent Voids*, and branching out after about 12 seconds. Divergence is shown in ex 26, from *Latitudes* at 7’48”, where an ascending motion drops off two descending grain-crunches, which in turn drop off a rippling sound mass in the bass region. A process of agglomeration occurs in *Lucent Voids*, beginning with the gesture at 15’08” – ex 27 – where textons gradually accumulate into a mass, and then disperse. Ex 28 from 18’43” in *Lucent Voids* (as heard previously for coagulated state) is an example of accretion and later also disintegration. Opacification occurs in the noisy texture of ex 29, from 12’50” in *Elemental Chemistry* (which also illustrated vaporous phase).

4.3.3 Perturbation

The principle of perturbation can be viewed as motion analogous to propagation, applying to fluctuations on a lower timescale, often alongside directional or growth processes. Such motion can occur both in textural interiors as, for example, oscillations among filaments and textons, but it can also be manifest on the outer contours of texture. One can think of perturbation as an animating force that introduces vibrations to a process that may be stationary or slowly moving on a larger timescale. Perturbation enhances physicality in textures, and can suggest a degree of disturbance or restrained volatility. Figure 13 shows the relevant variables of perturbation, which are *contours* (*angularity* and *curvature*), *entropy*, *speed* and *intensity*.

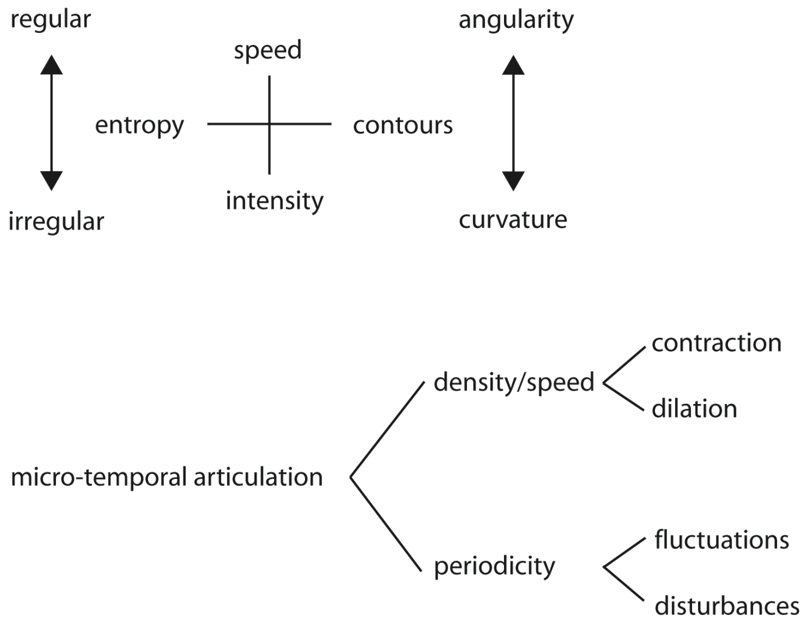

Figure 13: Perturbation.

Contours are to do with the shape of the perturbations, but also the changes that may be present in degrees of speed, intensity or entropy on a higher level. *Micro-temporal articulation* is a further variable describing the temporal alterations occurring in micro-time, which may also influence motion characteristics; it is a question of propagation density causing contractions, dilations, accelerations, decelerations, and disorderly disturbances, which often have source-bonded material references.

4.3.4 Spectral Contours

The 'shape' of motion is manifest as contours which have a strong influence on both the physicality and spatiality of texture. *Linear* motion is characterised by stability, in that its path remains constant; a linear ascending motion, for example, does not increase or decrease its speed, and can therefore seem to be freed from gravitational constraints. This suggests a physical condition of the space created by the music. On the contrary, *curved* motion – either *accelerating*, or *decelerating* – can suggest that a counterforce is present which is gradually overcome, or conversely, increases its constraints. *Angular* contours represent more abrupt changes in directionality, which can introduce a more mechanical or technological character to textures. Angularity can be a combination of linear trajectories. Perspectival motion is not perceived as contours in the same sense; rather, it complies with spectral activities, or at least, what we hear is often influenced by the spectral shape of motion.

4.4 Special Motion Types

Based on the general motion principles, a group of *special motion types* highlights particular characteristics and musical values of spatial texture in terms of behavioural associations, source-bonded materiality, and spatiotemporal structure. They are not formal categories, but rather musical concepts of motion that apply to the acousmatic medium. Thus the reader will notice that different types can apply to the same texture: their purpose is to highlight aspects that could be relevant in a given scenario.

4.4.1 Stationary Motion

As a consequence of propagation, textons and filaments may fluctuate or pulsate on a low timescale, without significant displacement in space. Thus even minor dynamic perturbations among iterations or temporal fluctuations may cause a sense of motion, as does the impression of interacting materials and forces, although generally everything about the texture is rather static. We hear motion, but nothing is really going anywhere.

This kind of *stationary motion* can occur as textural interior propagates, but is also applicable to surface-textural exteriors. The variables of stationary motion follow the principle of perturbation. The spatial manifestations in this motion type are not about significant displacements of sound – rather they tend to depend on the implied source of energy causing the impression of motion. *Explosive* or *dissipative* forces are often inferred in popping or crackling textural sounds; *frictional force* is relevant when there is an implication that texture results from the contact motion of surfaces, or the *internal friction* of elastic objects under deformation, or the breaking of brittle, rigid, materials – friction is also present in the resistance of vibrating objects or the viscosity of fluids; *gravitational force* can suggest, for example, the collision of objects falling to, or bouncing against, surfaces. The physical forces are inherently implied in the percept of motion, even if source-causes have no important role in the musical structure and syntax of a work. Ex 30, from the opening of *Catabolisms* (0’09”), exhibits stationary motion in the crackly texture.

4.4.2 Locomotion

When textural spectromorphologies are propelled across areas of perspectival and spectral space in entitative states, we may perceive locomotion. This quality is determined mainly by a continuous, streaming displacement between localities in perspectival space – rather than individual objects appearing in different areas – so that a sense of moving, sounding, objects is evoked. Two conditions of locomotion describe the causality behind the moving spectromorphologies: *Self-propelled*[129] locomotion implies that objects move by their own force, whilst *compelled* locomotion implies that entities are driven by other spectromorphological activity. Since locomotive spectromorphologies move freely in space, an association with airborne activity seems logical in most cases; another suggestion is locomotion within fluid media, in which case a degree of resistance might be suggested in the motion contours. Ex 31 illustrates self-propelled locomotion in *Latitudes,* at 9’05”: squelchy propagation streams are chaotically flying around the perspectival field.

[129] Here we can draw an analogy to the flock motion of birds and shoals of fish. In computer simulations they are referred to as self-propelled particles or boids (Ball 2009c: 124-63).

4.4.3 Phasic motion

The relations among multiple perturbational, temporal cycles in textures which are spread in spectral and perspectival space can create patterns of emergent motion due to the phasing interrelation of rhythms, which may be more or less regular. A relevant example of phasic motion in source-bonded spatial textures is the rhythmic organisation among the chirps of cicadas, creating a rippling motion across an environment. Two types of phasic motion are defined. *Spectral ripples* occur in the relative cycles of perturbations among spectral strata, or partials in a filament texture. The term *perspectival ripples* refers to the animation of cycles due mainly to temporal differentiation among zones. As illustrated in many of the textures of my compositions, an oblique phasic structure is possible, where spectral ripples occur in different stratified latitudes.

The phasing can occur as a phase relation between amplitude fluctuations, so that emergent motion trajectories appear across spectral or perspectival space. The modulation of spectral properties is also possible, as well as phasing occurring among regular iterations in multiple texton propagations.

Ex 32 shows accumulating spectral ripples beginning at 2’10” in *Elemental Chemistry*. Ex 33 illustrates perspectival ripples from *Cataract* at 8’26”; the phasing among pulsations around circumspace creates an expanding and contracting dynamic. In ex 34, from 3’00” into *Lucent Voids*, the spectral ripples in the resonances are distributed in the perspectival field: higher strata are further to the rear and modulate faster.

4.4.4 Fractional Motion

Fractured, inconsistent, or complex directional or reciprocal processes which often comprise a piecing together of parts, is here termed *fractional motion*. Mainly applicable to textonal textures, this motion type tends to draw attention to interior due to its being pattern-oriented. The continuum from *patterned*, through *semi-patterned / figured* to *statistical* (see figure 14, p. 88) describes the character of organisation within the process. Semi-patterned motion can be a combination of patterned and statistical, so that, for example, ordered figures recur unpredictably, or a sporadic motion occurs statistically among fixed spectral states.

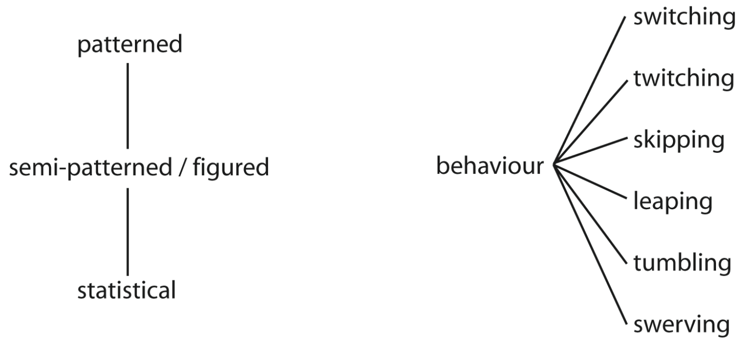

Figure 14: Fractional motion.

The fractional directivity associated with this kind of motion is primarily spectral, and can include pitch lattices, or brief streams of textons in varying shapes or stratification, although perspectival motion tends to be complementary. The structuring can be aided greatly by the grouping of streams onto spectral strata, and zoning in circumspace, so that patterns have different central regions. Small-scale body-motion or utterance analogies are often conjured up in fractional processes, and some terms alluding to this are introduced in the diagram in figure 14.

In ex 35 we return to the branching textons in *Lucent Voids* to hear an example of fractional motion: the streams of textons have recursive patterns which alternate in spectral directionality and fixity. Ex 36, which has ancestry to *Cataract*, shows another fractional pattern where textons leap among different spectral positions.

4.4.5 Signal Motion

Zoned spaces, *behavioural spaces*[130] and *signal spaces*[131] present interesting aspects of motion tied to the metaphor of communication. The summed activity of several, simultaneous

[130] 'A zone of perspectival space produced by the interaction of sounds which, spectromorphologically and texturally, indicate collaborative, group identity.' (Smalley 2007: 55)

[131] 'A type of behavioural space produced by the signal calls of the participants, either to communicate with each other, or to communicate their presence to other inhabitants.' (ibid.: 56)

propagation streams or textures, with distinct, different spatial locations, can give rise to interactive patterns in spatial texture. An example is animal-like signalling, creating motion projecting across spatial dimensions, by analogy with communication. This type of interaction, *signal motion*, may occur among several textures in a complex network of activity, and is caused by the interrelation of activities in different zones, as if signals are sent from one place to another in a call-and-response type of communication. Such communication can happen not only in perspectival field, but also among spectral strata, as if communicating entities were elevated to different altitudes. Entropic processes have an effect on signal motion, and can create cacophonous and confused textures, with disarray among projected signals.

Ex 37, from *Elemental Chemistry* at 4’55”, illustrates signal motion occurring among spectral strata. In ex 38, from *Lucent Voids* at 14’20”, we hear a more complex instance of signal motion: bird-like tweets are occurring in zones on the sides suggesting a lateral dimension, while the textonal chirpy and croaky sounds articulate a longitudinal path from the distal front towards more centred localities in circumspace.

4.4.6. Aggregate motion

When some form of global behaviour emerges out of collective morphologies, they display *aggregate motion.* This motion type is a catch-all for flocks or clouds of textons and filaments, displaying globally statistical tendencies of motion, such as those present in Xenakis’ stochastic music,[132] and the cloud textures Curtis Roads deals with in *Microsound.*[133] The scale of motion here is distinctly different from, for example, fractional motion, where patterns are seen on a lower level.

The diagram in figure 15 (p. 90) shows the different types of aggregate motion. Smalley’s *flocking* texture motion type – ‘the loose but collective motion of micro- or small object elements whose activity and changes in density need to be considered as a whole’[134] – is relevant as one type of aggregate motion. *Cloud motion* refers to a denser aggregate of minute activity, whose

[132] Xenakis 1992.

[133] Roads 2001.

[134] Smalley 1997: 117.

motion may imply the presence of pressure forces such as wind. *Swarming* aggregates consist of multiple fluctuant propagations in entitative state, together forming a more or less entropic mass of activity: the interior of the swarm may thus consist of spectromorphologies in locomotion.[135] *Streaming* motion, another term adopted from Smalley's texture motion types, is 'a combination of moving layers, and implies some way of differentiating between the layers, either through gaps in spectral space or because each layer does not have the same spectromorphological content'.[136] Here, textures are segmented by differing strata or internal materiality. In this case each stream has a more or less dense aggregation of matter. Streams may reside on a fixed stratum, agitated by stationary motion, or display flow-motion characteristics, whereby they fluctuate and move along in a laminar or turbulent fashion.

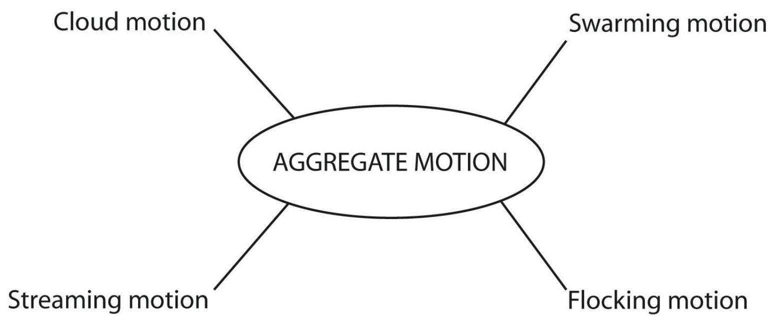

Figure 15: Aggregate motion.

Flocking motion is illustrated in ex 39, from *Cataract* 7'05", where textons accumulate into a statistical mass. Cloud motion can be heard in ex 40, from *Lucent Voids* 1'06", where first a quasi-gestured noise cloud appears in the lower-mid spectral range, and then another cloud is introduced in a higher stratum. Ex 41 shows an instance of streaming motion in *Cataract* at 3'20" – slowly fluctuating textonal propagations create streams which interlace in spectral space. In ex 42, from *Catabolisms,* at 3'35", we have a form of swarming motion in squelchy textures which here orient themselves through spectral and perspectival space in an entropic manner.

[135] Scott Wilson (2008) has developed the Spatial Swarm Granulator as part of the BEASTMulch library in SuperCollider. It is based on algorithms simulating flock behaviours among animals and distributes granular textures over an arbitrary array of loudspeakers.

[136] Smalley 1997: 117.

4.4.7 Commotion

Textural motion which appears unstructured and occurs among a disparate array of spectromorphological material, I term *commotion*. What distinguishes commotion from other entropic motion scenarios such as aggregate motion, or turbulent flow motion, is the cacophonous clash of activity within a heterogenous group of events. We may recall Arnheim's definition of *disorder* in the previous chapter: 'the clash of uncoordinated orders'.[137]

Ex 43 – starting at 9'30" into *Lucent Voids* – shows an entropic state where the behaviours of textures are chaotic and unaligned on a lower timescale, although they are distributed globally to create a structured space together. We might say that it is disorderly on the surface, but structured in a more general, spatial sense.

4.4.8 Flow Motion

Fluidity has a source-bonded presence in many textures, but it also appears in the structures of motion. The concept of flow here is primarily a question of dynamics, and may coincide with many of the other motion types in various ways. Essential to flow motion is the temporal continuum that permeates many textural structures, and it can manifest in slower fluctuations over longer time-scales, as well as in more active textonal or filament aggregations. Flow motion therefore has relations with several levels of structure.

As described in physics, fluid dynamics involve relationships among *streamlines*, the trajectories of flow in a fluid system (see figure 16, p. 92). When flow is steady, or *laminar*, these run in parallel, but when the speed of flow increases, they begin to curl back on themselves due to friction imposed by viscosity or obstacles, forming eddies, which can turn into vortices. This kind of *turbulent* flow is entropic – in states of high turbulence, vortical patterns may break up into more chaotic forms.[138] Scientists apply the physical principles of fluid dynamics also to general collective motion phenomena, such as animals in flocking or swarming motion, human

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[137] Arnheim, 1966: 125.

[138] Ball 2009c: 25-32.

crowds, and traffic; pattern formation among inorganic particles, such as ripples and dunes in desert sands, created by the flow motion of wind in combination with gravity; or gaseous or vaporous cloud formations shaped by flow currents. These examples are all suggestive of motion phenomena in spatial texture.

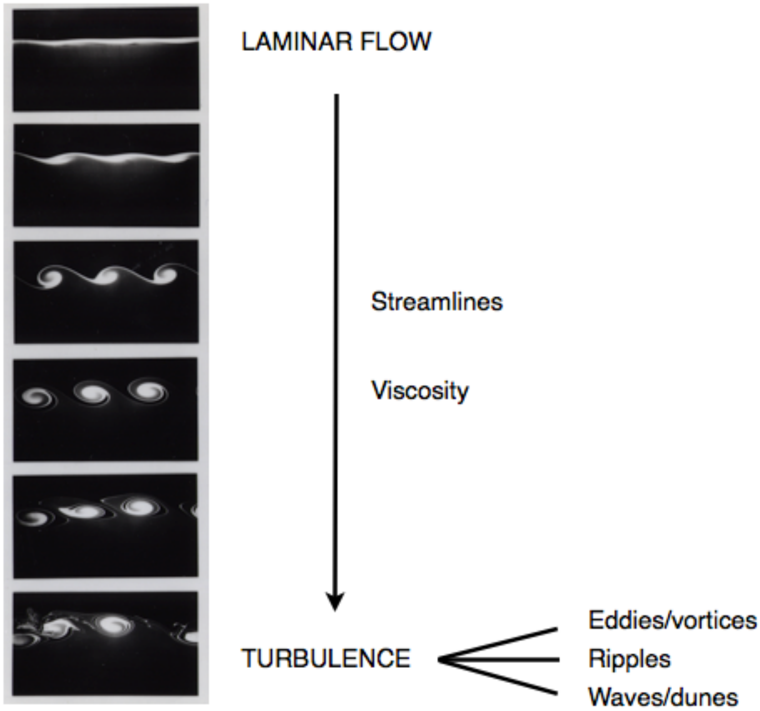

Figure 16: Flow motion (image: Sreenivasan, n.d.).

