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Spectral Spatiality
in the Acousmatic Listening Experience

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PhD Thesis

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Declaration

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Peiman Khosravi

Abstract

Sounds are often experienced as being spatially higher or lower in congruence with their frequency ‘height’ (i.e. pitch register). The term ‘spectral spatiality’ refers to this impression of spatial height and vertical depth as evoked by the perceived occupancy of evolving sound-shapes (spectromorphologies) within the continuum of audible frequencies.

Chapters One and Two draw upon a diverse body of literature to explore the cognitive and physiological processes involved in human spatial hearing in general, and spectral spatiality in particular. Thereafter the potential pertinence of a spectral space consciousness in the acousmatic listening experience is highlighted, particularly with regard to more abstract acousmatic contexts where sounds do not directly invoke familiar source identities. Chapters Three and Four further elaborate aspects of spectral space consciousness and propose a terminological framework for discussing musical contexts in terms of their spectral space design. Consequently, it is argued that in acousmatic music, spectral spatiality must be considered as an inseparable aspect of spatiality in general, although its pertinence only becomes directly highlighted in particular musical contexts.

The recurring theme in this thesis is that, in acousmatic music, 'space' is not a parameter but a multifaceted quality that is inherent to all sounds. As well as providing an analytical framework for discussing spatiality in acousmatic music, this thesis highlights the compositional potentials offered by spectral spatiality, particularly in relation to the creation of perspectival image in multichannel works. For instance, the possibility of (re)distributing the spectral components of a sound around the listener (circumspectral image) is discussed in context, and a software tool is presented that enables an intuitive and experimental approach to the composition of circumspectral sounds for 6 and 8 channel loudspeaker configurations.

This thesis is useful for both composers and analysts interested in aspects of spatiality in acousmatic music. It also offers some insight into spectral space consciousness in non-acousmatic music, and may therefore contribute towards a more general understanding of the nature of our spatial experience in music.

Introduction

> "Space is a myth, a ghost, a fiction for geometers."
>
> —James J. Gibson[1]

The premise of this thesis is that in acousmatic music more abstract sounds can be experienced as visuo-spatial forms whose elevation and vertical motion is largely denoted by the sound's spectral structure. The term 'spectral spatiality' is used to refer to the impression of spatial height and vertical depth as evoked by the perceived occupancy of evolving sound-shapes (spectromorphologies) within the continuum of audible frequencies. By 'spatial' I do not refer to an abstract 'space', conceived as detached from our immediate spatial experience of the world, but rather, the felt experience of spatiality on a phenomenological level. That is, in certain contexts sounds are experienced as being spatially higher or lower, in congruence with their spectral 'height' (i.e. pitch register). This thesis focuses on how this apparent verticality of the frequency domain can become an integral aspect of meaning-making and contribute towards the experience of spatiality in the acousmatic listening context.

In Chapter One I shall introduce the topic in order to lay out the groundwork for an in-depth investigation. Chapter Two draws upon a diverse body of literature to explore the cognitive and physiological processes involved in human spatial hearing in general, and spectral spatiality in particular. Thereafter I demonstrate the potential pertinence of a spectral space consciousness in the acousmatic listening experience.

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[1] Gibson, James J., *The Ecological Approach to Visual Perception*, Taylor & Francis Group (1986), p. 3.

Chapters Three and Four further elaborate aspects of spectral space consciousness and propose a terminological framework for discussing musical contexts in terms of their spectral space design. Consequently, it is argued that in acousmatic music, spectral spatiality must be considered as an inseparable aspect of spatiality in general, although its pertinence only becomes directly highlighted in particular musical contexts.

In *Space-form and the Acousmatic Image* Denis Smalley suggests that the acousmatic spatial image is manifold, resulting from the interaction of three interconnected facets - *perspectival*, *source-bonded*, and *spectral* spaces. Here perspectival space is defined as “the relations of position, movement and scale among spectromorphologies, viewed from the listener’s vantage point.” Smalley then goes on to say that using “the adjective ‘perspectival’ to qualify ‘space’ may seem tautological, but I need to differentiate the perspectival attitude to space from other approaches, like that of spectral space, for example”.[2]

Source-bonded space refers to spatial contexts evoked by the identification of familiar sources.[3] For instance, regardless of the loudspeaker configuration, the acousmatic experience of bird utterances can immediately recall the sky-bound and agile nature of birds, even suggesting types of spatial motion and behaviour associated with birds. In the same way, a recording of an orchestral performance will evoke the familiar ‘sound-stage’ even if the sense of panoramic width is missing in the perspectival projection of the sound (for instance, in a mono recording).

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[2] Smalley, Denis, ‘Space-form and the Acousmatic Image’, *Organised Sound*, Volume 12, Issue 01, 2007, p. 48.

[3] Ibid., p. 38.

Although I am primarily concerned with the spectral facet of the acousmatic image, it soon becomes apparent that spectral, perspectival and source-bonded spaces are intrinsically interlocked: a discussion of spectral spatiality will inevitably entail aspects of perspectival and source-bonded spatiality. While retaining the focus on the spectral dimension, we must at times venture into discussing relevant features of perspectival and source-bonded spatiality in order to build an intelligible argument. A further complication arises from the highly subjective nature of human spatial experience in general, and in acousmatic music in particular, which by virtue of its diversity of sonic materials and the different listening behaviours they may encourage, can lend itself to a multitude of interpretations and approaches. I have therefore attempted to remain focused in terms of when and where the experience of spectral spatiality is pertinent.

Other than being an integral part of my own musical thinking, I believe spectral spatiality to be directly or indirectly essential to the experience of certain acousmatic works. Here I set out to define the commonalities among musical works that encourage the experience of spectral spatiality, as well as defining a number of criteria for discussing aspects of spectral spatiality within the musical context.

Finally, I would like to briefly discuss a particularly far-reaching assertion that is made here about the meaning of the term ‘space’. Throughout this thesis, I have argued against the notion of ‘space’ as a parameter, and have attempted to develop a theoretical framework in which ‘spatiality’ is thought of as a multifaceted *quality* that is inherent in all sonic phenomena. It is demonstrated that the deeper significance of space as a meaningful musical attribute only becomes apparent when we consider the inherent spatiality of sonic 'matter': how do sounds suggest spaces and spatial qualities as a result of their intrinsic spectromorphological structure? In short, this study encourages a shift of paradigm: not *sound in space*, but *the spatiality of sound*. I go as far as to suggest that in order to explore the meaningfulness of space in the context of musical experience, we must first do away with the notion of 'space' - that is, as an empty canvas in which sounds are arbitrarily positioned in a parametric fashion.[4] I am, therefore, in agreement with Gibson that "the concept of space has nothing to do with perception"[5], and instead prefer to refer to *spatiality*, which is a multifaceted quality, inherent in, and inseparable from, sound matter.

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[4] In this sense, the term 'spatialisation' is problematic and is avoided throughout this thesis.

[5] Gibson, James J., *The Ecological Approach to Visual Perception*, Taylor & Francis Group (1986), p. 3.

CHAPTER 1

Preliminary Discussions

1.1 The Frequency Domain and Spectral Spatiality

Sonic phenomena can be regarded as complex time-varying spectral structures formed through the distribution of energy within the frequency domain, which covers the continuum between the lowest and the highest thresholds of audible frequencies. One can be more or less objectively orientated in the spectral examination of sound phenomena. A computer-generated sonogram can be seen as more objective, in the sense that it merely visualises time-varying spectral energy, regardless of what is perceptually salient.[6] For instance, a seemingly multi-layered and rich sonogram display may belong to a harmonic sound whose higher spectral components are fused, giving rise to the perception of a single pitch. In other words, what looks like a chord on the sonogram may in fact be a single ‘note’. Furthermore, in a musical context, not all spectral structures are pertinent to the listening experience and therefore an analysis based entirely on the physical spectral content of a work can be potentially misleading.