In spatial texture it is often the momentum and global coordination among topologies which causes flow motion. The impression of flowing sound is often conjured up in textures which propagate in multiple streams running in parallel or sinuously interlacing, not unlike streamlines. In these situations, texture often gathers momentum, as structures are mobile, and no fixed background against which things are moving is present. As the temporal and spectral rates of change increase and become more erratic, texture can approach the typical granular state of fluidity.

Thus, recalling the aggregate motion types, it becomes clearer how these, under certain circumstances, can be considered as instances of flow motion. Streaming motion would be a case of more laminar flow, while *convolution* and *turbulence*[139] – also appearing in Smalley's texture motion typology – occur under more complex circumstances, the former denoting a non-laminar but still differentiated flow of streams, and the latter, a more chaotic and fractured state. Flocking and swarming motion can form flow patterns when the emerging tendencies of motion exhibit fluid continuity. Dense surface textures in cloud motion can accumulate in formations conceptually resembling swelling dunes, or ripples, where phasic motion travels across circumspace in rhythmical patterns. A form of turbulent flow is then implied in the interaction of pressure energy, mass and friction upon a rather uniform surface texture. The discussion of turbulence inevitably points in the direction of entropic processes: streamlines, and complex emergent forms in flow motion occur in non-equilibrial entropic processes, but increasing disorder can also catabolise texture into a more choppy condition.

The thickness in flowing textures is here described as *viscosity* (see figure 16), representing the frictional resistance to flow. Viscosity is not only present in textures which display obvious source-bonded fluidity, but a general measure of the ease with which the music flows in textural relationships. If viscosity is high, the texture moves in a slow, syrupy manner, suggesting weight and thickness. Low viscosity, on the other hand, is synonymous with speed and agility in propagation, imparting lightness and malleability to texture.

Flow motion can be heard in ex 44 from *Lucent Voids,* at 1'40". Liquidity is present in the source-bonded textures, but flow is also suggested in the motion contours. Descending streams of droplets in the higher altitudes are lining the peripheries of circumspace and sometimes crosses the perspectival field, with the lightness of low viscosity. There are textural layers in the lower areas which have a thicker and more swampy quality. The macro-texture gradually acquires impetus as the descending motion in the higher droplets seem to be sucked downwards by lower layers.

[139] 'Convolution (coiling or twisting) and turbulence (irregulation fluctuation, possibly stormy) involve confused spectromorphological entwining, but nevertheless tend to concur in their chaos' (Smalley 1997: 117).

4.5 Critical Forming Processes

Motion in spatial texture creates shape, exposes material elasticity and plasticity, and can have transformative capacities. There are three types of process at work in the formation of music through motion in spatial texture: *deformotion, morphogenesis,* and *transformotion*. They are referred to as *critical forming processes* because they all challenge the identity and expected transformational potential of textural topologies.

4.5.1 Deformotion

The Oxford Dictionary of English[140] defines *deformation* as 'the action or process of deforming or distorting', or 'the result of a distorting process'. It is a process that allows some aspects of an object to remain unchanged, so that we know that a distortion has occurred. The deformation of spatial textures gives important clues to the potential of their topologies, through stretching them and challenging their supposed constraints. And, as Arnheim writes in *Art and Visual Perception*[141], perspectival understanding of space is linked to deformation:

> Deformation is the key factor in depth perception because it decreases simplicity and increases tension in the visual field and thereby creates an urge toward simplification and relaxation. This urge can be satisfied under certain conditions by transferring shapes into the third dimension.[142]

Although Arnheim is discussing still, visual images, some aspects of his view are relevant to sonic spatial forms in motion. The deformation of acousmatic space through time accentuates spatial relationships among textures, and informs the listener of their nature and the conditions of the global space which they occupy. This is related to expectation, the role of which Arnheim further elaborates upon as follows:

> Deformation always involves a comparison of what *is* with what *ought* to be. The deformed object is seen as a digression from something else. How is this "something else" conveyed? At times only by previously acquired

[140] The Oxford Dictionary of English 2010.

[141] Arnheim 1974.

[142] Ibid.: 259.

> knowledge. Alice's long neck is perceived as a deformation, whereas the stem of a flower is not. When the peasant in his first visit to the zoo said of the giraffe, "There is no such animal!" he was comparing it to some vague norm of animal shape.[143]

Also in sound, regardless of its remoteness from known materials, we have such expectations, and they have an important role in the acousmatic experience. In distinctly source-bonded textures, we are aware of the spatial and acoustic conditions of certain materials, and may, more or less consciously, employ these upon encountering relationships and transformations in the music as we hear it. But, also in more alien sonic circumstances there are inferred perspectival, spectral, and source-bonded relationships, conditions and potentials. Thus, even if we do not know *what* something we hear is, we may form an expectation of spatial behaviour: for example, spectral distributions and perspectival motion will be measured against gravitational expectations, and similarly texton properties and global densities will suggest ideal proximities and distances in relation to other materials. Processes of deformation can both enhance and subvert these ideas; it can be a way of creating a plausible sound environment, or another mode of contesting the listener's expectations through warping a world whose dimensions we otherwise might take for granted. Deformation is therefore a relevant structuring factor in spatial texture.

I associate the following conditions with deformation in spatial texture:

1) *Plasticity*, and *elasticity*.
2) *Abnormal behaviour*: spatial and temporal deviations from acoustic plausibility.
3) *Image warp*: the general re-proportioning of structural relationships in spatial texture so that magnitudes are affected; gradually changing contrasts, warping spatial perspectives.

These three aspects in continuous temporal elaboration constitute what I have termed *deformotion*; indicative of processes where motion causes deformation. A distinguishing aspect of deformotion is that some essential aspects of identity in the spatial texture remains: it is therefore not a transformation. *Plasticity* may be inferred through source-bonded spatiality, or by the

[143] Arnheim 1974: 259.

manner in which motion manifests as a reshaping of textural topologies, particularly through biased densities and oblique spectra – thus extending spectra variably in perspectival space. *Elasticity* occurs in cases where textures have tendencies to return to an original shape after deformation, or at least offer resistance through suggested friction. This condition is something that generally has to be developed over time, allowing listeners to become acquainted with the physicality and behaviour of the texture, since the consistency of cycles of deformation needs to be established.

Abnormal behaviour is a case of textures deforming in a manner that does not comply with expected acoustic processes and behaviour. It is a behaviour that is artificial in the sense that it is unreal or implausible, but physical in the behaviour itself. For example, resonant textures that fluctuate in an exaggerated aperiodic vibrato can exhibit a physical fluidity although they are not known to behave in this manner in reality.

Image warp has a particularly strong effect when imposed upon source-bonded environments, since the familiarity of the setting is in inherent tension with the deformotion process. In a music that emphasises relational processes among textures, deformotion can also occur as a more general re-proportioning of spaces, as textures attract or repel one another, causing the impression that the structure of space is elastic under the influence of, for example, stretching, melting, or inflationary processes.

Deformotion can thus occur both with individual textural spectromorphologies and in higher-level structures where a multitude of motion processes are occurring at once. Growth and directionality are the two principles of most importance in the latter case, while in the former, perturbation is also influential. The one growth process that is most strongly associated with deformotion is boundary growth: inflations and dilations, in particular, have a strong propensity to create deforming structures.

4.5.1.1 Deformotion in *Lucent Voids*

Deformotion is an important aspect of *Lucent Voids*, occurring both in abnormal spectromorphological behaviour on a local level and as a more all-encompassing warp of images. Ex 45**,** which begins at 6’05”, shows the evolution of a textural space that is entirely elastic. New textural processes are spawned throughout, and they all interact in a manner that suggests that an underlying, stretchable space-time fabric is present. In the opening, the spectrum of fluctuating resonances creates a subtly deforming spectral texture; the slimy texture which enters at 0'21" shows a kind of elasticity or viscosity in its materiality; and the fluttering higher strata, simultaneously moving in the rear circumspatial peripheries, try to pull the space in its direction. After about 0'34", a noise morphology seems to get sucked into an indentation in the front, as a rumbling bass enters. Later, at about 0'50", and at 1'12", ascending phasic noise strata glide towards the rear peripheries continuing to pull the space in this direction, while lower resonances begin to appear at around 1'01", dilating frontal and lateral space to create an expansion that warps the image depth as it contrasts with the proximate slimy material. The space is constantly changing, yet it maintains its essential features. Deformotion in this example occurs within individual textures, but also among them.

Elsewhere in the piece we also hear abnormal behaviour. For instance at 10'30" – ex 46 – where, after a few seconds, a series of inharmonic gestures enter, which have an abnormal fluctuating deformotion behaviour, perhaps as if they were melting bells. The fluctuating strata also help giving the space an unstable impression. This kind of deformotion, which is to do with unlikely behaviours imposed upon familiar sonorities, is frequent in my pieces. As an example we might consider the unsteady counterpoint in ex 25 – not least the the brass-like sounds emerging at 0'45", which acquire a viscous quality; or – in *Elemental Chemistry* – the continuously deforming and transforming spectra which seem to exist in a liminal territory between bell-like and vocal-like spectromorphologies (see ex 55).

4.5.2 Morphogenesis

Topological flexibility allows not only for textures to deform, but often the spatiotemporal dynamics also moulds the propagation of texture into more distinct events with clear spectromorphological shapes. This aspect of topological shaping is afforded by the physicality of interaction among textures, often where entropic processes result in orderly formations which in turn propel the music forward, or conclude processes: the amorphous is rewarding us with the shapely.

This phenomenon is essential in all the compositions in this project, where, amidst an underlying flux of textural masses, we find that textures organise into contours and shapes, which become events rather than continua. But this tends to be a process that remains ambiguous until it has been completed: we do not necessarily know the degree to which formations are being cast as we proceed along the textural continuum. Spectromorphologies often appear spontaneously in the ecology of textures as if born out of the continuum. Whilst being part of the elastic mass, they can simultaneously have a role as characteristic spectromorphologies.

Morphogenesis, thus, is the critical forming process that constitutes the birth of spectromorphological events from texture – sounds which are both forms and surface properties simultaneously.[144] They can happen on both local and global levels; in the former case, we encounter spectromorphologies of a shorter duration, which we can hear are from the same topological substance as more extended textural surfaces present. In the latter case, textures which have little evolutive shape on a local timescale acquire contours through directionality or growth over larger spans of time, forming macro-morphologies which encapsulate lower-level activity. Directionality, growth and spectral contours are thus crucial to morphogenesis.

In terms of structural function, morphogenic processes often carry a gestural impetus. We can also say that morphogenic processes of the local scale are orbiting freely in Smalley's object/substance indicative field[145]: they may often be heard equally as remotely source-bonded 'plastic' objects, or as matter in the process of taking shape.

In ex 47 from *Catabolisms* – at 1'38" – spectromorphologies are shaped like mouldable matter out of the textural continuum: two elastic crunches enter at 0'13" and then three appear at 0'38". Deformotion also has a role in the process, as textural topologies are being stretched into shape. Ex 48, from *Lucent Voids* at 15'12", shows an agglomeration process which shapes into

[144] The term, *morphogenesis*, was coined by mathematician Alan Turing, who theoretically demonstrated that chemical, self-oscillating, reaction-diffusion processes are an early evolutionary phase in the creation of new life forms (Ball 2009a: 154–8).

[145] Smalley 1996: 89.

graduated contour: the texture of accumulating textons becomes spectromorphology, and once this is complete, other elastic propagating spectromorphologies also appear.

Morphogenic processes, especially from *Catabolisms*, will reappear in examples given in chapter 5, where it will be apparent that morphogenesis is often important in the formation of *topological threads* – textured sequences or continua with focal or peripheral roles in the musical discourse.

4.5.3 Transformotion

Under some circumstances, motion pushes texture to its material and spatial limits, causing not only deformation, but a more thorough recomposition of the textured space – a transformation has occurred and a new spatial state of affairs has been reached. Such a process is here known as *transformotion*. While deformotion may serve to establish the consistent structures of textures, transformotion establishes new phases in the textural continuum, introducing, or reconfiguring, materials and spaces through motion. This type of forming process depends on a number of simultaneous aspects of motion, such as growth and spectral directionality, which must carry some degree of physicality, so that the transformation is warranted, as if the motion causes the transformation. Lower-level alterations in temporal and spectral definition of textons' properties also have powerful capabilities to change both the material and spatial identity of texture.

These processes often have a logic whereby what begins as deformotion becomes transformotion – a gradual warping which escalates into a transformation. Other kinds of transformotion processes can occur in densification and branching, where textures coagulate into surfaces of very different spatial and material character, or furcate into a more complex environment. Transformotion may result in a change in source-bonded environmental, or acoustic conditions; extreme changes in magnitude and focal levels; changes in altitude or depth that not only have vertical implications, but also affect textural identity; significant macroscopic alteration between homogeneity and heterogeneity. Thus, transformotion applies to a multitude of aspects of spatial texture.

4.5.3.1 Transformotion in *Cataract*

One of the characteristic aspects of *Cataract* is the manner in which it journeys through very different textural environments in a continuous fashion, especially where transforming texton properties within textural topologies create transformotion processes, which often also coincide with transitions between textural states. A heterogeneous succession of sound worlds is created, where transformotion has a role in many of the transitions.

In ex 49, which begins at 5’37”, transformotion occurs in a process where glissandi spawn a morphogenic, descending stream of textons – apparent after around 0’30” – settling in a proximate aggregation of metallic- or glass-like objects at about 0’50”. Another transformotion occurs again after this, as a richer environment appears with a wave-like approaching gesture, after 1’05”.

Another transformotion process, where texton properties are an important part, is illustrated in ex 50, beginning at 10’50”. We first hear a drone and multiple textonal textures, but after about 0’16” seconds, a lower bass enters along with a higher descending glissando, whilst a transformation among textons towards more fragmented, crackly sonorities occurs. The glissando and the bass add emphasis to the transforming texture, where textons are orienting themselves away from the higher regions, and their impact sonorities suggest a presence of gravity. At 0’33” a cascading texture coincides with the appearance of richer textonal layers, and at 0’44” an ascending texture enters as textons acquire a lighter materiality in the higher altitudes. Textons transform again after a circumspatial stratified noise texture enters at 1’08”, which washes through the texture as its materiality changes.

4.5.4 Linked Critical Forming Processes in *Latitudes*

In *Latitudes*, a 2’50” passage, beginning at 7’50”, shows an extended process which links morphogenesis, transformotion and deformotion. The excerpt can be heard in ex 51. Figure 17 shows a schematic representation.

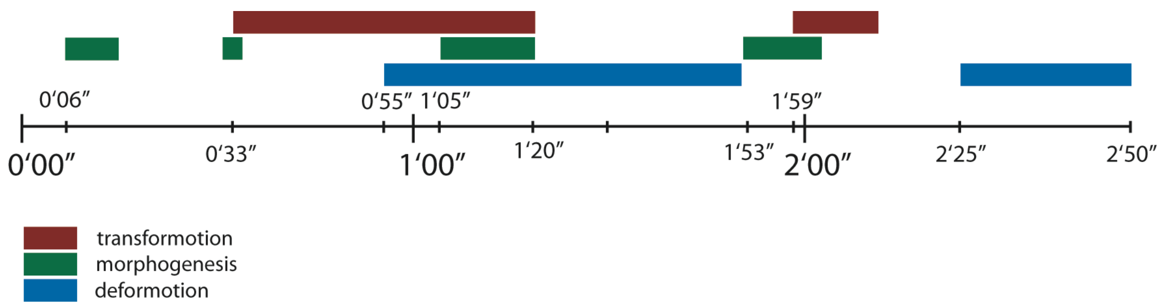

Figure 17. Schematic representation of critical forming processes in ex 51 from *Latitudes at* 7’50”–10’40”.

At 0’06” a morphogenic process occurs as a diversion from an ascending glissando: two spectromorphologies are moulded out of an elastic texture, dropping off a third in the lower depths of spectral space. As the rippling motion of this texture continues, a transformotion process occurs when the resonant texture breaks up into a dense, approaching mass of grains. This happens at about 0’33”, and takes us up to a different spectral plane where new textures begin to emerge. The transformotion continues until about 1’20” and is manifest in the emergence of new textural strata and the squelchy, fluctuant propagations appearing at 1’05”, which are also morphogenic.

Beyond 0’55” we can also note that the peripheries of circumspace, and spectral contours are undergoing deformotion. The textons that gradually emerge make the circumspatial peripheries mobile. The descending glissando entering at 0’55”, followed by an ascending one at 1’20”, gives spectral space a certain malleability. A longitude is established, as resonances in both front and rear become more prominent, and begins to elongate the perspectival field around 1’40”.

After 1’53”, descending cascades create another transformotion process, which leads into a different, larger space, with deep bass, diffuse noise textures, and fluctuating resonances. A deformotion process, where the perspective slowly warps, begins at 2'25". In this phase there is an impression that space is reshaping due to altering peripheries and changing perturbation speeds, although the essential nature of the texture does not transform. We can see the deformotion as a physical repercussion of the descending spectral impact.

The processes engage in the forming of the music in different ways: morphogenesis constitutes a more gestural and event-oriented process; transformotion creates radical alterations over a longer duration – here representing a climactic phase in the work; and deformotion creates an ambiguous, warping, elastic state.

4.6 Summary

Motion in spatial texture is experienced in the continuum between the *interior* and *exterior* focal schemas, and works through four *general motion principles*: *directionality, growth, perturbation,* and *spectral contours*. The *special motion types* comprise species of motion that have particular musical value in textural processes. They are not exclusive, but rather emphasise certain structures and percepts which are relevant depending on their context, and can combine and coexist in any kind of rhizomic manner. Finally, three *critical forming principles* are introduced, which challenge the stability of spatial texture and our acousmatic environment, thus critically forming the music through time. The processes *deformotion, morphogenesis* and *transformotion* are strongly associated with continuous processes, and have the following characteristics:

Deformotion: Proportions in spatial texture are altered. Spatial relationships are stretched and distorted in an elastic manner, although some aspects of identity remain.

Morphogenesis: Spectromorphological events are shaped out of the textural continuum.

Transformotion: Spatiality and materiality in texture undergo significant transformations changing the nature of an entire environment. A significant deformation can become a transformation; this is context-dependent – a work establishes its expected boundaries.

5. WEAVE – A COUNTERPOINT OF FOCI AND PERIPHERIES

Our initial elucidation of the concept of topology, in chapter 2, left some higher-level aspects yet to be considered. The connections among modes of propagation and distributions in low-level topology do not tell us how textures are structured relatively over the course of a work or passage. This chapter takes a view that considers the formation of *topological threads,* forming a spatial network over time. We may view this as an overall *weave* – a macro-structural texture of textures, bringing to attention the style and manner in which propagating processes relate to one another; how they begin and end; how they follow or counterpoint one another; and how individual textures stand out or integrate with other processes.[146]

5.1 Topological Threads

Topological threads are formed by single textural topologies, or sequences of morphogenic processes, which are differentiated enough so that they can be followed through the music. The structural criteria of the weave influence the formation of threads and their varying structural roles, and are illustrated in the diagram in figure 18 (p. 104). These are not only aesthetic features, but they also have a necessary perceptual function in the segregation and integration of textural processes, which on a lower level of perception can be related to aspects of auditory scene analysis.[147]

[146] 'Weave' may appear similar to Pierre Schaeffer's *trame* (Chion 1983: 134), translated as we*ft* by Dack and North (Chion 2009: 148-149), but the terms should not be confused. Weft, in Chion's words, 'belongs to the type of prolonged sound that could be analysed as an amalgamation of different intermingled constituent objects, but which present to the ear as macro-objects bound together by the sensation of a "causal unity"' (Ibid.: 149). I do not conceive of the weave as a type of macro-object or sound – it is rather a structural abstraction which, as such, does not indicate any specific morphological typology.

[147] Bregman (1990) distinguishes between two main principles of organisation of auditory information: the integration of sequences of sounds and the integration of simultaneous auditory components. Relating these to what musicians refer to as the horizontal and vertical dimension in music, he has thoroughly discussed the role of primitive auditory scene analysis (as opposed to schema-based) in the perception of music, including melody, timbre, and contrapuntal texture (ibid.: 455-528). Here, he also recognises the extended potentials for ambiguities offered within the area of computer music, due to transformations made possible with audio synthesis and processing technology. The latter case, obviously, needs to be considered with an extended sound palette in mind, featuring phenomena outside of conventional instrumental and vocal repertory – thus entering the more general context of auditory scene analysis. For a concise and more current review of perceptual organisation of auditory streams, see Fishman and Steinschneider (2010).

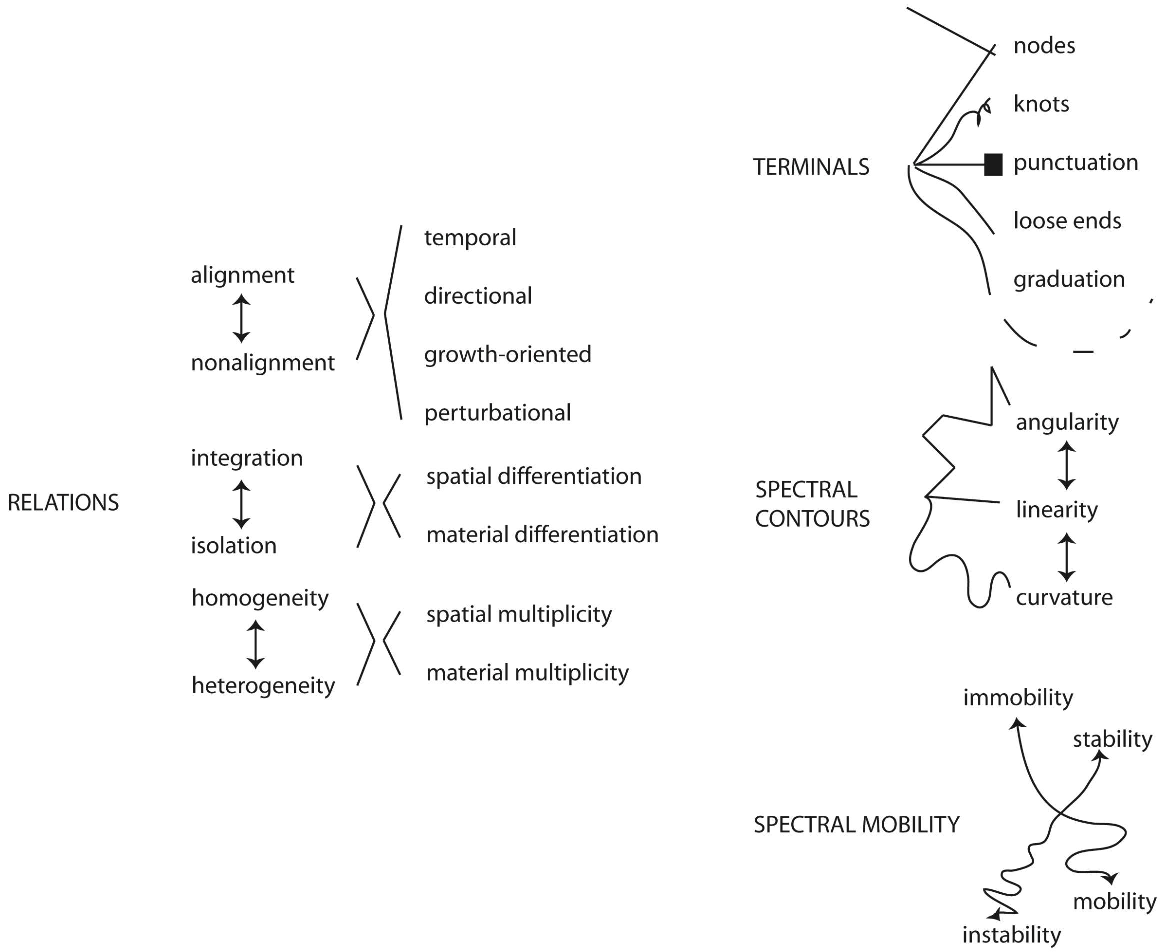

Figure 18: Structural factors of the weave.

Within the group of *relations* (on the left of the diagram), three continua – *alignment–nonalignment*, *integration–isolation,* and *homogeneity–heterogeneity* – describe a set of aspects concerning relative properties of the weave. *Temporal* relations, the first factor described by the *alignment–nonalignment* continuum, is an important influence upon the integration and separation of structures.[148] In a weave with highly-aligned temporal relations several processes may begin or end at the same moment, which can make the structure appear more united and orderly, although it may also prevent individual elements from standing out, as they are structurally grouped together with other events. Temporal nonalignment, on the other hand, implies that events or textural onsets are not concurrent, and can therefore result either in a highly fragmented, scattered structure, on one extreme; or conversely, in a structure that depends more on the establishment of several simultaneous continuing paths – structurally similar to horizontal

[148] Onset synchrony tends to be conducive to simultaneous grouping in auditory scene analysis, since 'unrelated sounds seldom start and stop at exactly the same time' (Bregman 1993: 17).

melodic lines in a polyphonic texture. Moreover, while alignment can result in clearly marked sections where all processes begin, end, or change, at once, nonalignment reflects a more complex temporal map where layers may have more polyvalent structural functions. Alignment and nonalignment can be operating simultaneously on different levels – there can be aligned processes manifest in the relation among lower-level subsets of more nonaligned textures and gestures.

The same continuum is also applied to the general motion principles – directionality, growth, and perturbation. Thus, *directional, growth-oriented,* and *perturbational* relations concern the similarity or difference among textural processes of motion and change, and the degree to which they follow one another or not. Alignment of directional relations thus implies that motion trajectories largely have a similar direction, whereas nonaligned processes can contradict or ignore one another. Directional nonalignment can work together with temporal nonalignment to segregate processes, in favour of a form of counterpoint in the sense that textures maintain independence in motion and duration. Growth-oriented relations concern whether processes of, for example, boundary growth or densification – including respective processes of decline – happen simultaneously among several textures at once (alignment), or if they have more individual tendencies. Perturbational relations are to do with the degree of alignment among, for example, oscillations or fluctuations, also reflecting a degree of textural segmentation on a lower timescale.[149]

Material and *spatial differentiation* both concern aspects of the *integration* and *isolation* of textures, and are interdependent. Material differentiation is a factor that influences segregation of textures by diagnosis of materiality – thus, source-bonded aspects and surface qualities. A texture will stand out if its materiality distinctly differs from that of other textures, and this could happen even if there is not a strong spectral or perspectival difference. Spatial differentiation is concerned with the degree to which topological threads segregate in spectral space, where perspectival relationships often act as an auxiliary aid or resultant effect. Source-bonded spatiality can also influence differentiation due to, for example, reverberant acoustics, possibly

[149] The grouping and segregation occurring due to perturbational relations is related to the phenomenon known as *common fate* in gestalt psychology, which 'in audition can be defined in terms of correlated changes in the frequencies of different partials or in their amplitudes'. (Bregman 1990: 657) Thus, complex spectra are integrated on the basis of similar perturbations, but also segregated where different spectra have different perturbations.

also creating perspectival relationships. Naturally, spatial and material differentiation influence one another. Generally, the more individual textures are, in terms of material character, behaviour, and spatial presence, in relation to one another, the greater the differentiation in the weave.

Spatial and *material multiplicity* is to do with the range of different kinds of spaces and spectromorphologies present, and has the same interdependence between spatiality and materiality as differentiation does. The *homogeneity–heterogeneity* continuum thus indicates variety, and we must understand that the presence of multiple propagating streams is not the same as the presence of multiple *different* propagating streams. In a materially heterogenous weave we can identify several different spectromorphological species, and in a spatially heterogenous weave we observe or inhabit several different spaces at once.

Terminals are the beginnings and ends of topological threads, for which a range of different types is given. *Nodes* are situations in which one process ends where another begins, so that there is a sense that a connection has taken place. *Knots* are more convolved, complex intersections which involve figured events. *Punctuation* describes a gestured onset and termination, where an event stops or starts a process. *Loose ends* are not punctuated and thus left to end beyond, or without, intersections, or begin suddenly and seemingly out of context. *Graduation* implies a gradual emergence or disappearance of processes, perhaps from, or into, the interior of another texture.

Spectral contours are imported from the motion principles, just to emphasise that they have an important influence on the characteristic mode of change in the weave. They can of course be manifest in more or less radical ways in a work. A weave featuring a balance between angularity and curvature is very different from one that emphasises either at the expense of the other.

Finally, *spectral mobility* is an assessment of general spectral motion among propagation streams, and the degree of spectral variety. Here, two crossed continua are proposed: *immobility–mobility* and *stability–instability*. An *immobile* spectrum is an extreme situation suggesting fixed strata or drones, whilst *mobility* suggests that there is a general spectral agility or flux. *Stability* is not immobile, but it implies a grounded or controlled spectrum that does not change radically or spontaneously. More entropic or volatile conditions are approached towards the *instability* end of this continuum, where motion is not only mobile, but also seems subject to uncontrolled forces.

A highly mobile or unstable weave can result in fragmentation if we are unable sequentially to connect sounds due to their spectral disparateness. These continua can be assigned to the overall behaviour of the threads inside the weave, but also apply to the spectral boundaries of a work or section, over longer durations: a work can have a highly mobile interior whilst yet being fairly static on a higher level, in the sense that more or less the same spectral range is occupied throughout.

Broadly speaking, alignment, integration, and homogeneity will compromise the independence of threads, since these conditions tend to cause propagation streams to join into a more solid whole. Thus, the above outlined factors of the weave are not only able to indicate aesthetic characteristics of a work, but – relations especially – also represent conditions for the formation of threads and their continued existence.

5.1.1 Focus and Structural Definition

Following the visual thinking that permeates this thesis it seems appropriate to approach the relative structuring of threads through the concept of focus, with the implication that what is deemed *focal* is considered the centre of attention. Focus has a spatial implication, but in music it is also time-dependent: even if we are prompted to pay attention to spatial relationships, our attention needs to be fed with temporal activity to be sustained. Threads often need to evolve somehow in order to take precedence over the surrounding context. Focus also relates to definition, enabling sufficient spectromorphological clarity for distinct presences in our perception.

A high *structural definition* suggests that we are able to probe the weave and distinguish most of its features clearly. What is focal depends on how we prioritise our attention based on the musical context we are faced with. Structural features that have a background role do not necessarily need to be undefined: a distal, blurred feature, for example, could very well draw our attention, perhaps due to its diffuse or mysterious qualities, or due to its perspectival orientation, if it forms a centre in the direction which the listener is facing. A circumspatial weave can present attention-drawing activity behind the listeners, which could possibly have a focal role although it would be outside the visual field. In our visual listening imagination, we are able to see objects although we do not face them. Focal spectromorphologies, then, are isolated so that there is little confusion as to their individuality; they attract attention because of their place in space and their temporal behaviour.

5.1.2 Focal and Peripheral Threads

Focal threads are formed by spectromorphological processes that are integrated enough to be followed, yet sufficiently complex, in relation to their context, to compel listening attention. They are to some degree isolated, and often unaligned with other threads, or else they would not stand out. These threads take a higher role in the structural hierarchy than other more peripheral activity and can perhaps be thought of as being a spectromorphological equivalent to melodic lines, in that they form a continuous path through the weave. A thread can of course contain a melodic line, or be characterised by pitch motion, but this is then situated within the context of spectromorphological factors pertinent to acousmatic music. There is a broad range of factors that may influence the formation of focal threads.

Peripheral threads are less independent and more subordinate to the whole. Even if clearly defined, they are not individual presences in their own focal right – rather, they function as a structural contribution. For example, two threads nonaligned in spectral directionality could serve to open up or narrow the overall spectrum of the weave, although individually they do nothing particularly worthy of focal attention. Peripheral threads often work towards larger-scale growth and transformotion, and when presenting such dynamic behaviour, they can bring about a different kind of causality in events, where the edifice in its entirety may be moving and reshaping without giving us a certain clue about what the key agent, or leading thread, of the process is. Thus, peripheral threads are just as important to the overall architecture as the focal, and as we shall see further on, scenarios are possible where the weave is made up entirely of peripheral threads: nothing stands out much more than anything else, yet an interesting textural space is formed. In such situations it may be the manner in which the overall space warps, due to the gradual motion of threads, that compels our interest. Processes which have a peripheral role in the long run can of course generate spectromorphological events that stand out in focus occasionally. Whilst focal threads lead or subvert the weave, peripheral threads work together, with more restricted purpose.

Regarding focus, we may consider the condition of figure and ground[150], about which Meyer writes the following:

> It is difficult, if not impossible, even to imagine a visual figure without also imagining the more continuous, homogenous ground against which it appears. But in "aural space," in music, there is no given ground; there is no necessary, continuous stimulation, against which all figures must be perceived. The only thing that is continuous in aural experience is unorganized, timeless silence – the absence of any stimulation whatsoever.[151]

Perhaps, however, we might imagine a ground even if it is not literally there – especially if listening visually. Nevertheless, we cannot take the existence and structural role of focus and periphery for granted: the image is alive and its features are modulated in time.

In ex 52**,** what can be considered one of the threads in a section of *Catabolisms* has been extracted from the full mix. It is an accumulation of brief inflating growth processes, which establishes a morphogenic thread where latitudes and strata are introduced and stacked to create a complex relational spatial texture, where textons form more proximate streams, and resonances create more distal regions. The thread forms a peripheral skeleton which punctuates the faster and more focal threads of texton propagations occurring on top. The full mix can be heard in ex 53 (beginning at 2'27" into the work). Also from *Catabolisms*, ex 54 shows a passage, beginning at 9'40", where a focal thread establishes out of filaments at about 0'24", standing out against the resonant background – the morphogenic noise-cascades and the elastic, deforming, texton propagations gradually form a coherent thread leading up to a climactic point.

5.2 Weave Types

Looking at the types of situations that may emerge with different structural manifestations of the weave, and what roles peripheral and focal threads play in these, we can

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150 Kubovy and Van Valkenburg have suggested that 'a perceptual object is that which is susceptible to figure-ground segregation' (2001: 102), and by extension that this also applies to 'auditory objects': 'as in vision, whichever stream is being attended becomes the figure and the other the ground.' (ibid.: 103)

151 Meyer 1956: 186.

approach a classification of *weave types,* describing how textural processes collectively and individually contribute to the overall structure of a work. In this discussion of we may take a view that is similar to the concept of texture in instrumental music, where familiar terms such as monophony, homophony, heterophony, and polyphony come to mind. Rather than referring to voices, however – as in word combinations with the ending *phony* – I shall refer to foci and peripheries, since quasi-visual, spatial saliences, trajectories, and relationships over time are more essential in the acousmatic medium. Figure 20 shows the different types. They indicate different kinds of scenarios: it is often not possible to apply one type to an entire work.

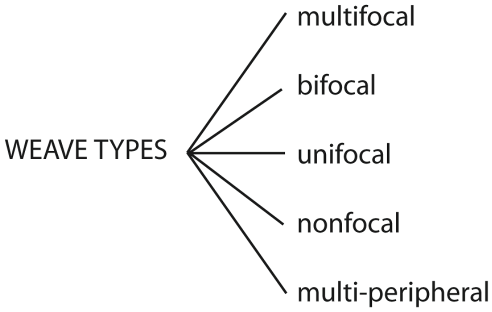

Figure 20. Weave types.

A situation where a single thread is leading the discourse, working against a peripheral texture, or alone, is termed *unifocal*. Essentially, there is one main process at work – one contour of motion, guiding our listening attention. This is context-dependent in that we shall ultimately consider what is happening at a particular moment or timescale in relation to the development of threads over longer durations.