The spectromorphological framework, on the other hand, explores the deployment of the spectral domain from a more subjective point of view where only perceptually salient features are underlined.[7] Thus the

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[6] Smalley, Denis, ‘Spectromorphology: explaining sound-shapes’, *Organised Sound*, Volume 2, Issue 02, 1997, p. 108.

[7] Ibid., p. 107.

starting point of the spectromorphological framework is the description of perceived spectro-temporal structures of sounds. This is of particular interest in forms of acousmatic music where recognisable source identities and/or more conventional musical attributes such as intervallic relationships and metre are less pertinent. In this context the deployment of the frequency domain is often the focus of the listening experience and directly conditions the creation of listening expectations.[8]

At first glance the spectromorphological approach seems to offer a formalistic method of describing sounds in terms of their intrinsic shapes or gestalts. However, upon further investigation it becomes clear that a formalistic approach based purely on intrinsic structural attributes is not only theoretically misleading but also meaningless on an empirical level. It is highly unlikely that sounds can be completely divorced from known or imagined source identities. Even if these identities are ambiguous and not immediately recognisable, the listener's mind always attempts to conceive the possible causes and sources of spectromorphologies.[9] In addition, it is probable that our inherently multisensory interaction with the environment conditions us to perceive input stimuli from different sense modalities in a holistic manner.[10] In this sense the experience of spectromorphologies is

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[8] Ibid., pp. 109-110.

[9] Even Pierre Schaeffer, despite his efforts in describing sounds in terms of their intrinsic abstract properties, points this out in his notion of *Facture,* as explained by Chion:

> He [Schaeffer] also emphasizes how, in the act of hearing itself, the ear, in order to appreciate the sound, is spontaneously sensitive to the manner in which *it hears it to be made* – not so much in the sense of identifying its source as in identifying the energetic process which gives rise to the sound object. This is why he creates the notion of *facture* (a word derived from to "make", to "do") to describe the way the ear perceives different types of sustainment of sound […].
>
> (Chion, Michel, *Guide to Sound Objects*, translated by John Dack & Christine North, p. 36.)

[10] Handel, Stephen, *Perceptual Coherence*, Oxford University Press (2006), pp. 3-6.

influenced and shaped by cause/source recognition, which is an inseparable aspect of our everyday experience.[11]

The hypothesis of this study is that the deployment of the spectral domain is intertwined with our experience of spatiality in acousmatic music. Listeners often attribute a certain spatiality to the continuum of spectral frequencies as a vertical dimension: spectromorphologies can be perceived as being ‘higher’ or ‘lower’, depending on their spectral make-up.[12] Smalley proposes the term ‘spectral space’ to emphasise this apparent spatial dimension of the spectral domain.[13] Admittedly, here the term ‘space’ is confusing and can be misinterpreted. In this context ‘space’ should be thought of as the ‘spatiality’ evoked by the manner in which spectromorphologies reveal or perceptually highlight the domain of spectral frequencies.[14] In Chapter Two I shall provide a detailed explanation of the cognitive processes that give rise to the apparent vertical dimension of the spectral domain.

1.2 Pitch Space as a Conditioning Factor

The function of the frequency domain, in directly influencing our musical experience, is culturally ingrained through the prevalence of pitch in music. The consistent deployment of pitch structures has trained us to attach

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[11] Smalley, op.cit., p. 108.

[12] In a simplistic sense this spatiality is also reflected in the visual representation of sounds on a sonogram, on which the vertical axis represents the frequency dimension and the horizontal axis represents time.

[13] Smalley, ‘Space-form and the Acousmatic Image’, pp. 44-45.

[14] Smalley, Denis, ‘Spectromorphology in 2010’, *Denis Smalley Polychrome Portraits*, Institut National de l’audiovisuel (2010), pp. 98-99

significance to the manner in which musical materials occupy the frequency domain and move within it. Perceptually, pitched sounds can be clearly located within the frequency continuum. Not only can we judge the placement of pitches relative to each other (in terms of ‘lows’ and ‘highs’) but we also have acquired a priori assumptions about the absolute extreme bounds of pitch space that typically correspond with instrumental registers.[15]

Pitch perception involves two aspects: pitch *height* or *register* and pitch *chroma*.[16] The former, which we will refer to as ‘pitch space’, is often represented as the vertical dimension defined by instrumental registers. (The reasons behind this are investigated in Chapter Two.) Chroma denotes the perceived quality of pitch that remains consistent regardless of register - in other words, the perception of octave equivalence. Chroma is often visualised as outlining a ‘circular’ pattern formed by the cyclical repetition of pitch classes throughout different octaves. Pitch register and chroma coexist in tonal music, together creating an imaginary spiral shape (a combination of the vertical and the circular).

The geometric image of chroma as circular belongs to a rather abstract, theoretical notion of space in music that is used to point out the recursive nature of pitch-class patterns throughout different octaves (registers), but psychoacoustically, chroma is not relevant as an aspect of space as such: pitches in different octaves are perceived as possessing the

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[15] In acousmatic music the extreme boundaries of spectral space have expanded outwards to include registers that are beyond the reach of orchestral instruments and are perhaps more closely associated with the spectral range and dimensions that exist outside music (i.e. environmental sounds including electrical noises, insects and so on).

[16] J. D. Warren, S. Uppenkamp, R. D. Patterson, & T. D. Griffiths, ‘Separating Pitch Chroma and Pitch Height in the Human Brain’, Proceedings of the National Academy of Sciences, 100 (17). pp. 10038-10042.

same chroma rather than directly evoking the visuo-spatial geometry of the circle.[17] However, the notion of chroma is intertwined with register insofar as changing chroma inevitably requires movement in pitch space, making it difficult to distinguish these two concepts in practice. For instance, tonal centres may occur anywhere within the range of an instrument, but the perception of motion in pitch space creates a secondary level of listening expectations that interacts closely with the notion of resolution onto a chroma (tonic). This relationship can be observed in its most simple form in Bach's chorale writing, for instance, where voice-leading and harmonic/tonal directionality are closely intertwined to create a complex and interactive web of motion tendencies within pitch space.[18]

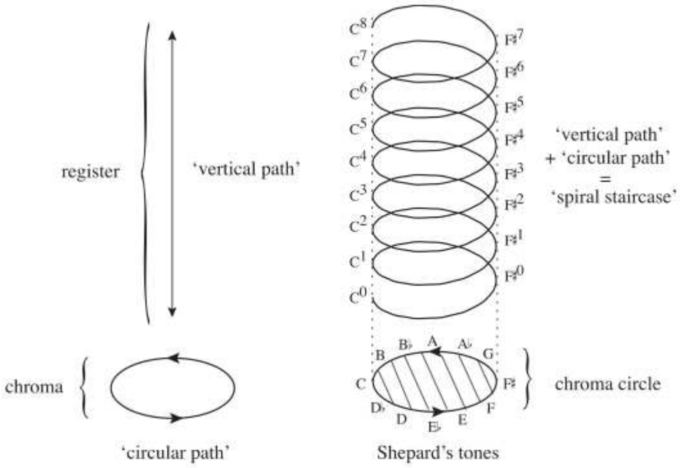

Figure 1. The imaginary spiral staircase resulting from the combination of register and chroma.[19]

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[17] The current discussion is concerned with the notion of chroma from a purely psychoacoustic perspective, but it should be pointed out that within a musical context a pitch-class or pitch-class-set is multidimensional in that its structural function depends on the melodic and harmonic context in which it appears. Often several dimensions coexist, creating a complex web of relationships.

[18] Here one should tread cautiously to avoid involving the relationship between performer's physical effort and change of register, particularly with regard to extreme instrumental/vocal registers, which is an important aspect in the experience of instrumental music.

[19] Image taken from Brower, Candace (2008), 'Paradoxes of Pitch Space', *Music Analysis*, 27(i), p. 68.