Multifocal weave implies that several focal threads are present and have a similar degree of influence on the overall structure. Such a weave is well-defined, although there may be no definite hierarchy among the processes at work. The threads can be structured in a form of spectromorphological counterpoint, where the temporal structuring of spatially-evolving processes strongly contributes interacting forces to an evolving coherent whole. This could also entail a more fragmented relationship, perhaps featuring zones of activity which all carry some kind of individual, structural distinctness worthy of attention, although they do not directly appear to acknowledge or respond to the existence of other processes. Ultimately, there is always a whole, but such a whole could of course be intentionally disparate: a chaotic, jungle-like scenario, for example, could require a condition of perfected disorder.

In principle, then, we may say that the multifocal weave shares some aspects of counterpoint, the essence of which, in Robert Erickson's words, lies 'in the balance of the lines, at once independent and dependent, forming a larger whole, yet each contributing its perfect wholeness'.[152] Faced with a multifocal weave, we are drawn into the musical interior and the relationships among the threads; we may even sideline global direction and pay attention to the interaction of structures unfolding in the moment – and we feel comfortable doing so because we are engaged and able to trust the form. A weave with two focal threads I term *bifocal*; a typical example is where propagation streams or gestures are behaving in a form of polarised counterpoint in panoramic space.

Nonfocal weave applies to clouds and masses, where the entropy or density is such that we are only or mainly able to perceive a textural totality, with no threads present. It is therefore not only a spatial image without clear centres, but also a condition of temporal flux or fragmentation that prevents threads from establishing: there are no points in the image of much greater value than any other, because they are not developed and emphasised over time. A multifocal weave can easily fragment into a nonfocal weave through entropic processes.

Without focus, placing structural weight on the global rather than the local, is also the *multi-peripheral weave*, which consists largely of peripheral threads as opposed to no threads. While a nonfocal texture is diffuse, the multi-peripheral has definition. Yet the threads do not draw enough attention to be considered central: we notice them, but their detail does not stand out before the whole of the weave. A clearly defined multi-peripheral macro texture can allow peripheries to contribute to transformotion and deformotion.

Ex 55 and ex 56 show two different multifocal passages from *Elemental Chemistry*. In 55, which begins in an entropic state at 0'30" into the piece, filaments in fluctuating propagation counteract one another, and after 30 seconds coincide in resonant gestures. The tails of these gestures also have fluctuations – both in fundamental frequency and in internal spectra – which keeps them unaligned and differentiated. The temporal incidence of gestures to follow is also nonaligned, so that several focal threads are maintained. Propagations of textons are engaged in the counterpoint, creating a dynamic of altering propagation densities and spectral orientations. This example has a high spectral mobility and a degree of instability because of the entropic fluctuations and the altering spectral centres formed by the different gestures.

Ex 56**,** beginning at 8'27", is a less gestural instance of multifocal weave. Spectrally

[152] Erickson 1977: 201.

stratified textonal impulse propagations are differentiated through different speeds of pulsation, and through nonaligned density changes, creating exchanges in the panoramic image. The image is also populated by meandering, fluctuant filaments, and perturbed spectra where, again, both spectral and temporal nonalignment maintains differentiation.

Ex 57 from 2’00” into *Lucent Voids* illustrates a complex weave which has both peripheral and focal threads. The different strata of fluid textures create a multi-peripheral texture. As other textures enter, animal-like sonorities in textonal patterns, resonant gestures, descending filaments, and morphogenic noise morphologies form focal threads which create zones and orbits in the perspectival field. The distinction between foci and peripheries becomes increasingly blurred – listeners will make their own choices.

5.3 Weave as Musical Discourse

Although some of the structural factors outlined in this chapter may evade our awareness in the experience of many pieces, I would argue that the global character of music is highly dependent upon the weave. This is especially true for music where texture has an important role as a forming principle: our expectations as listeners are influenced by the manner in which textural streams work with or against one another. Meyer suggests an explanation of how the mind structures the stimuli of a musical texture and suggests some situations where an incompleteness in texture can cause expectations to arise; thus situations where textural organisation itself becomes a central part of the structure of a work.[153] Although he speaks of instrumental and vocal music some of the ideas are applicable. First, we may establish expectations of recurrence based on changes in textural organisation: ‘a change from one type of textural organisation to another or changes within one genus (homophonic, polyphonic, etc.) will activate expectation of return to previously established modes of organisation’.[154] Thus, we might be encouraged to listen out for the different kinds of relationships represented by the weave types, and appreciate the dynamic of a discourse that undulates, builds suspense, and surprises us on the bases of degrees of textural complexity. Second, ‘abnormally wide distances between parts of the

[153] Meyer 1956: 188–90.

[154] Meyer 1956: 188.

textural field' may create the expectation that the structural gap is to be filled somehow: 'whether the field is organized into equally well-articulated figures or into a figure-ground distribution, the several parts of the texture may be so widely separated in musical space that they are expected to come together or be "filled in" by other stimuli'.[155] This is a matter of structured expectations based on the temporal evolution of spectral space. Third, Meyer suggests that incompleteness can arise due to uniformity: if musical material appears to form a background before which no foreground is present, then we will expect something with a more focal role to emerge. A multi-peripheral or nonfocal weave potentially raises such expectations in acousmatic music, where homogenous mass-textures are commonplace. The weave offers an enhanced understanding of how textural structuring and articulation can generate musical discourse.

Finally, we must acknowledge that timescale is very important in the weave – focal threads, for example, can take longer durations to be established, through the emergence of connected events and processes.

5.3.1 Weaving Incompleteness in *Lucent Voids*

In the opening of *Lucent Voids* – ex 58 – expectations are formed by the ambiguities of an incomplete, multiperipheral weave, where very different textures are creating spatial relationships without drawing significant focal attention.

The bass and the high, stratified noise texture of the opening outline the peripheries of a spectral void. More mid-range-oriented, resonant textures subtly emerge after about 0'23", creating a distal periphery in the front. At 0'45", a deforming impulse texture enters from the higher stratum, orienting itself into the centre regions of the perspectival field, and establishing a web in front of the distal activity. Reverberant croaky iterations emerge in the frontal distance at 0'55", suggesting an ambiguous acoustic interior. A network of largely peripheral threads – both spectral and perspectival – has been established, and they create an impression that much of the suggested space remains empty.

After 1'10" a higher stratified cloud of noise enters, while the rest of the image clears up:

[155] Meyer 1956: 189.

some lower-mid region resonances, and the distant croaky texture constitute the peripheries of a new void. After the distal texture is punctuated with a reverberated thud at 1’27”, immersive space and spectral space are suddenly filled by a cascade of fluid textures, propelling the piece forward with gently turbulent activity.

In this except, relational spatiality is what gives the music its character: the spatial gaps suggested by the textural contrasts may trigger our speculations about what this environment could have in store. The centre of spectral space largely remains vacant throughout, and no distinct foreground activity is present. Thus, the longer-duration discourse of this work has plenty of time to establish since there is space available for events to take place.

Incomplete spaces form one of the significant aspects of structure in *Lucent Voids*, and are established through spatial and material differentiation, isolating textures through temporal, spectral, growth-oriented and perturbational nonalignment, and through spatial and material multiplicity creating a heterogeneous weave.

5.3.2 Global Discourse of Threads in *Elemental Chemistry*

Elemental Chemistry is largely multifocal on a local level, but also establishes a multifocal discourse over its full duration. Three global threads can be distinguished. First, a main focal thread is made up of the fluctuant harmonic filaments and gestures, which also approach more inharmonic states towards the end of the work. Second, impulse-based textures form a thread which alters between focal and peripheral roles, which has two sub-types: resonant impulses which establish a sonic link with the first thread, and pure, dry, noise impulses which have a closer relation to the more source-bonded textures, in that they may suggest, for example, waves and vaporous atmospheres when densified. Third, there is a mostly peripheral thread of environmental textures, partly derived from field recordings, including water textures, insect sounds and forest environments. These threads each reach separate exhaustive stages at different points, whilst simultaneously collaborating to shape the work. Although one needs to hear the full duration of the work to appreciate the accumulation of the threads, the examples given here highlight important moments.

The first thread reaches its final statement in the section between 8’45” and 9’55”, where the fluctuant, resonant spectromorphologies are carried along by wave-like, noisy textures. This is the last we hear of this material, and the point where interaction on a gestural timescale is the most active. Ex 59 shows this part. Following this, resonant impulses come into the foreground as they are engaged in their final build-up of tension, in rhythmic phasic motion, which is released in a climax at 10’43”, where bass enters and results in an expansion of spatial magnitude. Ex 60 begins at 10’10” and leads to the larger spaces at 11’20” – the climax occurs at 0’34”.

The following section opens the largest spectral space of the piece, and also has the greatest impression of perspectival scale. It is the setting for the culmination of the more source-bonded environments, where cicada-chirps are transformed into frog-like utterances, as they descend in spectral space. Crickets come into the foreground for the last time as they are engaged in an accumulation of tension similar to that of the resonant impulses. A loosely rhythmic, spectral texture is formed between 11’53” and 12’52”. This process is completed in the final accumulation of impulses: the characteristic swelling densification processes that counterpoint the resonant gestures throughout the work here comes to a punctuation in the form of an opaque, vaporous, cloud of noise, which eventually dissipates in the most primitive textons. Ex 61 is an excerpt from 11’53” to 13’08 – the cicadas/frogs are left behind by this stage, but the crickets are present.

The three threads also meet and mix in a contextual blending at different points throughout the work, for example, between 4’15” and 5’59”, where the impulses open with a vaporous state which is suited to the emerging forest-like environment, and the synthesised material becomes cricket-like sounds and mosquito imitations. Here, the environmental thread comes into focus. Ex 62 is taken from 4’15” to 5’25”.

This kind of global discourse among threads thus creates a polyvalent form, nurturing the music with a chemistry of different relationships, and results in a succession of culminations which emphasise different aspects of spatial texture.

5.4. Summary

Topological threads are formed by texture motion and linked morphogenic processes. They form a weave, whose structural conditions are described as *relations*, *terminals*, *spectral contours*, and *spectral mobility*. Further, threads can be divided into *focal* and *peripheral* types, where the former have a more leading role and the latter, a more supportive function. A set of *weave types* describes different structural relationships among peripheral and focal threads, and how a form of counterpoint can be established in processes of spatial texture.

6. TEXTURAL TERRAIN

Motion, critical forming processes, and the varying relations among foci and peripheries, result in a shaping of space, where boundaries, distances, vertical altitudes, and perspectival fields outline a textural landscape. Though certainly this landscape is transient and in motion, we are able to perceive the spatial, structural elements, through which it is shaped, and through which we are able to get a sense of its magnitude. Textural *terrain* is introduced here as a view of macro-space, which comprises structural elements essential to the spatiality of a work: a form of land relief of spectral verticality in the perspectival field. Strata, densities, motion and growth, qualitative states and phases – particularly textures in fluid, gaseous, or vaporous quality – accumulate to form a comprehensive sonic geo-morphology. Thus, we get a sense of what substances or entities an acousmatic world consists of. But *terrain*, here, does not necessarily imply an obvious reference to nature – we are also interested in the shapes of space in a more abstract sense, and how they are formed by textures in motion. No restrictions are made concerning sound materials.

Terrain can incorporate different styles in which higher-level topological connections unfold: for example, a terrain seemingly formed in real time by continuous processes, or conversely, one that is being presented, or perhaps built, part by part, by the intervening composer-architect. In reality, many terrain-related processes, such as erosion, or growth and spread of vegetation, happen on a timescale which only allows us to experience incremental results, but not real-time change. The re-contextualisation of space and time possible in acousmatic music can, nevertheless, guide our imagination towards phenomena on such scales, and even further, towards spatial structures which, in reality are not perceivable without technological aid, such as microscopic chemical reactions or nebular formations. An aesthetic where the shaping and the warping of spatiotemporal magnitudes seem to occur within textural processes is different from one where the terrain is presented in a more discrete fashion. The unfolding terrain is therefore an important factor of coherence and structure in a work. It affects our impression of the 'metaphysics' of the music – whether we feel that we are travelling through a landscape which was already there, or whether we feel that it is being formed around us while we hear it, by natural, human, or technological forces. Thus, the topological axis of time holds important clues to the implied causalities behind acousmatic music.

Marrying the real-time experience of unfolding spaces and environments on a regional level – whilst absorbed within the continuum of a work – with the condensed mental image of the music on a larger time scale, terrain can be thought of as a reflective, aerial map of the essential textural formations, the spectral contours, and perspectival expanses. The manner in which these are traversed throughout the journey of the work becomes, in itself, a spatial structure. Thus, it is an image generated while we perceive it, but fulfilled as we have heard a section or piece in completion. In works where space-form is delineated in more discrete temporal sections, different views of terrain, which feel complete, might be manifest inside. There is usually also an accumulation taking place over longer durations, where different viewpoints, changes and ruptures generate a total terrain.[156]

6.1 Objective Space

Terrain takes shape as spectral articulation in the perspectival field, and through source-bonded spatiality. But the global diagnosis of spatial relations, through which we are able to approximate what the entire acousmatic landscape might 'look like' – if we could take an aerial view, or alter our own position in space – also involves a process similar to what Husserl described as perceiving with the 'natural' or 'empirical' attitude[157]. This results in, amongst other things, the awareness of what he termed 'objective' space:

> Each I finds itself as a middle point, so to speak a zero-point of a system of coordinates, in reference to which the I considers, arranges, and cognizes all the things of the world, the already known or the unknown. But each I apprehends this middle point as something relative. For example, the I changes bodily its place in space, and while it continues to say "here" it knows that "here" in each case is spatially different. Each I distinguishes objective space as a system of objective spatial locations (places) from the phenomenon of space as the kind of space that appears with "here and there," "in front and in back," "right and left."[158]

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[156] The discussion of the temporal aspect of terrain continues in chapter 7.

[157] Husserl 2006: 1-21.

[158] ibid.: 6-7

Alva Noë makes a similar point regarding perspective and its role in perception:

> Perceptual content has a dual aspect. There's the way experience presents the world as being, as it were apart from your perspective. This is one aspect of its content. And there is *the way* the world is presented in experience, a way that always incorporates some reference to how things look or sound or feel from your vantage point.[159]

We can perceive both the perspectival shape and the actual shape of an object at once, and this is relevant not only to how composed perspectives in the acousmatic experience accumulate phenomenologically, but also to how these relate to conditions within which the music is situated. The perspectival and spectral impressions accumulated during the course of listening are influenced by the awareness of a context incorporating the symmetries and acoustics of the architectural space in which the performance takes place, the symmetries and extent of the loudspeaker system, and the relation of this to the listener's own location within the space. We can infer aspects of spatiality which are influenced by circumstances of presentation. Certainly, these considerations come in addition to prior experiences, including different pieces heard in the same space, and knowledge of repertory; the spatial idioms of acousmatic music influence the expectations and perceptions of centres, peripheries, biases and uniformity within texture. In Smalley's writing, 'containment and transcendence' are described as two different conditions the acousmatic spatial image may have in relation to the physical space in which a work is heard[160] – containment referring to spaces that are perceived as nested within the physical listening space, as opposed to spaces which seem to transcend the listening space, and subvert those boundaries.

The terrain is thus influenced by the listener's empirical diagnosis of *objective space*, and what the possibilities and limitations of the present physical, acoustic, architectural and technical conditions are. If these aspects are successfully managed in performance, the interaction between physical context and phenomenal space can aid the music. For example, I often find that spaces with high ceilings and deep frontal longitude positively influences the sense of vertical and perspectival extension in the music, because of how the visual context amalgamates with the sounding terrain – ample physical space is allowed for the terrain to be cultivated. But smaller

[159] Noë 2004: 163.

[160] Smalley 2007: 53.

rooms can also add to the impact of greater magnitudes suggested in the music, in the impression of spatially transcending reality.

A quasi-geographic assessment of the textural landscape is thus facilitated, where the underlying dimensions of spectral verticality and the perspectival field – latitude and longitude, altitude and depth – emerge as textures create and populate a terrain.

6.2 Structural Features and Schemas of Terrain

The structural forces of the terrain interact in deformotion, transformotion, and morphogenesis, and in the balancing of the spatial environment through time. Certain features may be the primary forces propelling the piece forward, instigating changes and transitions. But this balancing is not only temporal: when simultaneously present, the elements also structure space at any instance.

In this outline of terrain structures, a distinction is made between spectral and perspectival elements. Importantly, however, this distinction is to be regarded as applying to the primary aspect of spatiality to which they are relevant. Thus, many of the spectral features rely on perspectival distributions, and vice versa. Together they form an inclusive terrain. The distinction between *instantaneous* and *evolutive* structures, made in relation to distributions in chapter two, is important here as well. Terrain has an inherent evolutive dimension in how spatial forces are balanced over time, yet many of its spatial images have instantaneous features.

The features suggested here are based on spatial structures that I have found relevant in composition and listening. However, I see no reason to exclude the possibility of others that are not identified here. In any case, the foremost relevance of the elements is their conceptual illustration of terrain as a principle of textural structure and form. We shall also look at some schemas that relate to how we understand terrain in the course of a work.

6.2.1 Spectral Features

Spine – An evolutive path tracing the spectral journey throughout a work or passage. The spine is formed by consideration of the listener's implied vertical position and orientation of attention. Thus, the spectral centre combines our sense of vertical disposition in the terrain and the spectral direction in which we "see" the terrain unfold. For example, in a given passage we might feel suspended in high altitude, but experience a gradual accumulation of activity below us, towards which we may feel that we are attracted, as it becomes the centre of activity.

Apex – A highest point of altitude in the spectral verticality. The role of the apex depends on its relationship with other elements in the overall texture of a passage; for example, it can be the leading force carrying the motion of texture forward, but it could also function as a summit resting upon other features of the spectral texture. An apex can be found within a passage, or if relevant, the apex of a whole work could be identified. In the absence of an apex, spectral space may appear open rather than closed, since it has no finite upper terminal.