1.3 Pitch Space and the Creation of Listening Expectations

Although we may not necessarily be aware of it, listening expectations regarding motion within pitch space play a role in even the simplest of tonal melodies, as demonstrated by Leonard Meyer and David Huron.[20] A good example is the so-called ‘post-skip reversal’ anticipation, which refers to the expectation that large melodic leaps will be followed by motion in the opposite direction. As Meyer explains, the conception of the leap is relative, and depends on the listener's prior exposure to the scale structures that prevail in a particular musical culture.[21] That is, the smallest steps are defined in the scale as increments, and leaps are perceived relative to these increments. It follows that in the West, intervals larger than minor third are perceived as leaps and are expected to be followed by movement in the opposite direction.[22] Meyer describes this expectation in reference to gestalt theory as the tendency towards gap-filling or the completion of incomplete structures.[23] In simple terms this means that a leap is perceived as a structural discontinuity (or a gap in the continuity of the melodic pitch structure), which creates psychological tension and implies a subsequent in-filling process to complete the structure; the structure in its complete form is predefined by the scale.

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[20] See Meyer, Leonard B., *Emotion and Meaning in Music*, The University of Chicago Press (1992) and Huron, D., *Sweet Anticipation: Music and the Psychology of Expectation*, MIT Press(2007).

[21] Meyer, op.cit., pp. 130-132.

[22] Naturally in a pentatonic culture this would not be the case, as a minor third may actually be the smallest possible step (see Meyer cited above).

[23] Meyer, op.cit., pp. 130-132.

Drawing upon the concept of statistical learning, Huron hypothesises that the post-skip reversal expectation is formed as a side-product of regression to the melodic *mean*, which statistically prevails in most melodic structures.[24] Looking at several hundreds of melodies from different cultures and periods Huron points out that melodies tend to have a central point or axis - a note at the centre of the pitch register occupied by the melody. The further away we get from this *mean*, statistically the more likely it is to regress towards it in the subsequent movements. Leaps can immediately distance the melodic tessitura from the *mean* and are therefore often followed by a change of direction back towards the mean. Huron argues that our listening expectations are learned and developed as a result of recurring patterns in our music (e.g. regression to the mean), but due to perceptual errors or memory shortcomings, often listening expectations do not directly follow the patterns themselves. For instance, instead of regression to the mean, listeners expect all large melodic intervals to be followed by a change of direction regardless of their relative location in pitch register and distance from the *mean*. Direct awareness of the melodic mean would require the melodic structure in its entirety to be perceived and remembered while the melody is in progress, a clearly impossible task. Consequently listeners are conditioned (through exposure) simply to expect all large leaps to be followed by motion in the opposite direction.

Thus Huron proposes that listeners are “sensitive to the frequencies of occurrence of different auditory events”, and it is precisely this frequency of occurrence that shapes our listening habits and expectations.

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[24] Huron, op.cit., pp 80-85.

In this sense our listening expectations regarding melodic motion in pitch register are created due to cultural exposure to recurring motion-patterns and arrangements of pitches within pitch register. These include: pitch proximity (prominence of stepwise motions), post-skip reversal (large leaps followed by a change of direction), step inertia (the expectation that small intervals are followed by small intervals) and late-phrase declination (anticipating that phrases will descend in pitch space in the latter part). [25]

1.4 The Emergence of Spectral Space Consciousness

Depending on the musical context, the listener may be more or less directly conscious of the vertical dimension of pitch space and how musical materials move within it. For instance, in situations where materials are present in extreme registers, or when textures/instrumental lines move across a wide register, the perception of exact intervals tends to become less relevant, and the manner in which pitch space is inhabited and explored becomes the driving force behind the creation of direct listening expectations.

Smalley refers to François Delalande's 1989 experiment, which aimed to reveal the listening behaviour of a number of experienced music listeners with regard to Debussy's piano prelude, *La terrasse des audiences au clair de lune*. The difficulty of breaking down the musical material of the prelude into single structural units through listening alone was highlighted in this investigation (a problem that analysts often face with regard to acousmatic music). On the other hand, a prevailing listening

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[25] Huron, op.cit., pp. 73-89.

attitude seemed to focus on the manner in which materials were placed, and moved through pitch space:

> Delalande uncovers the following list, which is based on placement in, and motion through, pitch space, also taking harmonic factors into consideration: transparency of texture, approaching and distancing, 'planes of presence', unveiling, a zoom effect, thickening of melodic line, widening of pitch range; up and down directionality, which includes falls and double falls, upward melodic staircase configurations, poles of attraction, and the feeling of weight. [26]

As another example, consider an excerpt from the penultimate bars of Liszt's late piano work *Nuages Gris*, where motion in pitch register makes the listener aware of a vertical spatial dimension (see **figure 2**). The initial impression is the separation between the lower and upper materials. The left hand material is somewhat stabilised through the use of a bass figure that oscillates between B*b* and A. The inner arpeggiated voice sequentially moves down in chromatic steps, which ensures the lack of tonal harmonic orientation. The high-register material floats above this in a dislocated manner, freed from any sense of rootedness or grounding. One soon becomes conscious of the directed ascending motion of the upper part that seems to levitate through increasing lightness rather than rising in a goal-

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[26] Smalley, 'Space-form and the Acousmatic Image', p. 45.

orientated fashion (perhaps a byproduct of the non-functional harmonic progression of the passage).[27]

Figure 2. The final 18 bars of *Nuages Gris*

The piece ends in the higher region without the presence of a definite root, creating a sense of textural elevation and weightlessness. Also note the lack of tonal resolution that helps keep the texture hanging in the upper register. Finally, we are left with the impression that the ascent could continue beyond the end of the piece with relative ease.

Here it is worth reemphasising that in the context of spectral space consciousness, space, or rather, spatiality, must be viewed as a potential of the sonic materials themselves: they afford spatiality, largely as the result of the manner in which they articulate and texture the spectral domain. In a sense, the remainder of this thesis is an attempt to develop the conceptual framework that stems from this assertion.

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[27] Although the increasing lightness and sense of elevation depends on performance interpretation, its realisation seems a feasible outcome of the spatiality suggested in the score.

1.5 The Problem of Analysis

The term ‘spectral space’ highlights the subjective spatial character of the frequency domain. Therefore in order for spectral space to be perceived, listening attention must first be engaged with the deployment of the spectral domain. Here we are initially interested in looking at musical contexts where the manner in which spectromorphologies occupy and move within the frequency domain becomes the focus of the listening experience. However, this spectromorphologically-orientated listening attitude is by no means a ‘natural’ practice, but a culturally-fashioned skill or habit that relies on the listener’s past musical experience as well as distinctive characteristics of the musical context itself. For instance, while some musical works or passages more easily lure the listener into embracing this listening attitude, practised listeners can focus their attention on the intrinsic spectromorphological dimension of sound in any context and with regard to any sound.[28]

In this sense it is no exaggeration to state that all spectrally complex sounds are pregnant with the implication of spectral spatiality that is ready to be unveiled as a perceived characteristic through the adoption of a particular listening approach. Consequently it follows that to explore the deployment of the frequency domain is to reveal its inherent spatiality; by virtue of highlighting the deployment of the frequency domain we are encouraging the manifestation of spectral space as a pertinent listening attribute.

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[28] Whether this exercise will reveal a musically interesting prospect for all sounds is a different question.

The reader may wonder about the usefulness of this approach, particularly if spectral spatiality is not explicitly or consciously experienced. One of the aims of an analytical study is to advance our understanding of musical experience by uncovering aspects that are not directly or consciously encountered under normal listening conditions, but which are nevertheless the source of many implicit expectations that structure the totality of the listening experience. Moreover, one must enquire: which listener are we dealing with, and in what context? If the experience of spectral spatiality is culturally shared amongst a group of listeners (on a voluntary or involuntary basis) with regard to certain works of music, then it must be considered relevant to the analysis of these works. It is thenceforth valuable to ask what is it that these works have in common in terms of their intrinsic structural features? How do these features function with regard to listeners' cognition and composers' intentions?

Here we must also point out the difference between spectral spatiality as a conditioning factor and its presence as the conscious focus of the listening experience. It is important to distinguish between what Delalande calls "a perceived characteristic and a characteristic which is pertinent to perception".[29] Often our listening expectations are influenced by structural features that are not themselves directly and explicitly perceived; according to Delalande these features can be called 'pertinent to perception' even though they are not perceived as such. As a culturally inherited model, spectral spatiality can be an important habituating factor that shapes our

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[29] Delalande, François, 'Music analysis and reception behaviours: *Sommeil* by Pierre Henry', *Journal of New Music Research*, Volume 27, Issue 1 & 2 June 1998, p. 38.

listening experience without necessarily being a perceived characteristic. However, this spatiality is only revealed unequivocally when the deployment of the frequency domain becomes a perceived feature of the musical structure. Even when the frequency domain is perceived directly it may happen that the listener/analyst takes its spatiality as a given and fails to underline its relevance to the felt listening experience, or perhaps lacks the appropriate verbal language to do so.

As a final note let us suggest that a musical composition is not simply a hieroglyph that necessitates a prescribed solution in order to be decoded. The musical work is always less lucid and far more complex and organic. Nevertheless, my thinking resonates with Vaggione's when he suggests that "in music there is always an effective way to listen".[30] In this sense, the question is not whether spectral spatiality exists in a musical work, but whether it is relevant as an aspect of meaning-making. To what degree and in what context does spectral spatiality contribute towards an effective way of listening? What are the perceptual processes and sonic structures involved in its experience? These are the questions that I intended to answer in this study.

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[30] Vaggione, Horacio & Antonia Soulez, 'Composing, Listening', *Contemporary Music Review*, Volume 24, No. 4/5, August/October 2005, p. 335.

CHAPTER 2

Spectral Space – a Metaphor?

Correspondences
Nature is a temple in which living pillars
Sometimes give voice to confused words;
Man passes there through forests of symbols
Which look at him with understanding eyes.
Like prolonged echoes mingling in the distance
In a deep and tenebrous unity,
Vast as the dark of night and as the light of day,
Perfumes, sounds, and colors correspond.
There are perfumes as cool as the flesh of children,
Sweet as oboes, green as meadows—
And others are corrupt, and rich, triumphant,
With power to expand into infinity,
Like amber and incense, musk, benzoin,
That sing the ecstasy of the soul and senses.

— Charles Baudelaire[31]

2.1 Prelude

In *Sound Structure in Music* under the chapter relevantly titled *Are Sounds Spatial?* Robert Erickson highlights the spatial dimension present in our experience of pitch register:

> Musicians have paid little attention to any intrinsic spatial qualities in musical sounds and textures, but there is compelling evidence that pitch, for example, has a vertical dimension.[32]

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[31] William Aggeler, The Flowers of Evil (Fresno, CA: Academy Library Guild, 1954).

[32] Erickson, Robert, *Sound Structure in Music,* University of California Press (1975), p. 142.

As Pratt noted in 1930, Stumpf, in 1883, had already found that adjectives meaning high and low (or words closely related in meaning) had been applied to tones in most known languages.[33] And it seems that the metaphorical terminology often directly reflects the musical experience itself. In his book *Sync or Swarm: Improvising Music in a Complex Age* David Borgo quotes Larry Zbikowski in an attempt to express this point:

> Although we speak of "musical space" (and locate tones within it), this space does not correspond, in a rational way, to physical space; although we speak of "musical motion," the motion is at best apparent, and not real. The concepts of space and motion are extended to music through metaphorical transference as a way to account for certain aspects of our experience of music. These metaphors are not an addition to musical understanding, but are in fact basic to it.[34]

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33 See Pratt, C. C. 'The Spatial Character of High and Low Tones', *Journal of Experimental Psychology*, 13(3) (1930), pp. 278-285. Here we shall limit our attention to the Western cultural influence in order to avoid unfounded generalisations. Looking outside Western European cultures we are confronted with numerous naming systems based on drastically different semantic frameworks. For instance Richard Ashley discusses different naming schemes for identifying the keys of the mbira instrument in Africa alone. Pitches of mbira can be named in reference to human age, gender, physical properties of the instruments (e.g. size of the resonating bodies), categorical aspects of a person or object such as "the lion" or "the mad person" (Ashley, Richard, 'Musical Pitch Space Across Modalities: Spatial and Other Mappings Through Language and Culture', Proceedings of ICMPC8 (2004), pp. 64-71.).

Levinson and colleagues' cross-cultural investigations suggest that "linguistic diversity aligns with cognitive diversity, as shown in people's language independent solutions to spatial tasks and unselfconscious gestures accompanying speech" (Asifa Majid, Melissa Bowerman, Sotaro Kita, Daniel B.M. Haun and Stephen C. Levinson, 'Can language restructure cognition?', TRENDS in Cognitive Sciences, Vol.8 No.3 March 2004). Indeed there is plenty of evidence that patterns in language reflect patterns in thought (see Boroditsky, p. 2). However, one could argue that the language used to describe musical pitches may reflect incidental factors associated with music-making: this does not necessarily rule out the relevance of the verticality of pitch register in the context of *felt* musical experience. On the other hand, if the vertical perception of pitch register per se is assumed to have its basis in universal human physiology (as it will be suggested later there is much evidence to support this), it would not by necessity find its way into the music of a culture in a meaningful manner or at least beyond the nonconscious level of experience. In other words, physiologically-based aspects of our cognition may be open to culturally-induced variations.

34 Borgo, David, *Sync or Swarm: Improvising Music in a Complex Age,* New York and London: Continuum International Publishing Group (2005), p. 46.

Is the spatial perception of pitch register culturally/ecologically learned or is it based on innate physiological attributes? To what extent is the notion of pitch space metaphorical as opposed to *real* on a perceptual phenomenological level? To what degree does our terminology of 'high' and 'low' pitches reflect our musical experience?

2.2 The Perception of Elevation in the Auditory Image

Let us briefly consider the auditory mechanism that enables humans to localise acoustic sources in the environment. Our ability to locate the right/left positioning of sound sources depends on interaural differences in intensity, time and spectral structure of acoustic signals. Interaural spectral differences result from the diffraction and reflection caused by the interaction of the incident wave with the listener's head that occupies the space between the ears. (This only affects higher spectral frequencies whose wavelengths correspond with the dimensions of the head.)

Since the ears are positioned laterally on the sides of the head, interaural differences cannot serve as useful cues for determining front/back positioning without head movement. In order to distinguish the front/back positioning of sources, we take advantage of subtle spectral changes in incoming signals caused by the forward-pointing pinnae. (Sound waves that encounter the back of the pinna undergo acoustic reflection and diffraction.) Likewise, the ears are vertically levelled so interaural differences cannot serve as useful elevation cues. But since the structure of the pinna is not symmetrical along its vertical axis the acoustics of the pinna provide the means for identifying sound-source elevation. As the angle of elevation of the source varies, so does the pattern of reflection and diffraction caused by the asymmetrically-shaped pinna. This results in spectral modifications above the frequency of 4 kHz, where the wavelengths become comparable with the size of the pinna, with the most significant cues, the so-called 'pinna notch', ranging between 6 and 12 kHz.[35] Studies have also shown that the elevation of complex auditory signals possessing only lower frequencies may be recognisable due to acoustic disturbances caused by the human head and torso.[36]

It has been demonstrated that the impression of elevation can be induced through the direct manipulation of the spectral content of the acoustic stimuli.[37] Significantly, there is a correlation between the increase in high-frequency spectral energy and the perceived elevation of sounds.[38] For instance, studies using narrow-band monaural signals (such as filtered noise or pure sine-tones) show "that perceived elevation varies with the centre frequency of a sound".[39] It is noteworthy to mention that this phenomenon was observed by Stockhausen who suggested the possibility of creating a sense of spatial elevation and motion by means of spectral design alone:

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[35] Susnik, Rudolf, Jake Sodnik & Saso Tomazic, 'Coding Elevation in Acoustic Image of Space', *Proceedings of ACOUSTICS* (2005), pp. 145-50.

[36] Ibid.

[37] Bloom, P. Jeffery, 'Creating Source Elevation Illusions by Spectral Manipulation', *Journal of the Audio Engineering Society* 25(9) (1977), pp. 560-65.

[38] Susnik, op.cit.