Base – A textural grounding of spectral verticality, creating a finite depth. The base counterbalances the apex, or provides a ground upon which other activity in spectral space rests. In order for full grounding to take place, the base should be spread in perspectival space so that its magnitude, in comparison with activity above it, is greater.

Ridge – A spectral arc ascending towards an apex and then descending: a connective phase between different passages, forming part of the spine.

Trench – A low dip in the spectral spine, which can have an impression of indefinite vertical depth in spectral space, created by bass-oriented textures which have no clear fundamental pitch, or which have unstable internal spectral motion.

Void – A structural gap in spectral space – this is an instantaneous feature, relying on simultaneous delineation of higher and lower limits of spectral space.

Strata/Clouds– Horizontal, spectral layers, concurrent with stratified distributions. Clouds are spectrally wider than strata.

Canopy – A high-altitude texture which appears to be above the listener, and forms a finite ceiling. A canopy can also be a stratum, but the essential structural role is different.

Slope/Precipice – An ascending or descending spectral contour. Although slopes in most cases are evolutive, instantaneous slopes can occur in the perspectival field, for example, if rear longitude is oriented towards the base and the front longitude towards the apex. A *precipice* is a sloping feature with a higher velocity and more drastic curve, such as a drop towards textural base, or a rapid elevation towards higher altitude.

Cataract – A cascading morphogenic process whereby texture accumulates into a dense deluge, falling from the higher altitudes of spectral space. Cataracts also take on a blocking function similar to perspectival *gauzes* (see 6.2.2).

Spheroid – A spectral 'ball of noise'.

Entropic Figure – An animated elastic topology creating an irregular, flexible entity. It is perspectival in the sense that it has an image-structural presence, but its motion and contours are spectral.

6.2.2 Perspectival Features

Projective Space – The outwards extension of areas in perspectival space through resonant texture, giving an impression of infinity. Such resonant texture in prospective space can, for example, convey an infinite longitude.

Gauze – A translucent veil in front of other activity, resulting from a degree of density in spectral texture and a contiguous spread in perspectival space.

Wall – A boundary in perspectival space, which gives the impression that the space in a given direction is finite. Walls have a vertical dimension, enabled by the width of spectral distribution. Further, there is a high spectral density which blocks the view in the relevant direction.

Concavity – An indentation in perspectival space, where centred areas of spectral texture seem to be more distal than peripheral areas. This can be articulated through deformotion processes extending longitude.

Convexity – The bulging of texture into proximate space and towards central circumspace. Concavities and convexities are phenomena which can appear in opposition within textural motion, where one is often dependent on the other.

Ring – An impression of full circularity created through peripheral distributions in circumspace.

Oval/Elongated Space – An impression that the extension of circumspace is greater in longitude than in latitude, or vice versa.

Zone – A distinguishable region of activity in the perspectival field.

Immersive space[161] – Smalley's term is applied here to situations where circumspace is spectrally filled, creating an environment which is densely populated by textural activity.

Field – the extension of perspective in any given situation. A field can extend and connect, for example, proximate and distal features, instantaneously, but it can also stretch or diminish over time as evolutive structures. A field may include zones. Fields may not be present in very dense immersive spaces, as our 'view' is limited.

6.2.3 Structural Schemas

We assess structural features in relation to our presence in the listening space, and thus understand what we perceive spatially through physical schemas. These function as spatial concepts by which we make sense of structures. Latitude, longitude, altitude and depth form basic dimensional schemas; interior and exterior spatiality schemas have been discussed already. Among the additional ones given below, some are freely adopted from Mark Johnson's writing on the embodied basis of meaning, thinking, and imagination.[162]

Balance - Johnson identifies several different manifestations of balance, such as systemic balance or psychological balance.[163] A balanced spatial image has a lateral symmetry and usually a clear frontal orientation, making us feel that we are facing in the right direction. Any

[161] 'The filling of spectral and perspectival space in circumspace so that the listener feels immersed in the image' (Smalley 2007: 55).

[162] Johnson 1987.

[163] Ibid.: 85-96

processes that subvert such expectations of symmetry may create new expectations of completion or compensation; expectations of restoring balance.

Path - This is to do with the sense of orientation towards and away from points along a path. Such paths are not only established instantaneously in the terrain, but often also manifest as a sense of time-orientation created by the discourse of the music. Thus path schemas can have extended relevance to music that has a kind of journey-form.

Cycle - Cyclical processes can be manifest in the return of material over the course of a work, with the completion of processes and climaxes, and with oscillations of dynamics and densities over longer timescales.

Proximity-distance – Relating to scale, this schema refers to the separation between near and far and is an aspect of spatial differentiation that emerges due to the relations among textures.

Vanishing point – Essential to our conception of perspective, the convergence of space as it recedes into the distance is an expected perceptual structure. Such an image can be present in the simultaneous layout of elements in the terrain, or emphasised through receding motion combined with ascending or descending spectral directionality. The end of *Lucent Voids* has an ascending-receding evolutive vanishing point.

Centre-periphery – Centre and periphery relate to ego-centres and objective spatial centres, and to the outskirts of the image in prospective space or circumspace, where horizons emerge. Spectral centres and peripheries are also often present. This is also relevant to weave types and how focal points of attention and extended backgrounds are presented.

We can say that the structural schemas connect and appraise the structural features; balance can be a question of spectral relationships in panoramic and lateral space; path can be to do with following and connecting spectral features, for example moving across ridges, or with the logic of moving from one space into another; cycles can be manifest, not only in recurrences among materials, but also in the deeper undulations of crescendi and densities that may underlie a work on longer timescales; proximity-distance relationships lie in textural contrasts accentuating the simultaneous existence of scalar features in textures; vanishing points can centre and deepen the image, or develop projective spaces; centre-periphery can present figure and ground relationships among defined features against projective backgrounds, or to the role of spectral voids and their implications.

6.2.4 Spine in *Cataract*

The form of *Cataract* can be viewed as trajectory in which sections often appear to have different vertical elevations, and where transformotion processes often have a vertical directionality. Returning to ex 50, we can hear how spectral features interact to form a spine in the final section of *Cataract*. In the beginning our attention may be fairly unbiased as a spectrally rather broad range of textures is present, from the low-mid drone to the higher-altitude canopy of textons. At 0’16” a descending glissando forms a more centred presence, guiding our listening attention towards lower altitudes, whilst simultaneously a base is introduced in the lower regions of the spectral verticality. When the cascading texture enters at 0’33” our descending process stops, whilst the base continues to subtly descend and fade. At this point, no clear apex is present. The ascending process beginning at 0’44” then takes us up to a higher altitude, leaving the base behind in the depths.

Looking at the whole passage, we can say that a spectral journey is taking place, where we as listeners have a form of attention-location within the spectral verticality. This forms the spine of the passage, which can be summarised as a descent-plane-ascent contour.

6.3 Scale and Magnitude

> Life has a range of magnitude narrow indeed compared to that with which physical science deals; but it is wide enough to include three such discrepant conditions as those in which a man, an insect and a bacillus have their being and play their several roles. Man is ruled by gravitation, and rests upon mother earth. A water-beetle finds the surface of a pool a matter of life and death, a perilous entanglement or an indispensable support. In a third world, where the bacillus lives, gravitation is forgotten ... The predominant factors are no longer those of our scale; we have come to the edge of a world of which we have no experience, and where all our preconceptions must be recast.[164]

Scale and *magnitude* can be added to the structural schemas, but require a separate discussion. They are an important aspect of both simultaneous relationships and change in

[164] Thompson 1961: 48.

spatiality throughout a piece. Here, latitude, longitude and spectral verticality are the primary factors, the extent of which are delineated by terrain features. Scale includes the relationships of suggested sizes among spectromorphologies in the terrain, whereas magnitude is to do with the holistic size of space itself. Magnitude is assessed as a measure of *extent*.

Longitudinal extent is the total distance running from distal, or projective space, towards the rear-most areas of circumspace. Longitude can be assessed in terms of *distal* or *projective extent*, and *rear extent* or *boundary*. Listeners have poor perceptual means of determining the character of rear space with detail; nevertheless, extent is an impression that the sounding space behind is open, while boundary denotes that there is proximate textural activity in these areas, due to which their extent is limited.

Latitudinal extent applies to the lateral landscape, including the width of prospective space, lateral space, and areas of circumspace. *Volume* or *extent* in circumspace are circumspectral, and often dependent on proximity or distance imparted by textonal or filament resonant material in texture.

If an open landscape is present, then circumspatial magnitude is a matter of extent, but if an enclosed space is implied in texture – especially in resonant spectral texture – it has *volume*. Magnitude in perspectival space is accentuated by the instantaneous or evolutive relationships between proximate and distal textural material: such relational percepts are vital for serious exploration of volume, extent and boundaries.

Vertical extent in spectral space is the summary of *altitude* and *depth*. Spectral magnitude can be instantaneous if textures are simultaneously present in different regions of spectral space, but in other cases evolutive magnitudes can be manifest in the spine over the course of a work or section, while, at a given moment, only limited regions have textural presence. Further, the spectrum influences perspectival and source-bonded impressions of magnitude: bass often coincides with the impression of larger sounding events at work, but also with distances and the extending of peripheries. Higher-frequency textural material seems lighter and smaller, but also acquires a more proximate role in the image.

Magnification is often related to situations where the materiality of texture suggests that we are perceiving something that we in physical reality, without technical means of magnification, would be unable to perceive in detail. Essential here is listeners' bodily experience of textural materiality and spatiality.

Magnitude and scale are not only a matter of dimensions, but are also influenced by timescale: growth occurring over longer durations, for instance, often evoke processes on larger and more universal spatial magnitudes; shorter durations may allude to smaller sizes, perhaps nested in larger-scale contexts.

6.4 Terrain in *Lucent Voids*

I summarise this chapter with a listening example. The forest-like section in *Lucent Voids*, roughly between 12’37” and 15’06”, is suitable for illustrating the concept of terrain. Over the course of this section one can hear how a place is being created, and although textures are in constant motion, the temporal dimension serves primarily to sculpt the terrain, by moulding new features out of the textural continuum; above all, it is the space that is being created that is important to the experience.

If we consider the accumulated image of the whole passage, one of the key structural axes of this space is the longitudinal path which reaches from the centre of the perspectival field towards the distal front. Its vanishing point is at a lower spectral plane than the perspectival centre, creating an instantaneous, spectrally descending trajectory towards the distal features.

The longitudinal path is framed by latitudinal dimensions established by bird twitters and fluctuant resonant morphologies appearing intermittently on the sides. Zones in the rear also appear in textonal textures, which balance the otherwise front-oriented longitude.

The passage can be heard in ex 63, and a score of cues is given in figure 20 (p. 128). The space is undergoing its initial elaboration during the first 1’00” of the excerpt. The perspectival field is gradually filled by a watery texture which spreads towards the rear after 0’09”. Twitters and other forest-oriented animal-like sounds, and fluctuant resonant spectromorphologies appear in the front and on the sides; some more distal bird sounds also appear in the front – these may not draw attention, but still adds to the spatial experience as a whole.

A peripheral, grainy texture inflates the space with an ascending motion at 0’50”, adding to the sense of magnitude, whilst also extending spectral space towards higher altitudes, and to lower depths by introducing some bass.

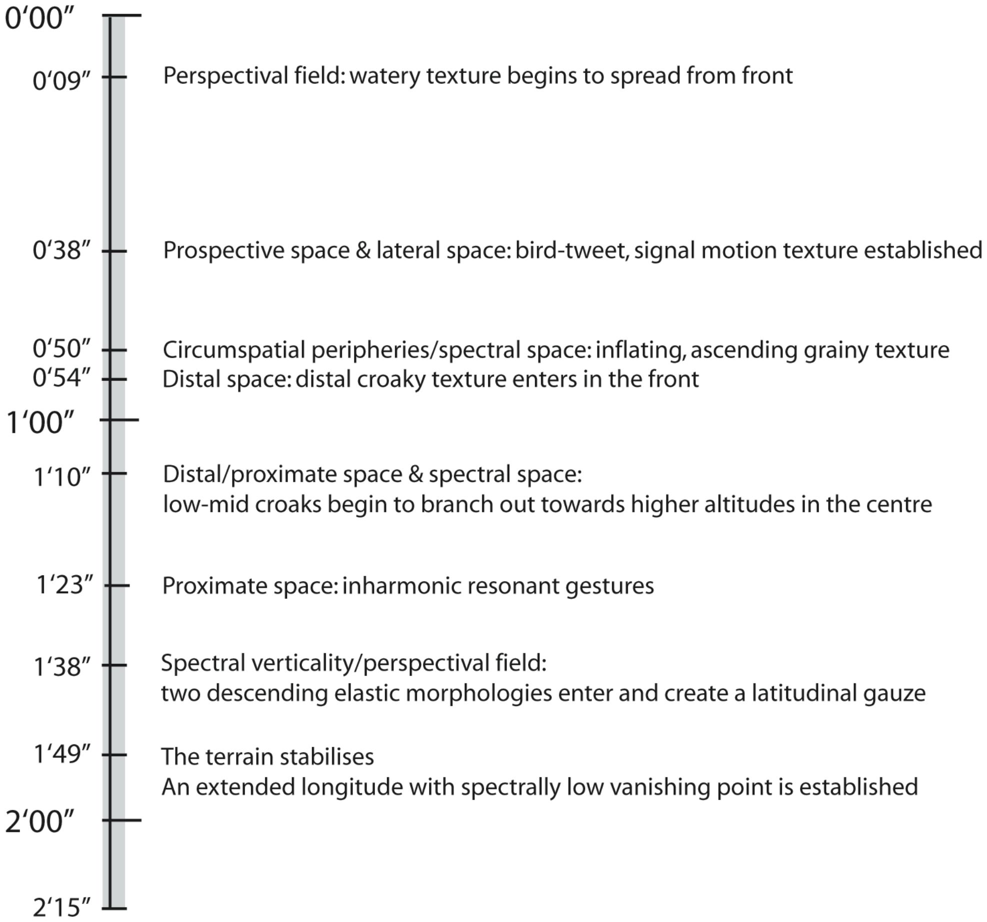

Figure 20: Cues for ex 63 from *Lucent Voids* at 12’37”–14’52”.

It is after this, at 0’54”, that the longitude begins to emerge with the croaky reverberant texture and the frog-like utterances in the front, later branching out into twitters reaching the centre of the perspectival field. The full longitude and the overall layout of textures in the terrain are established at about 1’49”. We are situated in a forest interior, which in itself has a contrast between a more reverberant distant vanishing point and a drier proximate space; we are inside and outside at once.

Over the course of this passage, the music has gone through a process of twisting itself into shape, as if the topology was always there, although it needed to be sculpted in order to form a coherent spatial arena. Change and permanence coexists: the terrain is deforming throughout, yet it also maintains its character as a place.

7. TOWARDS A TOPOLOGY OF EMBODIED SPACE-TIME

> It is a succession of states each one of which announces what follows and contains what precedes. Strictly speaking they do not constitute multiple states until I have already got beyond them, and turn around to observe their trail.[165]

Bergson's words, I find, describe well how space and time meet in the experience of the terrain. A spatialisation of time happens on at least two levels: in the present, time is often immediately absorbed into a spatial experience, as we often do not consciously reflect on its passing; but on a higher level, time also acquires a spatial dimension in the memory of what we have experienced. As Smalley writes, in space-form-oriented music, time is largely a means to articulate space:

> I can collapse the whole experience into a present moment, and that is largely how it rests in my memory. The temporal disposition of, and relations among, sounds serve to articulate and shape spectral and perspectival space, but even though my perception of sound is the product of time, I ultimately sideline time's formative role. So space can be more significant than time, or at least we can profit by starting with the idea that time can be placed at the service of space rather than the reverse. Time becomes space.[166]

In most pieces, however, the above happens in multiple stages; extended passages are collapsed into spatial moments or images, but transitions also become spatial features in themselves. This contributes to the formation of a topology in the terrain of an acousmatic work – a logic of connections, where spaces, states, transitions, are beaded into a spatial thread of time, perhaps analogous to Bergson's metaphor of time as a colour spectrum[167] 'with imperceptible gradations leading from one shade to another'.[168] Motion and the spatial layout of the terrain amalgamates with the experience of temporality in spatial texture; the experience of space in the present combines with images in memory, and with future predictions.

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[165] Bergson 1992: 163.

[166] Smalley 2007: 37.

[167] Ironically, this is one of the metaphors Bergson examines in order to explain the concept of *duration* – a form of pure, non-spatial, time experience for which, as far as I am aware, he never found an adequate metaphor, presumably because there is none. To him, this metaphor has a flaw in its relevance to *duration*, since, although it expresses the unique coloration of each moment, it also evokes a spatial succession of states (Bergson 1992: 164–6) – but that is precisely why it applies to my thinking. For more on Bergson's view on time and space, see Deleuze (1966).

[168] Bergson 1992: 164.

We can consolidate the concepts of instantaneous and evolutive spatial structures with two modes of real time interacting in the unfolding of textural terrain. *Transparent time* is associated with an experience where we are primarily engaged in the exploration of terrain as a 'place', as if in a suspended present. We cannot easily quantify time passing, and our attention is drawn to spectral and perspectival relationships among features that appear to have a more permanent presence in the currently inhabited space.[169] Time is transparent because it is not primarily engaged in evolutive processes of shape-building, but rather, seems to disappear altogether.

Evolutive time, in contrast, is associated particularly with morphogenesis – where events form a more conspicuous imprint on memory – and with transformotion and entropic processes, where larger scale transitions take place. Evolutive time creates time-dependent spatial contours. This type of time ultimately reaches beyond real time and can encapsulate durations of transparent time, when, for example, spatial environments are transformed or terminated. As evolutive time extends into memory, sequences and networks of spaces and events become an extended terrain. One dimension of this landscape is often a spatial metaphor for time, where time acquires orientation and a moving relationship with the listener.