[39] Ibid.

> I can even simulate sounds moving up the wall with only two fixed speakers. Not all sounds, you understand, only those of certain frequencies. And you have to cheat to give an impression of "writing" with sounds vertically up and down the wall, or from front to back. The sounds should brighten in the high frequencies as they move upward, and lose brightness as they move downward. In this way an impression is created that the sound is moving up and down, because of the way our ears are constructed, and the way the sound reflections change depending on the distance of a source from the ground, house walls, trees, and so on. I used to sit at my desk with my eyes closed and wonder how it was that I could hear the birds outside my window were flying up or down, high or low. After a while I perceived that the impression was due to changes in the brilliance of the sound, and so now, when I do the same thing in the studio: phase-shifting plus continuous changes of frequency and amplitude, I can get a similar effect.[40]

The results from a 2005 study by Susnik and colleagues confirm that human subjects consistently perceive the test stimuli (modulated pink-noise, bandpass-filtered white-noise, lowpass-filtered pink-noise/white-noise, and sine tone, all played for a duration of 100ms to 24 volunteer subjects in an anechoic chamber) as varying in elevation in congruence

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[40] Stockhausen, Karlheinz & Robin Maconie, *Stockhausen on Music*, Marion Boyars Publishers Ltd (2000), pp. 149-151.

with frequency variation.[41] As the results of empirical experiments carried out by Susnik *et al*. indicate "in certain cases subjects were able to perceive up to 60 different elevations in the range of -40° to 90°."[42] Note that this investigation does not take into consideration head-related transfer functions (HRTF), which would in this context describe the precise spectral transformations resulting from reflections and diffractions of the body, head and pinna and would therefore depend on the individual subjects' physiology (the exact shape and size of the head and the pinnae). Unlike experiments using HRTFs, with this "artificial elevation coding" subjects cannot judge the absolute degree of elevation of sounds but are nevertheless able to have a relative notion of height among a set of stimuli.[43]

The above phenomenon is sometimes called 'Pratt's effect' in reference to Pratt's 1930 experiment[44] that is considered the first systematic empirical attempt to put the notion of pitch 'height' to test.[45] As suggested above, more recent studies have affirmed the direct influence of spectral envelope, fundamental frequency or sine-tone frequency on the perception of relative elevation of stimuli: higher-frequency stimuli are systematically

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[41] Cabrera and Morimoto have carried out a similar study using complex harmonic stimuli. When the complex tones lacked any spectral component above 7 kHz, the fundamental frequencies of these tones were used as the main cues in the judgment of elevation, regardless of the actual positioning of the sources. However, with broader-band square-wave tones the fundamental frequency did not seem to have any noticeable influence on the perceived elevation. See Cabrera, Densil 'Influence of Fundamental Frequency and Source Elevation on the Vertical Localization of Complex Tones and Complex Tone Pairs', *The Journal of the Acoustical Society of America* **122**(1) (2007), pp. 478-88.

[42] Susnik, op.cit., p. 145.

[43] Susnik, op.cit., p. 150.

[44] Pratt, C. C., 'The Spatial Character of High and Low Tones', *Journal of Experimental Psychology*, 13(3) (1930), pp. 278-285.

[45] Cabrera, Densil & Masayuki Morimoto, 'Recent Studies on the Effect of Signal Frequency on Auditory Vertical Localization', *Proceedings of ICAD 05* (2005), pp. 1-8.

perceived as being higher up in space regardless of their actual spatial positioning.[46] According to Cabrera, 'real' source localisation on the vertical plane requires complex signals with frequencies above 7 kHz. When localisation becomes blurred, for instance due to the absence of spectral complexity (when using sine or narrow-band noise signals) or acoustic reflections in the listening environment, Pratt's effect seems to become perceptually prevalent.[47]

Blauert explains Pratt's effect as part of the 'directional bands phenomenon'[48], which originates from observations (1969/70) that 1/3-octave band filtered noise, emanating from a single speaker placed directly in front of the listener (at zero angle), seems to change its apparent elevation on the median plane depending on the centre frequency of the filter.[49] According to this research, bands around 8 kHz are heard overhead whereas other centre frequencies seem to produce the effect that the sound originates from the front or the rear.[50] This is confirmed by the experiment of Itoh *et al.* (2006) "which shows a general increase in image elevation associated with 1/3- or 1/6-octave band center frequency up to about 8 kHz, after which the image usually descends".[51] Although these studies use

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[46] Ibid.

[47] Cabrera, Densil 'Influence of Fundamental Frequency and Source Elevation on the Vertical Localization of Complex Tones and Complex Tone Pairs', *The Journal of the Acoustical Society of America* **122**(1) (2007), pp. 478-88.

[48] Blauert, Jens, *Spatial Hearing: The Psychophysics of Human Sound Localization*, rev. ed., MIT Press, Cambridge (1975), pp. 103-117.

[49] Cabrera, 'Influence of Fundamental Frequency and Source Elevation on the Vertical Localization of Complex Tones and Complex Tone Pairs', p. 479.

[50] Ibid.

[51] Ibid.

narrow-band noise, Pratt's effect has been observed with regard to broader-band noise and can be thought of as being dependent on spectral envelope rather than pitch.[52] Furthermore, Pratt's effect has been observed even in the presence of interaural differences (for example when the stimuli emanate from speakers placed on the lateral plane).[53] In fact, the actual spatial positioning of the sound stimuli does not seem to influence significantly the perceived elevation when the perception of prevalent pinna-related spectral features is eliminated by filtering out frequencies above 7 kHz.[54]

Blauert's directional bands phenomenon does not explain the occurrence of Pratt's effect in the absence of frequencies above 7 kHz - that is, when pinna-related spectral cues are missing.[55] Cabrera *et al.* propose the possibility that "learning from environmental transfer functions in everyday life" may lead to the establishment of associations between low frequency and low elevation.[56] Others have attempted to describe Pratt's effect as being purely metaphorical, resulting from linguistic or visual associations. However, experimental data support Cabrera's theory: (1) Pratt's effect has been observed in the responses of children as young as 4 years who do not seem to have formed any obvious linguistic associations

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[52] Ibid.

[53] Cabrera, Densil & Masayuki Morimoto, 'Recent Studies on the Effect of Signal Frequency on Auditory Vertical Localization', *Proceedings of ICAD 05* (2005), p. 4.

[54] Cabrera, 'Influence of Fundamental Frequency and Source Elevation on the Vertical Localization of Complex Tones and Complex Tone Pairs', pp. 478-88.

[55] Ibid. p. 486.

[56] Ibid.

between pitch and height ("low" and "high" tones); (2) it is influenced by the presence of visual stimuli. (The visual scales provided for the annotation of the elevation angle influence the magnitude of elevation but <u>not the relative vertical ordering of stimuli.</u>) (3) It does not necessarily originate from visual associations since it has been observed in congenitally blind subjects.[57] (4) It operates on an egocentric, rather than absolute, spatial coordinate system. That is, subjects lying on their backs or sides still perceive the 'elevation' in reference to their body's vertical axis rather than the direction of gravity.[58] This final point can be explained on the basis that when lying down, the listener's ability to judge the degree of elevation of sound sources is eliminated altogether and thus listeners tend to rely on the intrinsic spectral structure of the sound. Note that Pratt's effect is revealed in a context where listeners are *primed* to judge the elevation of auditory stimuli and when the stimuli lack sufficient localisation cues. (This explains the influence of the visual dimension.) In this light we may conclude that (a) Pratt's effect has its basis in the physiology of spatial hearing and that (b) it is pertinent in the context of subjective decision-making rather than as a *natural* perceptual phenomenon.

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[57] Ibid., p. 478.

[58] Roffler and Butler devised a slightly more complicated context for subjects lying on their sides by asking them to locate the position of the tones (emanating from a vertical array of hidden speakers) on an inverted T-shaped panel placed in the room. Subjects predominantly perceived higher-frequency stimuli to occupy a 'higher' position on the panel in relation to their bodies but occasionally estimated their placement on the absolute vertical plane of the panel, regardless of the actual speaker from which the sounds were projected. (Soffler, Susan & Robert A. Butler, 'Factors That Influence the Localization of Sound in the Vertical Plane', *The Journal of the Acoustical Society of America* (1967), pp. 1255-1259. Also see Cabrera 2005/2007.)

As proposed in Chapter One, in music, spectral spatiality comes to the fore in a context where listeners are also primed and habituated to *feel* the apparent vertical motion and relative positioning of sound 'sources' as musically significant and meaningful. Thus spectral spatiality must to an extent be inherent to the musical work itself and therefore culturally ingrained as a meaningful quality of our musical imagination. In other words there must be more to the experience of spectral spatiality than the mere perception of *up* and *down*.

2.3 Ecological Influences

In attempting to explain the connection between pitch and vertical height Wishart speculates that in comparison to larger earth-bound creatures, smaller sky-bound animals produce utterances in the higher frequency range.[59] Similarly, Pratt points out the seemingly intuitive semantic connection between size and pitch by noting that lower pitches "give the impression of voluminousness and massiveness as contrasted with the thinness and smallness of high tones".[60] According to Pratt this is also reflected in our experience of musical motion where rapid passages can sound "light and airy" in the higher register, whereas they feel "heavy, clumsy, and labored" in the lower register.[61] He then goes on to suggest an ecological link:

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[59] Wishart, Trevor, *On Sonic Art,* Gordon and Breach (1996), p. 191.

[60] Pratt, op.cit., p. 280.

[61] Pratt, op.cit., p. 280.

> Thin, small, light, airy: these are terms suitable for objects which, if not always found at high altitudes, are at any rate up and away from the ground. Dark and gloomy objects tend to be nearer the surface of the earth, the massive parts of a structure support the smaller parts, and heavy objects are generally lower in space than light ones.[62]

From an early age we learn that larger resonating bodies have a lower fundamental frequency compared to small resonating objects, which have a higher fundamental frequency. This is an important aspect of source recognition and auditory scene analysis (the ability to segregate auditory stimuli into coherent and identifiable sources).[63] Pitch height is therefore an intrinsic part of *timbre* identification: Warren, Uppenkamp, Patterson and Griffiths have demonstrated (through analysis of brain scans captured under strictly-controlled lab conditions) that, in fact, information regarding pitch height is processed in a different part of the brain than the information regarding pitch chroma. Thus it can be ascertained that “pitch chroma provides a basis for presenting acoustic patterns (melodies) that do not depend on the particular sound sources” and that our brain is neurologically conditioned to process patterns of pitch chroma - that are, for instance, crucial for speech recognition - independently from pitch height - which “provides a basis” for mental representation of acoustic signals as “separate

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[62] Pratt, op.cit., p. 280.

[63] J. D. Warren, S. Uppenkamp, R. D. Patterson, & T. D. Griffiths, ‘Separating Pitch Chroma and Pitch Height in the Human Brain’, Proceedings of the National Academy of Sciences, 100 (17). pp. 10038-10042.

sound sources".[64] Thus we recognise a melody (i.e. tonal patterns or intervallic pitches) regardless of whether it is sung by a man, a child or a woman - different timbral identities formed partly due to variation in size of vocal tracts and consequently pitch height.[65]

The experience of spectral spatiality must, therefore, be influenced by ecologically-learned factors that allow us to perceive sound-events as belonging to spatial objects and agents in the environment. (More on this later.) In this sense, spectral spatiality may also carry meaning that is rooted in aspects of our bodily interaction with the environment, an interaction that functions as the basis of our spatial cognition. Here it seems apt to make a brief detour to explore aspects of the theory of 'embodiment', which can help explain the deeper implications of spectral spatiality in the process of meaning-making in music.

2.4 Embodied Meaning – Introduction

> "[…] to perceive you must be in possession of sensory-motor body skill."
>
> — Alva Noë[66]

In his 1768 paper 'On the First Ground of Distinction of Regions in Space' Kant hypothesised about the inevitability of the egocentric and anthropomorphic basis of human spatial reasoning.[67] He argued that "the

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64 Ibid., p. 10038.

65 Ibid., p. 10039.

66 Alva Noë (2004) quoted in Smalley, 'Space-form and the Acousmatic Image', p. 40.

67 Levinson, op.cit., p. 12.

human body frame is the source of our basic intuitions about the nature of space" and that therefore we are physiologically preconditioned to comprehend the world as a three-dimensional domain.[68] In his *Critique of Pure Reason* Kant defines the category of three-dimensional space as a cognitive a priori for the existence of the phenomenal world, or more specifically as one of the "two pure forms of sensible intuition", where sensibility is defined as "the capacity (receptivity) to acquire representations through the way in which we are affected by objects".[69] According to Kant, we cannot conceive of, or apprehend, anything as existing without this a priori.[70] Shabel notes[71] that, for Kant, "even the 'symbolic construction' of algebra and analysis […] is ostensive, and dependent on the spatial construction of geometry".[72] Despite his

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[68] Asifa Majid, Melissa Bowerman, Sotaro Kita, Daniel B. M. Haun & Stephen C. Levinson, 'Can Language Restructure Cognition? The Case for Space', TRENDS in Cognitive Sciences, 8 (3), March 2004, p. 108.

[69] Shabel, Lisa, 'Reflections on Kant's Concept (and Intuition) of Space', Studies in History and Philosophy of Science, 34 (2003), p. 47.

[70] Note that more recent neurological evidence seems to question the validity of Kant's notion of a transcendental cognitive a priori or pure reason that pre-defines the modes of subject-object relationship. Evidence suggests that instead of being based on some absolute universal a priori, the connection between spatial cognition and more abstract modes of thinking results from the inherently embodied nature of the mind. (See Johnson, p. 20.)

[71] Ibid., p. 46.

[72] There is compelling evidence that the neurological and neurochemical brain structures involved in mental processing of abstract thought are closely related and directly evolve out of those used in spatial cognition, in particular that of *extrapersonal* spatial interaction (distant space that is beyond the body's immediate peripheral reach). According to Previc, the faculty of abstract reasoning in humans has evolved out of the mammalian brain system responsible for extrapersonal spatial interaction:

> The same […] mechanisms that stimulate exploratory locomotion and vertical climbing in rodents and oculomotor exploratory behaviour in lower primates facilitate the search for abstract patterns and meaning in humans in a space that is internally generated but distally oriented.

(Previc, Fred H., 'The role of the extrapersonal brain systems in religious activity', *Consciousness and Cognition* 15 (2006), p. 526.)

Fascinatingly, extrapersonal spatial processing in humans appears to be hardwired for bias towards the upper visual field (looking at the line of horizon, for instance, entails the displacement of the eyes to the upper visual field). Hence subjects often involuntarily gaze upwards during abstract mental processing tasks. This vertical upper bias also characterises schizophrenic visual hallucinations and out-of-body experiences, which are associated with the neurochemical increase in dopaminergic activity also involved, in milder dosage, in extrapersonal spatial processing. Moreover there has been some attempt to account for the upper bias of the concept of 'God' and the apparent connection between religious experience and the extrapersonal brain system. (Previc, 2006.)

questioning of Kant's concept of the universality of the human spatial framework, the cognitive anthropologist Stephen C. Levinson asserts that "it [space] seems to be central to human cognition, providing the essential framework for concrete thinking about objects and events as well as for abstract thinking about many other domains...".[73]

A prevailing notion in modern cognitive science is that spatial cognition is an inseparable and intrinsic part of experiencing the world and constructing mental representations.[74] As Lakoff and Johnson have elaborated, all semantic concepts and abstract human thoughts can be seen as largely rooted in our basic sensorimotor capacity to interact with the environment and are therefore inherently spatial and corporeal.[75] There is compelling empirical evidence that suggests more "[…] abstract domains such as time are indeed shaped by metaphorical mappings from more concrete and experiential domains such as space".[76] Metaphorical mappings used in everyday life are not just byproducts of language but are

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73 Levinson, Stephen C., 'Studying Spatial Conceptualization across Cultures: Anthropology and Cognitive Science', Ethos, 26 (1), Language, Space and Culture (Mar., 1998), p. 9.