7.1 Spatial Metaphors for Time

In their book, *Philosophy in the Flesh,* George Lakoff and Mark Johnson offer a demonstration of how our conceptualisation of time is based on embodied experience.[170] They maintain that apart from measuring time according to iterative events, such as clocks, musical tempi, or other experienced recurrences, we also have an internal clock, where 'the sense of time in us is created by such internal regular, iterative events as neural firings'[171], regulating our body's rhythms. Further to this, although literal time cannot be experienced in itself, it is represented by the succession and comparison of events as metonyms of time passing.

[169] Transparent time can be related to Jonathan Kramer's vertical time, which represents 'a potentially infinite "now" that nonetheless feels like an instant', and where 'whatever structure is in the music exists between simultaneous layers of sound, not between successive gestures' (1988: 55). In the present context, I can imagine other ways of using the term *vertical time*, but will not develop that.

[170] Lakoff and Johnson 1999: 130-169.

[171] Ibid.: 138.

> This does not mean that we do not have an experience of time. Quite the reverse. What it means is that our real experience of time is always relative to our real experience of events. It also means that our experience of time is dependent on our embodied conceptualization of time in terms of events. This is a major point: Experience does not always come prior to conceptualization, because conceptualization itself is embodied. Further, it means that our experience of time is grounded in other experiences, the experiences of events.[172]

Beyond metonymy, however, a metaphorisation also happens, from which our conceptual and linguistic dealing with time is derived. Lakoff and Johnson suggest two main *conceptual metaphors*[173], based on bodily experience of motion, which are both linked to a *time orientation metaphor*, where the location of the observer represents the present, the space in front of the observer, the future, and the space behind the observer, the past.

First, the *moving time metaphor* represents time as objects passing us, the motion of which in turn represents the passing of time. Suggested linguistic examples of how we use this metaphor include 'the deadline is *approaching*', 'the time is long *gone*', and 'time is *flying by*'[174]. In a variation of this, time is represented as a substance, the amount of which represents duration, and the flow of which, past the observer, represents the passing of time.

Second, in the *moving observer metaphor,* or *ego-moving metaphor,* times are represented as extended locations along a spatial landscape: 'there is going to be trouble *down the road*. Will you be staying a *long* time or a *short* time? What will be the *length* of his visit? ... He left *at* 10 o'clock'.[175] The use of spatial schemas in the mental conceptualisation of time has been evidenced by Boroditsky and colleagues,[176] whose experiments have suggested that an asymmetrical relationship between space and time operates in our embodied understanding of the

[172] Lakoff and Johnson 1999: 139.

[173] In Johnson's words, "the idea behind conceptual metaphor theory is that our abstract concepts are typically defined by multiple, often inconsistent conceptual metaphors. Each conceptual metaphor consists of a systematic mapping of entities and relations from a sensorimotor source domain to a target domain that is abstract. For example, in English we have multiple metaphors for conceptualizing the act of intellectual understanding. The dominant metaphor is UNDERSTANDING IS SEEING, in which elements of the source domain (vision) are mapped onto the target domain (intellectual understanding)." (Johnson 2007: 165)

[174] Lakoff and Johnson 1999: 143.

[175] Ibid.: 146.

[176] Boroditsky 2000; Boroditsky and Ramscar 2002; and Casasanto and Boroditsky 2008.

world: space is often used to conceptualise time – not only in language, but also in non-linguistic judgements – but the reverse is less common.[177]

Essential here is that our experiential understanding of physical motion is projected, or mapped, onto our conception of time. In *The Meaning of the Body*, Johnson further asserts the relevance of these conceptual metaphors as experience-based:

> The metaphor is not merely a linguistic entity – a collection of words only. The cross-domain mapping is based on experienced correlations of motion and temporal flow (and not on any supposed after-the-fact similarities between spatial motion and temporal flow). The mapping constitutes our conceptual understanding and guides our reasoning about time. And the mapping is, in turn, the basis for the language we use to talk about time. Here is as clear a case as one can find of meaning and concepts being grounded in the qualities and structures of bodily experience.[178]

Building on these manifestations of spatial time, Johnson further suggests some metaphors where musical motion and time are represented spatially. First, we can recall Johnson's three fundamental experiential principles underlying our learnt knowledge about motion, already referred to in chapter 4: (1) our perception of objects moving, (2) the movement of our own bodies, and (3) our felt awareness of our bodies being moved by forces.[179] These are combined with the time-orientation metaphor. Thus, in the *moving music metaphor*, musical events are represented as objects in motion, passing the observer, whereas in the *musical landscape metaphor* the observer is journeying along a spatial path. And, in the *music as moving force metaphor,* motion is represented by physical forces, moving and carrying the observer through emotional states along a spatial orientation.[180] Of course, a spatial musical landscape can exist regardless of whether one is journeying or not. In this discussion, however, Johnson is referring to the motion of time in cases where such a journey can be traced.

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177 The experiments investigated how people respond to ambiguous questions such as 'next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?'. Participants would answer either Friday or Monday with consistent dependence on how they had been primed with spatial images and statements in ego-moving or object-moving perspectives (Boroditsky 2008). People would also adopt different metaphors depending on whether they were in the beginning of a train journey or lunch line (taking the object-moving perspective), or approaching the destination, or end of the line (adopting the ego-moving perspective) (Boroditsky and Ramscar 2002).

178 Johnson 2007: 31.

179 Ibid.: 247.

180 Ibid.: 248–54.

7.2 Motion of Sound and Motion of Time

Following the discussion of motion in chapter 4, I would contend that the principles of experienced motion are embodied *before* the time-orientation conceptualisation enters the picture. Johnson seems to suggest that musical motion is immediately conceptualised with the time orientation metaphor, and further, he does not quite explain what a musical event is. In the context of acousmatic listening, we need to be careful in clarifying the processes through which time becomes spatial, and how the motion conceptualisation associated with it works. It is obvious that motion in spectral verticality (including motion of pitch) and perspectival field is perceived as such first and foremost – with its inherent directionality and metaphorical associations – and thus cannot immediately be conceptualised by time-orientation metaphors spatialising events in front of and behind an observer. Our embodied spatial conceptualisation and experience of physical motion in music happens on one level first, as we have seen in chapter 4. It is after this, in the awareness of events having occurred, and in the expectation of events to come, that the time-space metaphors become relevant.

Thus, my view is that aspects of motion, deformotion, transformotion, morphogenesis and terrain, are first perceived in their own right, in instantaneous or evolutive time. Beyond this, a higher-level spatial time orientation is formed only when such motion congeals into events, leaves the present like conglobulated matter floating off into memory, and we find ourselves in the bigger picture of past, present, and future. The motion and formation of sounds and spaces then becomes an elastic, metonymical clock, and their order and relationships generate a metaphorical geography, essential to the mental visualisation of the terrain.

7.3 Formation of Events

The temporal parsing of the spatial terrain can be considered in relation to what Kendall refers to as the 'event schema'[181], which manifests in our understanding of time passing due to our ability not only to segment sounds in the auditory scene, but also to comprehend their

[181] Kendall 2008, 2010a.

energetic profile through embodied cognition. In Kendall's explanation, such events can be of short durations of seconds or less than seconds, but also larger-scale processes expanding over several minutes, where the mind may be grouping extended sequences of smaller events into larger chunks of time.[182] Kendall's model for the event schema features dynamic and static phases through which we understand the beginning, continuation and end of events.

Although in the present context we are discussing spatial processes which do not necessarily have clear beginnings and ends, it seems fair to suggest that somehow we still do our best to group such experiences into temporal sections, even if often we do not know *what* such a section might be distinguished by until we notice that it is over and has been replaced with something else. In the unfolding of the spatial terrain of a work, lower-level morphogenic processes would constitute events in a rather clear sense, often on a shorter timescale; likewise transformotion could allow us to perceive events in the form of transitions. Spaces that last over longer durations can be more elusive, however: we do not necessarily remember how we entered them, and we may not easily perceive their disappearance until moments afterwards, if a complex of overlapping processes is taking place. Notwithstanding, we can often remember the image of a section as a segment in the temporal flux, and often also its order in relation to other parts of a work.[183] Trying to grasp the topological connection of temporal segments in a work is part of what is compelling about musical experiences. The question then becomes how such a topology might be manifest in the spatial dimensions of a terrain.

7.4 The Terrain and its Space-Time Dimension

If considering the whole of an experienced work in memory alone, in my mind I can see what I remember as a spatial journey – a three-dimensional terrain, incorporating spectral verticality and perspectival latitude, extended and shaped along a longitude of spatialised time. I am able to skew this image as I wish: I can see it from left to right, or as a forward journey, and I

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[182] Kendall's examples of events include a short four second excerpt from the opening of Smalley's *Pentes*, as well as the first five and a half minutes of Truax's *Riverrun*, and the first seven and a half minutes of Xenakis' *La Legende D'Eer* (Smalley 2000; Truax; 1987; Xenakis; 2005).

[183] Kendall (2010a) also speaks of a 'conceptual blending' emerging when we piece a work together – this relates to identifying more contextual connections, which can include extrinsic relationships that may influence the spatiotemporal journey, for example temporal associations carried within the material. For more on temporal associations and source-bonding, see Pasoulas (2011).

may be able to look back at the piece. Or perhaps I can see it as passages, where sounds, or sections, are temporal objects passing by me, or textures floating as substances past me. Either way, time has to borrow a spatial dimension if it is to be incorporated.

But if I situate myself *within* any remembered space and re-experience it as in real time, the perspectival field will reclaim its dimensions, since four-dimensional spaces would not be logical to lived experience. Scanning my memory, I am able to alternate between the two kinds of view: alongside the time-orientation terrain, still or moving images melt in, where I am situated within ‘pure space’ rather than spatialised time, re-imaging the space as I remember it unfolding.

It appears, however, that perspectival and temporal longitudes often blend, as if the future is waiting behind the horizon of the landscape, hidden by a topological curvature. This phenomenon, I suggest, is often conditioned by the front-oriented terrain that acousmatic works tend to have, where, for instance, approaching motion is very common: it can become a metaphor for the future approaching. In a similar fashion, we can have the impression of travelling towards the future when projective spaces are manifest in the distal image, anticipating something we cannot yet fully grasp.[184]

Thus, even if time is often transparent in the experience of a work, we find it hard (if not impossible) to think of it in non-spatial terms when we consider ourselves in the context of past, present and future. And the spatial time orientation often intrudes upon the immediate image, since it is an essential dimension of the cumulative past, and the expected, speculative, future. A complex is generated from space-form images where time has already been sidelined, and from evolutive processes of spatial change and articulation. The spine, as a terrain feature, is one of the key resultants of these spatiotemporal processes; it is formed in the collaboration of present experience and memory, and becomes a spatial trace representing the spectral contour of the music.

[184] Traces of earlier events in distal space is also a structural device, in which case the future might be seen as hidden by the past.

7.5 Formation of Space-Time in the Elastic Present

I doubt that it is possible to say that the temporal axis of a whole work can be conceptualised exclusively in terms of either of the time-orientation metaphors (*moving observer* or *moving time*). However, an extrapolation of these in combination with Johnson's musical motion metaphors can be fruitful for describing interacting conditions where we find ourselves untouched by, approached by or drawn towards the future – depending on the character of an acousmatic scenario at work. What I propose here is based on how the time-orientation metaphor emerges in the listener's embodied experience of spatial texture, recognising the influence of directly spatial orientations and motion processes.

Whilst listening to spatial texture we are suspended in the *elastic present*. We can imagine this as a substance of varying malleability, with which the forces of spatial texture inevitably have to interact in order for time to pass.[185] In more 'static' landscapes, where time is transparent, our elastic present dilates into the past and future in equal measures. We may on these occasions feel that time is non-existent, or that it flows through us like a stream with no friction. In such a condition, real time does not become shapes or motion trajectories.

If, on the other hand, a greater degree of motion is present, and the terrain is warping – confusing, dilating, or contracting spectral and perspectival space – our elastic present is subjected to forces of deformation. We are swirled within a space-time which – although not passing us, or letting us through – challenges the stability of the present and the temporal transparency. It may eventually carry us to a new place in the evolving terrain as if we are lifted towards, or pressured into, a new phase in the process. This condition – *force-time* – corresponds to the *time as moving force* metaphor. Here, deformotion and transformotion can give us the impression of drifting in, or being pushed along by, textural masses because the force itself is the terrain. It is not so much about leaving or arriving, but rather about being suspended in a moving present, which possibly transforms into new states.

When forces acquire clearer contours, event-like shapes are formed, where surrogates of gestures, or dynamic textural wave formations may be present. In such conditions we may have

[185] For a discussion regarding time durations and other factors relevant to what we perceive as the present, or the 'specious present', see Pasoulas' study on timescales in electroacoustic music (2010: 24–8).

the impression that a wave of future is pushing itself through us with a force that is greater than our resistance or counterflow, or that we are being inundated with sound: our elastic present gradually contracts until an event has passed. Such passing time relates to the *time as moving objects* or *time as substance* metaphors, and I have termed them *event-time* and *substance-time.* Event- or substance-time tend to remain if their passing does not cause overarching changes in the terrain, so that we still feel more stationary than the temporal flow, or when the temporal direction is aided by processes which pass us spatially, for example, from front to rear. Event-time is not only applicable to individual spectromorphologies, but could also apply to sections.

Beyond such events or contours, however, we may have the impression of gliding effortlessly into the future, as if descending past the crest of a wave. Here, our elastic present projects to the future, as a dominant direction suggests that we are travelling towards something. These conditions apply to the *time as moving observer* metaphor, and are associated with anticipation and arrival. I refer to this as *projective time*, since we are being projected through the terrain, or are making future projections associated with anticipation and goal-oriented journey.[186] Ascending and descending spectral motion, or distal perspectives, for example, can create such anticipations. In other situations, where the terrain changes and we enter a new space, we have the impression of arrival, also feeling that we are travelling through spatial time, even if we have only passed from one stationary space into another.[187] Projective time can be empowered by projective space.

Thus, space-time motion represents how the flow of time blends with spatial experience; how the imagined spatial direction of time is influenced by spatial texture. The experience is a form of oscillation where the elastic present is pushed to and fro by the interacting forces of an accumulating past and a mobile future; our present can dilate into the future, allowing us to see it before reaching it, or it may contract if the future simply dawns upon us without warning. It may

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[186] Huron's ITPRA theory (2006) on the psychology of expectation in music could be relevant here. It could be interesting to speculate on the possible effects that the different phases of the temporal response chain – Imagination, Tension, Prediction, Reaction, Appraisal – could have on our conceptualisation of time motion. For example, tension and surprise, which he analyses in detail, would seem relevant to projective time and object/substance time. This is beyond this thesis, however.

[187] A note of interest to event/substance-time and projective time, is that it has been suggested that the positive or negative emotional valence of expectation has an influence on spatial metaphors for time. Margolies and Crawford (2008) conducted experiments on this showing that 'participants who imagined a negative event were more likely to report that the event was approaching them, whereas those who imagined a positive event were more likely to report that they were approaching the event' (ibid.: 1401).

float upon the force of time, stand amidst its flow, or actively forge itself into the future. And the arrival at/of the future produces the past: cultivating the terrain of a work in our minds. These different kinds of temporal motion are thus under constant reevaluation, and work in the continuum between transparent and evolutive time: force-time, event/substance-time and projective time are intermingled and sometimes happen simultaneously in different layers of the music.

We see, then, how the nature of states and processes and the continual deformation of the elastic present influences the imaginal terrain of a work; places and regions present in our image of the work have different sizes, not only because of their experienced spatial magnitudes and their clock-time durations, but also because of how we have experienced the present and its temporal dynamic along the way.

In circumspatial composition formats, there are great potentials for exploring the idea that spatial motion and terrain structure influence temporal direction and the accumulating space-time topology in an acousmatic work. Ultimately, such a topology also involves implications beyond the successive temporal process, where parts of a work are connected in a less linear fashion in the listening imagination. Space-time linearity can certainly be subverted if more complex, convolved or conflicting motion directions are present. Time can flow vertically, latitudinally, longitudinally, in curves and angles, from interior to exterior, etc., but I suspect that, when considering ourselves in the global course of a work, we may still want to assemble a trail behind us and speculate upon a destination ahead.

7.6 Deformations of the Elastic Present in *Lucent Voids*

Space-time motion orientations are undoubtedly subjective diagnoses, particularly dependent on what the listener focuses on in the weave. Further, space-time is context-dependent in that relationships such as recurrences and developments over longer durations may influence how we perceive the terrain in shorter durations. The following discussion concerns two passages taken from *Lucent Voids*, to give tangible examples of how these concepts might be applied.

The terrain of *Lucent Voids* unfolds in a process that expands and contracts the elastic present. New 'sections' or 'places' in the terrain are often approached in projective time, but enter as event-time or substance-time, as if time is floating through us, transforming our spatial context. This process is illustrated in **ex 64** which is taken from 3'55"–6'20". **Figure 21** Shows a schematic outline of the excerpt.

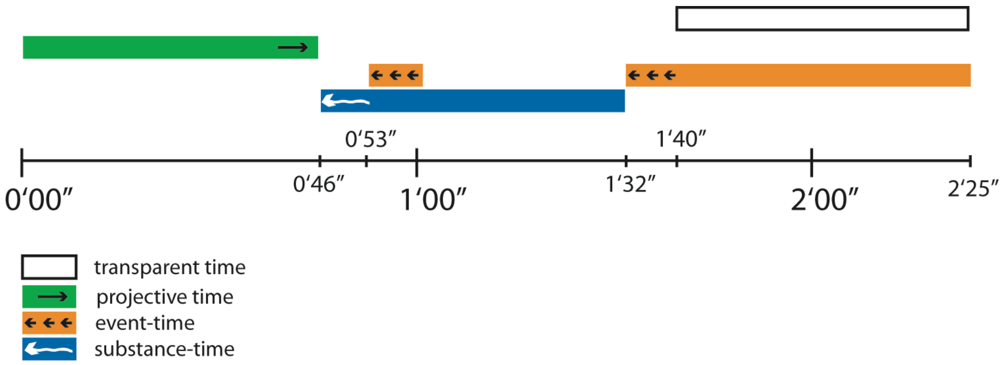


Figure 21: Schematic representation of space-time motion in ex 64 from *Lucent Voids* at 3'55"–6'20.