74 The term 'mental representation' or 'mental image' must be used cautiously here. Johnson eagerly warns us against the danger of falling into the "classic representational theory of mind" by citing Damasio's explicit rejection of it: "The problem with the term representation is… the implication that, somehow, the mental image or the neural pattern *represents*, in mind and brain, with some degree of fidelity, the object to which the representation refers, as if the structure of the object were replicated in the representation" (Johnson, Mark, *The Meaning of the Body*, University of Chicago Press (2008), pp. 64-65.) Whereas the classic representational theory of mind encourages the subject/object dichotomy on the one hand and the mind/body division on the other, 'representation' as used here should be thought of as the "felt awareness of something going on in our body" that emerges through and is only meaningful within the holistic context of the organism-environment interaction:

> We must stop treating percepts, concepts, propositions, and thoughts as quasi-objects (mental entities or abstract structures) and to see them instead as patterns of experiential interaction. They are aspects or dimensions or structures of the patterns of organism-environment coupling (or integrated interaction) that constitute experience. […] thoughts are just modes of interaction and action. They are *in* and *of* the world (rather than being just *about* the world) because they are processes of experience (Johnson, p. 117.)

75 Boroditsky, Lera, 'Metaphoric structuring: understanding time through spatial metaphors', *Cognition* 75 (2000), pp. 1-28

76 Ibid.

essential to our capacity to process abstract modes of thought: they "ground" our "more abstract structures of meaning".[77]

2.5 Embodied Meaning – Image Schemas

According to Johnson all aspects of meaning are structured through the organism-environment interaction and are therefore inherently bound to sensorimotor capacities.[78] Since our bodies are free to move and act within the environment, felt qualities of motion can be considered to play a crucial role in cognition and the structuring of human thought and experience.[79] Consequently, Johnson and Lakoff[80] put forward the theory of *image schema*, suggesting that sense-making is deeply rooted in our corporeal encounter and interaction (on a pre-reflective and non-conscious level) with the environment, which manifests recurring patterns and structures (schemas).[81] Thus image schemas describe "basic structures of sensorimotor experience by which we encounter a world that we can understand and act within".[82] As such, image schemas are abstracted from the most fundamental "structural features of all human bodily experience"[83]; they typically operate beneath the conscious surface of our

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[77] Johnson, 2007 p. 17.

[78] Johnson, 2007.

[79] Ibid.

[80] See Johnson, Mark, & Lakoff, George, *Metaphors we Live by.* The University of Chicago Press, 1980.

[81] Johnson op.cit., pp. 19-27.

[82] Ibid., p. 136.

[83] Ibid., p. 136.

experiences and thoughts (Johnson and Lakoff refer to this as the *cognitive unconscious*[84]) and are responsible "for our understanding of spatial terms and all aspects of our perception and motor activities".[85]

2.6 Embodied Meaning – Verticality and Gravity

The VERTICALITY schema corresponds to the vertical axis of our body and "the way in which we experience the body in relation to the ground" and gravity.[86] Verticality schema can be thought to be involved in the experience of spectral spatiality and the sense in which it is perceived in relation to gravity. The connection between verticality schema and earthbound gravity or rootedness is highlighted by Brower:

> At a somatosensory level, we experience the ground as a maximally stable location, while associating ascending motion with overcoming the force of gravity (thus effortful or tensing) and descending motion as giving in to the force of gravity (thus relaxing).[87]

Note that Western tonal music is conceived and perceived as being 'root' orientated in its harmonic structure, in the sense that higher triadic pitches are vertically supported upon a harmonic root. A triad is felt to be

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[84] Ibid., p. 139.

[85] Ibid., p. 141.

[86] Johnson, op.cit., p. 137.

[87] Ibid., p. 60.

inherently less stable if it is not in root position (i.e. the root is not present in the bass). Here we may ascertain that the vertical schema is mapped on to the structure of the harmonic spectrum where the fundamental frequency is denoted as the root or ground upon which all other components are erected. (Note that triadic harmony is probably derived from the structure of the harmonic spectrum.)[88]

Stéphane Roy discusses Francois Bayle's concept of gravitational archetype in reference to Bayle's *Ombre Blanches*, defining it as the tendency of material positioned high in spectral space to gravitate towards the lower regions.[89] This implies that ascending movements will create psychological tension since they are going against the natural tendency of moving towards the ground. Descending motion in spectral space resolves this tension by deferring to the gravitational force of the ground. In the same way, according to Bayle, higher spectromorphologies need more effort or energy to sustain themselves over longer periods of time.[90] It should be noted that although our conception of space is directly rooted in our bodily experience, we do not necessarily experience musical elements (spectromorphologies) as extensions of our own body. Rather, we experience them in *relation* to our body. No doubt there is a sense in which we project ourselves into the space of the music, being immersed in it, experiencing it from within; as Brower suggests in relation to a particular

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88 Brower, Candace (2008), 'Paradoxes of Pitch Space'. In *Music Analysis*, 27(i), p. 66.

89 Roy, Stéphane, 'Functional and Implicative Analysis of Ombres Blanches' Journal of New Music Research Vol.27, No. 1-2 (Swets & Zeitlinger Publishers, 1998), p. 174.

90 Smalley, 'Space-form and the Acousmatic Image', pp. 45-46.

harmonic progression in Wagner's *Parsifal* "we grasp the paradoxical nature of the polar progressions of Wagner's Parsifal only by projecting ourselves into its musical space, thereby experiencing from within that space the feeling of decentredness…."[91] This is, however, not the same as projecting ourselves onto the musical elements themselves (as the notion of gravitational archetype seems to suggest). The gravitational archetype as described by Bayle can be misleading if viewed as a context-independent formula, and does not account for many musical situations in which, as Smalley points out, harmonic rootedness is annihilated, allowing spectromorphologies to elevate without any sense of tension.[92]

Jonathan Harvey proposes the idea that Western music history is characterised by a progressive "liberation" from the harmonic root through the advance of atonality in Western art music - harmonies radiating outwards from the centre, rather than implying earth-bound rootedness:

> The original connection of serialism with heaven, or transcendental consciousness of some sort, will strike many as grotesque - especially those who find serial music turgid and negative, expressive of pain and conflict [...]. But my ear suspects that in such music the bass is still struggling at the bottom, alienated and bearing an enormous tension of dislocated dissonance, trying to be a root under somewhat unfavourable and stressed conditions. Music which floats, in which it is unattractive and implausible for

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[91] Brower, op.cit., p. 59.

[92] Smalley, 'Space-form and the Acousmatic Image', pp. 45-46.

> consciousness to read a bass at the bottom, is a different matter.[93]

Harvey then asserts that the move away from the earthbound rootedness of tonal harmony has liberated the composition of space in music, much in comparison to painting:

> The Bass moves into the middle: this is our musical revolution. [...] Why is it important or interesting for this to happen? Why was it important for painting to grow beyond earth/sky gravitational systems and liberate space?[94]

Although the above comment underlines the embodied nature of spectral spatiality in music, the idea of liberating the verticality of spectral space from the gravitational system is questionable. As a universally omnipresent force on our bodies, gravity structures the verticality schema and is therefore inherently bound to it. The experience of verticality or height is only meaningful to us within the embodied and earthbound framework. We may experience sonic elements as ‘weightless’ but this weightlessness is only meaningful in relation to our embodied earthbound existence.

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[93] Harvey, Jonathan, ‘Reflection after Composing’, *Tempo, New Series*, No. 140 (March, 1982), p. 3.

[94] Ibid., p. 2.