The opening of the excerpt features a large resonant texture creating an extended circumspace, where an ascending glissando suggests a directed process, creating a projective space-time. A forward orientation is implied by a projective space emerging in resonances in the front, behind a thin stratum of textons, around 0'25". Projective time begins to fold back upon itself at 0'46", where a descending process begins and the texture crunches up into two cataracts which invade the perspectival field and push themselves towards the rear (at 0'53" and 0'57"). Event-time and substance-time intermingle here, passing the listener whilst a different space begins to materialise in the texture. The cataracts create a ridge, after which a resonant space is opened by a graduated onset gesture at 1'32". This space is fairly static in that it is framed by a stable spectral texture in the background. But there are inharmonic spectromorphologies in the foreground which impart temporal motion to the experience. Thus, we can say that transparent time and event-time exist as two layers here: one which keeps us in an extended moment, and another which passes us as a series of events creating an evolutive pattern.

In its entirety, this excerpt demonstrates how the elastic present is deformed in the interaction among processes with different spatiotemporal directions. First the elastic present is extended towards the future, then it is contracted and deformed as the big events occur. After this it dilates again with a less biased direction as transparent time sets in.

Ex 65, another excerpt from *Lucent Voids* – taken at 10'00"–12'45" – gives an example of how spatial relationships influence the elastic present and the links between simultaneous and successive spaces. Figure 22 shows a schematic outline of the excerpt. In this example we can hear how a series of inharmonic gestures appear as a projective future, suggesting itself before we actually enter it. Later, force-time has a role in carrying us over a spectral ridge towards new places in the terrain.

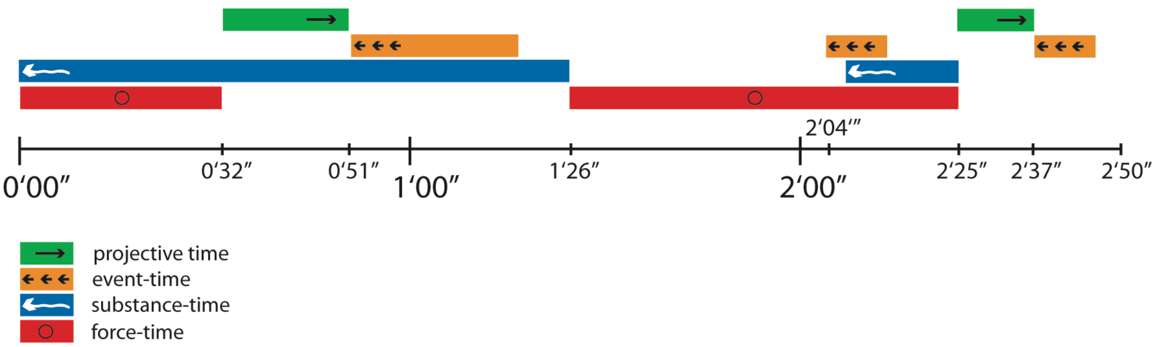


Figure 22: Schematic representation of space-time motion in ex 65 from *Lucent Voids* at 10'00"–12'50".

During the first 10 seconds we experience a process of increasing textural perturbation, where all textural layers seem infused by a wind-like force: we can say that force-time suspends us against substance-time passing us in perturbed textural strata. At 0'32", a series of deforming, inharmonic, resonant gestures appear in the front, whilst previous textures are still present as an obscuring layer in more proximate regions. The gestures appear as a projective future in front of us, which we have not yet entered. It is only when the rumbling textures in lower spectral space is punctuated with a wobbly resonant gesture at 0'51", and the inharmonic, pitch-like material begins to branch out, that we arrive at a new stage in the process and begin to leave previous material behind. This experience is projective in the sense that we have 'seen', or imagined, something before entering it. Simultaneously, however, time has passed us as events and substances which are now drifting off into memory.

A process of subtle spectral ascension begins at 1'25" where the inharmonic texture densifies and grows in the higher altitudes. Time becomes an ascending force. We become more aware of altitude when two lower cascades enter at 2’04”: they create a counterflow of event-time transforming into substance time. A descending apex emerging at 2’25”, and a following stream of scattered filaments, suggest a more directed process towards lower regions, projecting the elastic present forward until the inharmonic gestures appear at 2’36”.

The excerpt shows how different types of space-time motion often coexist, and how spatial relationships can divide them. Moreover, the process of adventuring the terrain is illustrated: first the spatiotemporal process occurs through the addition and subtraction of spatial layers, as if we are forging through obstacles, step by step; after 0’51”, when the lower frequency grounding disappears, we arrive at a place that somehow feels like a destination, after which spectral forces take us on a journey in higher altitudes, and finally allow us to land in a new environment. The process from 1’26” to 2’36” in the excerpt becomes a spectral ridge between different environments. Although it is more than a minute long and feels quite extended in the present, I find that in the context of the work it seems shorter in memory – perhaps because it is a transition. Thus as our elastic present dilates and contracts, our sense of duration is affected, which in turn affects our impression of relative distances traversed in the terrain.

7.7 Summary

In the experience of the terrain unfolding, time is at the service of space on at least two levels: it articulates space immediately, as *transparent time* or *evolutive time*, and it gains a metaphorical, spatial orientation once projected into memory as a sequence or network of events. Our presence in acousmatic space-time is represented by the *elastic present*, which negotiates the terrain in the interaction among four conditions of motion direction: *force-time*, *event-time*, *substance-time*, and *projective time.*

8. ABOUT THE COMPOSITIONS

Listening examples have already illustrated how concepts of spatial texture are manifest in the compositions; what follows is an introduction to each of the works, discussing spatial texture material, structures, form, and composition processes. The reader may get a sense of how theoretical concepts of the research relate to compositional interests outside the thesis subject, and how technique and aesthetic language have evolved together in the exploration of the topology of spatial texture. For me, each work relates to the principles of spatial texture in an individual way. The works form a multiverse of different space-time arenas: 'cosmographies' with their own perspectives on the morphology of space.

8.1. *Elemental Chemistry*

Stereo acousmatic, 13'48", 2008-09.

One aspect that strikes me about *Elemental Chemistry* is its peculiar relationship between the natural and the artificial. A source-bonded wholeness emerges, as scenes and sounds of some familiarity, whilst simultaneously we hear a constitution of elementary synthetic processes, organised in complex structures. The piece evolves in a seemingly self-regulating process, where malleable sonorities guide themselves into 'chemical' reactions resulting in a blending of the elements of sound and the elements of nature. In the textural interior, field recordings also enter as transparent image layers. Although these may elude the listener, they add to the grounding of the music in a familiar context, subjected to an imaginal warp.

8.1.1 Spectromorphological Material and Spatial Texture

Distinct to *Elemental Chemistry* are the harmonic spectra which, in an interplay of morphogenic processes, are deformed into various phases which we can associate with certain extrinsic archetypes. One such archetype is utterance – human or animal – which appears in the form of vocal-like sonorities with a fluctuating behaviour and a formant-like spectrum. These have a foreground role during the first three and a half minutes of the piece, and their spectral mobility creates a continuous spectromorphological warp not only of the sounds themselves, but also of the imaginal biological entities which potentially could produce such sonorities: in the lower spectral range, a human embodiment may be evoked, whilst the higher ranges suggest utterances of increasingly smaller life-forms.

Another relevant archetype here is the attack-decay, resonant spectromorphology, evoking spectra of glass or metal objects at different instances. As with the utterance aspect, however, these rarely behave in a manner that is logical to our experience of the existing world. The resonant tails tend to deform to a degree that surpasses such plausibility, and their distinctly synthetic quality often evades natural spatial presences. Rather, the image protrudes in an almost intrusive manner. The artificial source-bonding is also emphasised by the noise and impulse textures, which have role in spectral structure, but simultaneously also may evoke vaporous atmospheres and other source-bonded associations.

The interlacing of focal threads creates a global continuum of deformotion and transformotion, although abrupt changes often occur on a lower level in the textural interior. This results in situations where we may enter environments without knowing quite how we got there. Although the form may not easily be remembered, a felt dynamic profile of accumulations and dissipations of energy structures the experience.

One global tendency in the work is spatial expansion, resulting in larger magnitudes towards the end of the work. The links among the different global threads and different climaxes lie underneath this process, creating a structure that may not be immediately known to the listener, although it has a logical dynamic, clearly intensifying towards the end of the work. Morphogenic threads, in both resonant and noisy textures, create recurring shapes which are developed through the course of the music. Quasi-melodic pitch contours, emerging in the spectra, also trace much of the work.

Between 8’50” and 10’00”, where an increasing rate of activity builds up towards the final culmination of resonant material and the climax, spatial time orientations are set in a turbulent relationship, where force-time, object-time and substance-time deform our elastic present, in the combination between textural growth processes and gestured events.

8.1.2 Composition Processes

Recordings of forests and seaside environments in northern Greece were the starting point of the composition process. The idea was to obscure and transform these with synthesised material whose spectromorphological characteristics would be informed by the environmental images of the recordings. All pitch material is derived from four goat shepherd's bells brought home from the area where the recordings were made. The bells themselves never appear in the piece but their spectral structure was used in the synthesis processes. Their internal spectra, as well as the relative intervals emerging among the bells became the pitch structure of the piece, as fundamentals for harmonic spectra which were then transposed to extend the register: thus a basic tuning emerged.

The majority of melodic contours are due to the accentuation of partials inside the harmonic spectra, rather than the relationships between the different fundamental pitches – the amplitudes and panoramic positions of all partials within each spectrum were individually composed. Noise and impulse textures were used as an extension of the noise present in the recordings, and often feature resonances relating to the bell spectra. Essentially, coherence is established on a lower structural level, through using a few highly malleable materials whose different combinations and 'mutations' on a higher level can take the music in a range of different directions.

All processes were designed and composed in SuperCollider[188], where topological threads were created, in which all dynamic aspects were shaped through continuous automation. Many of these threads are several minutes long and temporally linked to all other simultaneous materials; thus the entire piece had to be composed on all structural levels simultaneously, in a linear process from beginning to end. I think this strategy is consistent with the experience of the work, as a continuous and temporally directional process.

Aside from the stereophonic original, a wave field synthesis version of the piece also exists, which was realised during a short residency at the Game of Life Foundation's studio in Leiden, Netherlands, in January 2011. For this version, about 110 stereo tracks from the original

[188] SuperCollider is a programing language for real time audio synthesis and processing.

mix were individually distributed in a continuous perspectival field. Although some differences in the relative levels among textures were inevitably introduced, I found this version rather successful in certain aspects, such as the greater perspectival differentiation between foci and peripheries, the enhancement of image warp in deformotion and transformotion processes, and the accentuation of detail and magnitudes in the more immersive environmental passages of the work. This version has had several performances, but remains specific to the system.

8.1.3 Comments

Although much of the source-bonded material of the work is fairly typical of acousmatic music, I find that the sometimes parodic manner with which it is handled gives the music an original, humorous edge. The creative process paid much attention to the mutability of the materials and the navigation through different environments, and an open-minded attitude was kept in terms of allowing the process to reveal its possibilities. This, I believe, has given the work a certain spectromorphological and spatial elasticity, agility, and variety.

I find the multifocal weave to be one of the most consistent and imaginative among the works in this folio in terms of spectral structure. The rather limited, but highly malleable, textural material succeeds in creating a transformational terrain, where contrasting magnitudes are evident, even in the stereo format.

Elemental Chemistry was awarded the Prix du Public at the Metamorphoses competition held during the Espace du Son Festival at Théâtre Marni in Brussels in 2010.

8.2. *Cataract*

Eight-channel acousmatic, 13’31”, 2010.

One could say that *Cataract* extends the artificial environments of *Elemental Chemistry* into a more alien territory. Being an altogether more abstract work, *Cataract* approaches source-bonded textural materiality from a more remote position. We hear plausibly physical and biological phenomena in the textures, but these are not much more than reminiscent appearances, since the spatial context is a less earthly domain.

The title carries a number of references. One alludes to the cascading textural motions – transformational deluges of sound matter, washes of noise, and glissandi. Another is an analogue between cataract as a medical eye condition (a clouding of the lens of the eye) and the way in which our sense of spatial, sonic definition is affected by degrees of textural opacity. I think of the ‘acousmatic cataract’ as a continuum where clarity intersects with clouds of noise and coagulated microsound, blurring our auditory vision. Finally, *Cataract* is a reference to Pythagoras’s curtain in the etymology of the acousmatic: paradoxically, the veil seems backgrounded as we move further away from an anecdotal world towards a more abstractly visual sound universe.

8.2.1 Spatial Texture and Form

Cataract is the first work of the folio to explore texton properties to a full degree, emphasising their local influence on the global emergence of textures. Much attention is devoted to patterned propagation of spatial texture, rather than statistical distributions. The attention to textons takes transformotion processes to a different level, giving the music a colourful terrain. As the first eight-channel composition of the folio, *Cataract* also develops and expands the use of textural distributions – peripheries, zones, vectors, and points are all prevalent.

The form of the work incorporates several different structural perspectives. One relevant aspect that can be traced in the work is the transformotion processes. These often coincide with spectrally cascading motions, and become increasingly rich towards the end of the work, from

10’46” onwards. The recurrence and development of descending and ascending, cascading contours, which form the spine of the work, and could be said to culminate in the texture at 9’20” to 10’00”, since this is spectrally the most opaque passage. Cascades occur after that as well, but with more of a background role. A third structural view can identify pairs of roughly-outlined sections. For example, the opening section (until 2’30”) has a short recurrence at 5’18”; the gaseous/vaporous section between 3’00” and 4’15 is related to the passage between 7’23 and 8’13”: both are also punctuated by similar front-to-rear cascades; the passage with perspectival phasic motion and an approaching-ascending cascade, between 4’45” to 5’14”, is related to that beginning at 8’26” which develops into the most dense of all the cascades. The texton-oriented conclusion of the work has an ancestry in the textures occurring between 6’00” and 7’20”.

Perhaps the most obvious structural thread of the work is the recurring, sustained, harmonic and inharmonic gestures, which help articulating the spectral spine. The gestures become increasingly inharmonic over the course of the piece and reach a final punctuating statement at 10’10”. Generally, *Cataract* has a polyvalent form, where cascades are kept relevant throughout, appearing in different contexts.

The opening is different from the other pieces in the folio in that it unfolds in a more obviously gestural manner. The gestures in *Cataract* intentionally stand out in an awkward manner, and although they have structural significance, their dull onsets, almost devoid of internal spectral dynamics, compromise their acoustic plausibility and escape reference to human agent. It is also the only piece whose pitch material is not derived from recorded sounds. The opening gesture is a major ninth dyad (F and G) which is later followed by another (D and E). All gestures were composed with pitched fundamentals, although in many cases they are obscured where spectra become more inharmonic.

8.2.2 Composition Processes

As the first eight-channel piece of this project, *Cataract* required a comprehensive rethinking of both aesthetic and technical approaches to composition. Technically, the eight-channel format prompted the development of multichannel textural synthesis processes where distributions are an intrinsic aspect of textural topologies.

There are two kinds of organisational strategies present. First, there are the more top-down-oriented processes where all textural parameters are continuously automated globally – all individual parameters of a topology (for example, grain densities or spectral parameters) have envelopes with specific values which follow a common series of temporal durations. A certain unity is thus formed in that the contour of change is coordinated along a temporal skeleton. This is the case with all the harmonic and inharmonic gestures and the surface textures of many of the cascades. Here, any granular textures are homogeneous surfaces, since texton properties can only be altered globally, statistically affecting many at once. A low-level topology is thus created by means of global coordination of propagation streams which may have local deviations. This strategy is efficient for creating malleable and mutable textural continua, although it often prevents heterogeneity on a lower structural level. In *Cataract* these topologies often feature fixed peripheries – that is, noise or impulses fixed to individual loudspeaker outputs – which are shaped through filters or biased densities, so that different parts of circumspace are accentuated in a temporal continuum, creating a global warping of the texture. In the sustained gestures, each partial is panned individually in the free field, or fixed along the peripheries.

Second, a bottom-up oriented approach is used where textons are articulated locally through the composition of complex micro-sounds. Thus, rather than distributing a mass of similar textons in space, each spectromorphology within the texture is composed individually and patterned carefully with other events in time and space, so that topological coherence emerges out of similarities among textons. This approach allows for the appearance of singularities which do not obey global uniformity, and draws attention to shorter timescales. In this case many of the micro-events contain partials which are differently distributed spatially. These two organisational principles together create a balanced musical discourse that has scale in both time and space.

Unlike *Elemental Chemistry*, *Cataract* was not composed in a linear process from beginning to end. Rather, the order of events, apart from the opening section, remained undetermined until later stages in the composition process.

8.2.3 Comments

To me, the series of textural transformations between 5’36” and 8’14” somehow summarises the style of the piece, and stand out as one of the most interesting passages in the folio, in how different kinds of directional processes are linked up in the navigation through spaces; how gestures ignite and punctuate processes in different ways; and in the graphic imagery created from filaments, textons, and cloud-like masses. The textonal transformotion processes occurring after about 11’00” are also noteworthy in terms of how the textures shift in materiality; how textons acquire a close physical and visual presence in the spatial image; and how the spectral spine diverges and eventually navigates to the higher altitudes as the piece concludes.

8.3. *Latitudes*

Eight-channel acousmatic, 13:45, 2011.

Latitudes is the most continuous of the works in this folio, unfolding in a process of gradual growth and transformation, evoking extraordinary magnitudes and timescales, perhaps as if cosmic histories were moulded out of a brief segment of time. Gesture is almost entirely absent, and the other-worldly nature of the music makes it a rather cold experience. Yet I find that there is a sensation of awe associated with being transported to this kind of ‘meta-human’ scale of space and time. Deformotion, morphogenesis, and transformotion have a meaningful role in this, not only as structuring principles, but also as metaphors of how physical masses slowly interact and mutate into new formations.

8.3.1 Spatial Texture and Form

The transparent resonant drone, introduced by the bell-like gesture at the opening, provides the initial substance of the process – a limited spectral texture in a panoramic aperture with hardly any prevalence of either proximity or distance. This creates an uncertain state of temporal suspension, drawing us into an emerging interior dimension, where we are enveloped by inflating clouds of noise.

The essential breeding ground for the growth processes is the continuum between resonance and noise. In principle, spectral space is expanded through strata and inflating vertical peripheries introduced by clouds and cascades of noise. This also expands circumspace, as resonances are distributed across the perspectival field. Circumspace also dilates as more diffuse textures are introduced along the peripheries. An example is the low-mid stratum emerging after the cascades at 2’00” – a deformotion process that puts the entire textural mass into a slow, viscous, turbulence. The spectral interior is generally animated through the perturbations of filaments and through the emergence of textonal activity as resonant textures break up into particles. This creates a background of changing pulsations which is present through most of the work.

The first half of the piece develops into a saturated texture, where resonances, noise, and squelchy vocal-like coagulations of textons are finally sucked into an elastic crunch at 6’47”. The second half opens up a more spacious environment, where proximities and distances have greater prominence. A characteristic texture here is the wobbly ripples propagating in latitudes between the front and rear of the perspectival field. The work becomes texturally more complex after this – see discussion in 4.5.4 on critical forming processes. After 11’30”, towards the end, perturbed strata and steady resonances create a translucent perspectival field and spectral texture.

Generally, we can say that *Latitudes* has a multi-peripheral weave, where topological threads are largely collaborating in a laminar mass-evolution of sound.

8.3.2 Composition Processes

Latitudes was composed in a linear manner, and I believe that this method in some ways is inseparable from the aesthetic result aimed at, where growth processes become an irreversible accumulation of history. The piece is also, in contrast to *Cataract,* entirely shaped by globally-automated processes, which are consistent with the spatiotemporal experience of the music, where magnitudes and masses are more salient than local detail. However, the coordinated topological processes are of far greater complexity than those of previous works. Variable stratified latitudes emerge extensively in all noise and resonance topologies, allowing spectra to expand and contract in perspectival space.

All the resonant material is derived from a set of antique lead crystal glasses. The glasses all have different global 'pitch' dispositions, although their internal spectral structures are fairly similar: both relative and internal ratios were used to create the spectral fabric. The approach to spectral organisation is thus similar to that of *Elemental Chemistry,* in that intervallic structures were derived from recorded sounds, but here frozen portions of the glass resonances were also used as oscillators within synthesis processes, in order to achieve a more organic sound than that of mathematical functions. When these are layered in transpositions, a chord-like spectrum emerges, where interior and relative relationships among the spectra are similar. Beyond this, the textural topologies are entirely synthetic, and some are able to interpolate between a metallic, unstable resonant behaviour, and drier textonal granularity. The type of texture shown in ex 11 is one of the most complex, and is featured in several incarnations throughout the second half.

8.3.3 Comments

One aspect I find interesting about the work is how its mysterious metaphysical quality somehow seeps into the embodied experience of hearing the music; it is a spatial experience that undermines our sense of time passing, despite it being a very directional process always in motion. The mystery partly lies in the unknown causality behind it all; there is no obvious agent behind the growth of the vast, transforming spaces out of the softly-glowing resonant texture.

8.4. *Catabolisms*

Eight-channel acousmatic, 12'14", 2011-12

Catabolic processes of fragmentation are here central to the exploration of how 'amorphous' textural sound matter is shaped in the interaction of turbulent exchanges of energy. As in our physical and cultural universes, creation and decay are always in mutual interaction. The anabolic tendency feeds on the catabolic effect, and thermal crises lie in the epicentre of this process, where a terrain of solid, porous, fluid, and elastic matter is brought into existence through the chaotic interaction among entropic systems.

8.4.1 Spatial Texture and Form

Catabolisms contrasts sharply with *Latitudes* in that it is constituted almost entirely of granular material, and has a much faster rate of activity with a greater degree of morphogenic articulation at local levels. This also brings a gestural presence into the work, which, together with the more eruptive and disruptive style, adds to the more event-oriented form. And although great magnitudes also feature in this work, the peripheries are always contrasted with more proximate focal activity, where latitudes, strata, parallels, and vectors, become structurally apparent features. *Catabolisms* explores entropic processes to a greater degree than the other works, and this has effects on how the polarity of homogeneity and heterogeneity is manifest in its spatial texture.

Textural characteristics include the rock-like, lumpy textures of the opening; the inflating-deflating processes; the sudden implosions where sound seems to be caught in a backdraft; and the elasticity and mutability of grainy textures in general. There is often an ambiguous, source-bonding manifest in the textural materiality, and the behaviour of motion, suggesting wind-like pressure forces, and clouds of dust being thrown about by turbulent forces.

One can divide the work into two global sections, both of which can be given several internal partitions. The first ends at 5’13” and the second begins thereafter, taking us to the end. What they have in common is that both end in a homogenisation of texture. Of course, it is not until the end of the second part that the texture reaches a full dissipation into nothingness. The work has several climactic phases, which are concurrent with the onset of thermal crises. Among these, there are two more significant consecutive climaxes in the latter half of the work, where the second can be seen as expanding and concluding the first. The first begins an accumulation of tension and energy at 7’08” which reaches a release at 8’23”, imploding in a rupture at 8’36”. The second begins with an inflation just after that, at 8’41”, and is completed in a series of cascades at 10’12”.

The weave of *Catabolisms* is more dynamic than previous works; there are several multifocal passages, but there are also parts which combine a unifocal and multi-peripheral weave. An example is the first 2’30”, where the weave gradually increases in complexity. Attack gestures, approaching inflating noise textures, and repeated descending, elastic crunches, together form a focal thread on a gestural timescale, whilst the crackly texture, the meandering bass, and other textonal activity in the higher altitudes, create evolving peripheries. Similar processes happen in the climactic phases mentioned above, where the cascading textures form focal threads against complexes of moving peripheries.

8.4.2 Composition Processes

Catabolisms is composed entirely of synthesis processes and applies global shaping of topologies on both longer and shorter timescales, resulting in a more dynamic and morphogenic texture. Local patterning is also used to a great extent, adding another structural layer. Interaction among structural levels is evident in cases where several topological threads of considerable local detail are brought under a global influence – for example, in the passage leading up to the imploding ruptures at 8’36”, or in the gradual homogenisation occurring between 4’00” and 5’12”. Some of the material is developed from discoveries in *Latitudes*: the crunching spectromorphologies are here brought into another context, and the resonant textures, although they have more of a background role in this piece, are similar and use the same spectral ratios. Although there is an ancestry in the material, its coloration has changed due to the different context.

8.4.3 Comments

I think the work is successful in its scope of articulation and drama, and in the coherence in materiality. I am satisfied with how climaxes are handled; how the linking of interruptions and eruptions create an intense accumulating experience; and how the dynamics of foci, peripheries, and magnitudes are dealt with over the course of the work. The textures and the spectromorphological dynamics have a strong physical presence in both large and small concert spaces, bringing listeners into close contact with the entropic processes.

8.5. *Lucent Voids*

Eight-channel acousmatic, 20'44", 2012.

The *lucent void* is a metaphysical notion that alludes to the uncertainty that underlies the collective fabric of human thought, knowledge, and cognition. Since this fabric is under perpetual reconfiguration it can never be complete, and we rely on the intrinsic creativity of speculative imagination in our mental navigation through its topology.

The concept is metaphorically manifest in the transportation through a reality within which we cannot rely on the permanence and linearity of space as we normally perceive it, but whose terrain keeps warping as we journey through it, seemingly distorting our own physical presence to negotiate unlikely combinations of the microscopic and the macroscopic, interiority and exteriority, the temporal and the non-temporal. The threads of this texture are often disparate, but are kept in orbit by the invisible attraction of a surrounding vacuum. It is a process in which the listener is the human protagonist, traversing a strange geography of images.

8.5.1 Spatial Texture and Form

Lucent Voids summarises the folio by bringing many of the ideas explored in the different previous pieces together into one musical process. The work further explores the emerging space-time topology of textural terrain, and the visual listening experience. Being of significantly longer duration than the other pieces, the work presents a greater variety in textural materials and spaces, and greater complexity in terms of structural layout and form. Spatially, the perspectival field and spectral verticality is often planned out to create sites with complex terrains.

A multifocal counterpoint of textures outlines peripheries, contrasts, foci, and voids, always in deforming and transforming relationships. We hear deformotion not only in an abstract sense, but are perhaps even more aware of it in the more source-bonded situations – for example in the jungle-like section gradually entering after the gestures at 12'36" – which present a disparity between what the environment *should be,* according to our perceptual common sense, and what it *is,* in this particular manifestation. This creates an abnormal reality where nothing is static, and the experience of deformotion is enhanced because of this cognitive dissonance.

Topological threads, both peripheral and focal, have a distinct role in this work, and are manifest in a heterogeneous sound palette where textures are highly differentiated, both spatially and materially. The form combines larger-scale, drawn out passages, with denser, more detailed activity, establishing a dynamic relationship between morphological interaction in the present-oriented timescale, and backgrounds evolving over longer durations.

Reverberant acoustic interiors is one of the types of spaces recurring in the work. An example is the croaky reverberant texture appearing in the opening section, at about 0’52”, creating a distal image at the front. This textural type recurs in the jungle-like passage, entering at about 13’32”, and has a similar function here, although the spatial and acoustic context is different. In both instances, relational spaces are created, where very dry surface textures occupy more proximate areas, thus emphasising an interior-exterior contradiction. The deformed brass-like sonorities emerging at 16’34”, are also situated in a room acoustic – a concert space might be evoked here, because of the instrumental reference.

Strongly source-bonded textures also feature, and may be divided into two types. First, there is physical inorganic material, which appears in the form of fluid textures (for example, at 1’40” to about 2’30”) and aggregations of more solid, rock-like objects (for example, at 9’09” and at 18’32”). The other type is biological activity, which occurs in the form of chirps and twitters on various occasions. To my mind, the slimy texture entering about 6’25” is an example of an instance where these two types are merged, simultaneously evoking images of both micro-biological activity and viscous fluids.

We may also distinguish an underlying force, evocative of wind pressure or gravitational attraction between textures, which is present in all the growth and morphogenic processes, where for instance, textons agglomerate (for example, at 15’15” to 15’25”); surface convexities are created as textures inflate (for example, at 10’10”); or concavities emerge where spheroids are sucked into a vacuum (for example, at 18’43”). Inflations and densifications create a cyclical oscillation – like a gravitational wave, which seems to affect the entire sound universe of the work. Its impact can be witnessed in the violent eruption at 8’41”, where phasic textures spout into spectral space and ripple across the perspectival field, or in the accretion and almost vortical textural motion occurring towards the end, around 19’00” to 19’40”.

The resonant note-like gestures and graduated continuant morphologies also form a clear focal thread of mostly inharmonic constellations throughout the piece. This material first enters at 2’29” and is largely contrasted with the rest of the material during the first half of the piece, whilst in the second half they participate in the weave in a more integrated manner, having a particularly close interaction with the more source-bonded textures at 17’35” to 18’00”. There are also two passages of a more pitch-like nature, at 10’50” and 16’00”, which branch out into an askew counterpoint of inharmonic tone-rows. The latter of these also gives birth to the polyphony of brass-like sonorities appearing between 16’34” and 18’00”.

The manner in which the music unfolds creates a string of states which simultaneously are also processes, transforming into one another along a slow wave propagation which forms a space-time continuum. One can identify five main climaxes, which are all of different character: the first occurs with the cataracts at 4’48”, functioning as an entry into a new stage; the second erupts in the spouting texture at 8’41”; the third, which is a less typical accumulation of intensity rather than a dynamic crest, occurs at 10’31”; the fourth, which is more about rate of change, happens in the section between 16’41” and 18’00”; and the final one occurs in a thermal crisis at 19’14”. One of the most important transitions occurs in the dense, high-frequency, resonant texture between 11’29” and 12’36”, which forms a spectral bridge between the more abstract, darker sound world largely dominating up until then, and the more familiar and inviting environments which dominate from there on.

Lucent Voids ends in a distal resonating vanishing point, where an ascending spectral trajectory creates the receding perspectival lines. The simultaneous granular material in the rear polarises the process – not only in terms of longitude, but also because it makes us aware of the listening space through its dryness. We are inside and outside the piece at once.

8.5.2 Composition Processes

Lucent Voids was first composed through free, exploratory, development of material into textural terrain segments, initially without determined temporal ordering. These parts were developed as space-time 'places' and then beaded together into a continuum where materials were developed further into a temporal plan. The spatial textures of the work develop elements from all the previous pieces, with the addition of new synthesised materials and recorded acoustic sounds (present in the more fluid textures). Among the five works, the presence of reverberant interiors is unique to *Lucent Voids*. Although they do not have a focal role, they are an important aspect of the more architectural approach to spatial composition.

The glass spectra from *Latitudes* are used here as well, although spectral structure is dealt with in a more complex manner: several microtonal scales derived from the internal spectra of the resonances determine the additive transpositions so that a kind of self-similar spectral chords emerge. These scales are also used as pitch lattices, and formed the basis of a serial process used in the polyphonic passages (10'50" and 16'00"). The sequences here are derived primarily from manipulations (retrograde, inversions, transpositions) of an interval series simultaneously applied to different scales and their corresponding resonant spectra.

8.5.3 Comments

The work completes this composition project through bringing all facets of spatial texture into the same arena. One aspect I appreciate about the piece is how the odd combination of textures and spaces become a colourful topological map of a rich sonic terrain. I also find the undulation of its slow sub-rhythm interesting in the way it contributes to a felt experience of being situated in an elastic space-time medium.

CONCLUSION

We can say that low-level topologies constitute the basic fabric of spatial-texture-oriented music; it is in these that sound comes into existence, ready to be shaped in an interaction that takes place in several processes that have been described throughout this thesis. The key principles by which a discourse in time occurs are *entropic processes*, and *critical forming processes*. Motion has an inherent role everywhere, but it is entropic processes, *deformotion*, *morphogenesis* and *transformotion* that generate significant change, where the physicality of energy dynamics and the elasticity or plasticity of space come into relief. Contrasting this, equilibrial and qualitative states take a less dynamic role: ultimately, the balance between states and processes is what effects the elastic present and the space-time dynamics.

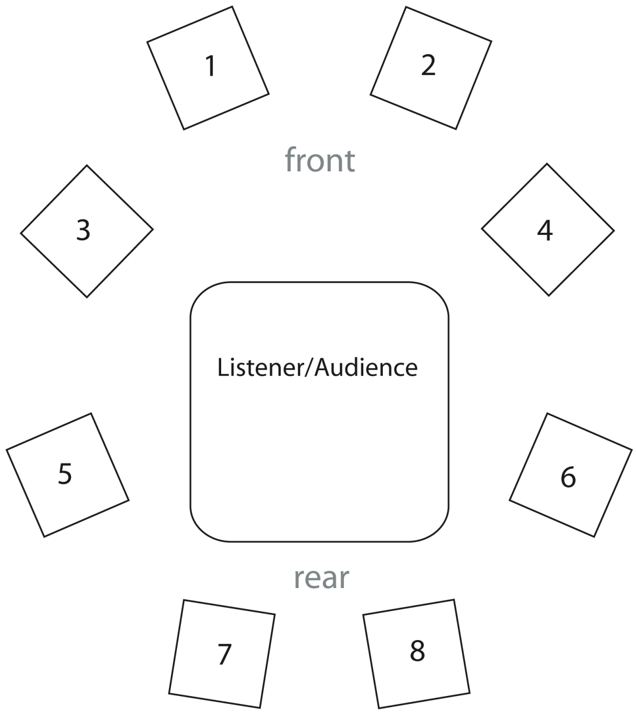
Although the processes of spatial texture are highly fluctuant and transformative, structural edifices also come into existence in the passing of time. These structures are represented by the *weave* and the *terrain*. They may each be thought of as a 'texture of textures' – but in different ways. Weave concerns the temporal connections and image layering among topologies – *topological threads* – and the manner in which a counterpoint can emerge in a work, either as a *multi-focal* or *multi-peripheral* condition of structure. Other weave types indicate scenarios where a more global and less contrapuntal tendency is regulating textural organisation. The interpolation between different types of weave has an important role in the formation of the dynamic profile of a work.

Terrain represents the spatial landscape that is formed in the relationships among textures, and our orientation within space at any moment in a work, but also our orientation *through* space, through time. Ultimately the terrain is formed in our minds as a graphic series of images and spaces, which amalgamate in a remembered topology where the time dimension is the spatial principle of connection. Terrain is the ultimate manifestation of the *visual listening* condition; a vista whose coloration, outline and gradients lie in the fine detail articulated by textons and filaments in the low-level topologies.

To a degree, we can say that entropic processes, morphogenesis, deformotion and transformotion 'replace' the role of gesture in the musical discourse: they all instigate change, and propel the music into new phases and new directions. As such they often carry a remote trace of gesture, although their causality, often lying in the global amalgamation of elastic processes, does not have an causality that is easily – even by remote metaphor – associated with a human agent. They are physical trajectories of energy caused by the chemistry of the present acousmatic world, rather than by a governing intention. The lack of human causality allows us to reach far beyond objective space, to explore suggested magnitudes that are outside our own scale. The important human presence, instead, becomes the listener, experiencing the physical process through an embodied engagement of imagination.

I. Eight-Channel Set-up for Works and Sound Examples

The eight-channel works are all composed for an approximately circular/oval loudspeaker array. On the DVD media, the audio files (all in 96 kHz sample rate and 24 bits) for each piece are numbered to indicate their corresponding channel and loudspeaker. The sound examples software follows the same configuration – the eight outputs of the user's audio interface must be routed to their corresponding loudspeakers. The figure shows the channel numbering and approximate arrangement of loudspeakers.



II. The Sound Examples Application

The application, Topology of Spatial Texture, can be found on the attached USB memory stick. It works on Mac computers only, and installation involves copying the application to the Applications folder.

The use of the application should be self-explanatory. There is a button for each example and a button for each piece, which both starts and stops sound. The 'HELP" button opens instructions for set-up. Importantly, the user must be set to 96 kHz sample rate in order for the music to be played at correct speed.

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