2.7 Interlude

Wagner’s Prelude to Act One of *Lohengrin* can be mentioned as a classic example of the utilisation of pitch space for the creation of spatial impression. Here we also have the accompanying literary programme from Baudelaire that clearly refers to allegories of movement through space.[95] (Italics appear in Baudelaire’s original text):

> I remember that from the very first bars I suffered one of those happy impressions that almost all imaginative men have known, through dreams, in sleep. I felt myself released from the *bonds of gravity,* and I rediscovered in memory that extraordinary *thrill of pleasure* which dwells in *high places*.[96]

He goes on to say that “no musician excels as Wagner does in painting space and depth, both material and spiritual”.[97] It is clear that his allegories of spatial dimensions reflect certain aspects of the spectral design of this passage, namely the light and thin quality of the violin timbre and the presence of high-pitched textures that consistently fall free of the harmonic root (the root-positioned A major triad is present only momentarily in bars one and two).

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[95] Baudelaire, Charles, *The Painter of Modern Life and Other Essays*, Phaidon Press Limited (1995), p. 116.

[96] "Je me souviens que, dès les premières mesures, je subis une de ces impressions heureuses que presque tous les hommes imaginatifs ont connues, par le rêve, dans le sommeil. Je me sentis délivré *des liens de la pesanteur*, et je retrouvai par le souvenir l'extraordinaire *volupté* qui circule dans *les lieux hauts*." Baudelaire, Charles, ‘L’Art romantique’, *Œuvres complètes de Charles Baudelaire*, Vol. III, Calmann Lévy (Paris: 1885), p. 225.

[97] Ibid., p. 116.


Langsam.
3 grosse Flöten.
2 Hoboen.
Englisches Horn.
2 Clarinetten in A.
Bass-Clarinette in A.
3 Fagotte.
2 Hörner in E.
2 Hörner in D.
3 Trompeten in D.
3 Posaunen (2 Tenor u. 1 Bass P.)
Bass-Tuba.
Pauken in A u. E.
Becken.
*) Durch Flageolet hervorzubringen.
(natürlich)
4 einzelne Violinen.
Sämmtliche übrige Violinen in 4 gleich stark besetzten Partien.
Bratschen.
Violoncelle.
Contrabässe.
pp
dim.
p
Langsam.

Figure 3. ***Lohengrin***

The first few bars of the *Lohengrin* prelude are marked by an effortlessly sustained sense of elevation within pitch space. For the first five bars there is no harmonic progression, all movement being presented through a spectral exploration of the A major triad alone. At the very outset a gentle push (created through a small crescendo from *pp* to *p*) from the lower violin part and oboe is all that is needed to introduce the chord and prompt its consequent upward motion. The orchestrated upward gliding through the spectral contents of the A major chord draws the listener's attention to the higher regions of pitch space. Texture is then left there, effortlessly floating in the upper register.

2.8 Multimodal Perception

An important character of image schemas is that they operate across different sense modalities. This is based on the idea that different modalities work together in the context of organism-environment interaction in order to make sense of the flow of experiences. Thus the theory of embodied cognition challenges the conventional separation between sense-modalities and instead views cognition as emerging from a holistic system of relationships. As Johnson elaborates:

> When you see a cup sitting on the table in front of you, you are not just having a *visual* experience. In addition to the activation of neural clusters in parts of your visual cortices, you are experiencing that cup as something you could reach for, grasp, pick up, and raise to your lips to quench your thirst. The cup affords not just a visual form; it also affords pick-up-ability.[98]

Similarly, in an acousmatic context a sound is not just a sonic experience but it is felt and internalised in the context of our embodied and multisensory cognition. As Huron asserts, sounds “are not organised in the brain like phonograph recordings” but are instead interpreted, distilled and represented.[99] Handel emphasises that perception is not by any means “passive” but it is an actively creative process.[100] Our mind has selectively

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98 Johnson, op.cit., p. 160.

99 Huron, op.cit., p. 7.

100 Handel, Stephen, *Perceptual Coherence* (Oxford University Press: 2006), p. 4.

to filter data collected from different sense-modalities and match them up to perceive objects in time and space.[101] Thus perception should be considered as a holistic system, much in contrast with the conventional classification of the different sense-modalities into independent faculties.

In his paper *Space-form and the Acousmatic Image* Smalley refers to the spilling over of other sense modalities into our sonic experience, mentioning that, for instance, “our sense of texture is learned through vision and touch as well as sound. [...] spectral motion, and movement and distribution of sound in space relate to our own experience of physical motion and cultural and natural environments.”[102] Furthermore, in acousmatic music we seem to be even more conscious of this sensory spilling than in non-acousmatic music. Our mind establishes links between all sense modalities (e.g. visual, kinetic, etc.) to enable an integrated interaction with the environment. As Smalley suggests “transmodal linking occurs automatically when the sonic materials seem to evoke what we imagine to be the experience of the world outside the music”[103] and continues to argue that acousmatic listening, far from inducing “some kind of sensory deprivation” enriches the multi-sensory experience[104]:

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[101] Handel, op.cit., p. 4.

[102] Smalley, op.cit., p. 39.

[103] Ibid., p. 39.

[104] Ibid., p. 39.

> From sound alone I can constitute in my imagination the layout and activity of a scene; or the shape of a spectromorphological event (however 'abstract') as its spectral space moves in relation to me; or the apparent size, dimensions and texture of an object. This is indeed a 'vision' where the auditory sense calls on the companion senses to participate in the enactment of spatial experience.[105]

2.9 Summary

We have provided indisputable evidence that the verticality of spectral space has its basis in the human physiology. We proposed that *up* and *down* of spectral spatiality is meaningful due to the emergence of ecologically significant (source-bonded) associations, and the directly-embodied (and therefore multisensory) character of the felt experience of spatiality in music. Here we may conclude that the metaphorical notion of spatial height can reflect pertinent qualities of our musical experience and imagination. Furthermore, the embodied and multimodal aspects of experience can emerge in a more explicit manner in acousmatic music: the lack of visual cues and immediately recognisable sound sources can enable the creation of a musical context in which the experience of spectral spatiality is brought to the foreground as a facet of sense-making. This brings us to the idea of *entities* discussed in the next chapter.

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[105] Ibid., p. 40.

CHAPTER 3

Defining Autonomous Spectromorphological Entities

3.1 Preliminary Discussions

3.1.1 Preface

We have argued that the spatial experience in acousmatic music must be viewed in a holistic fashion that reflects the embodied and multimodal nature of cognition. At this point we must leave behind the conventional conceptual dichotomy between ‘abstract’ and ‘representational’: the notion of representation is too simplistic in this context, since it views sounds as signs for external objects and ideas but it frequently fails to grasp the embodied and multisensory nature of all sonic experience, no matter how unfamiliar or ‘abstract’. In this chapter we introduce a terminological framework for detailing the intrinsic spectromorphological behaviours by means of which more abstract acousmatic sounds afford a sense of spatiality. Ultimately our intention is to observe the way in which these affordances can influence the construction of meaningful musical contexts.

3.1.2 Sounding Events and Spatiality

In *Perceptual Coherence* Stephen Handel suggests that “the usual distinction that vision gives us objects and audition gives us events is a trap”, which “misleads us into thinking about vision as a spatial sense and about audition as a temporal sense".[106] He then goes on to assert: "all perceiving concerns" things that "exist in space and time simultaneously".[107] Similarly, in a 2010 paper Gary Kendall considers the inherent spatiality of sound events by describing them as "intrinsically spatial" because they "take place in space":

> Listeners can often infer the physical scale of the actions, objects and agents that produce events, as well as the likely physical context in which events take place.[108]

In this sense the spatiality of sound is not merely about the perceived position and movement of real or virtual sound sources in relation to the listener (perspective) or the acoustics of a spatial setting; but rather, the entire experiential context in which sound exists *spatially* and is perceived as belonging to spatial objects and interactions.[109] For example, the discernment of human gestural activity in the energy-trajectory of a sounding event affords a sense of embodied spatial motion and intentionality that is profoundly meaningful to us and arouses distinct

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106 Handel, Stephen, *Perceptual Coherence*, Oxford University Press (2006), p. 5.

107 Ibid. p. 5.

108 Kendall, Gary (2010), 'Spatial Perception and Cognition in Multichannel Audio for Electroacoustic Music', p. 229.

109 Smalley discusses three conceptually distinct (but phenomenally interconnected) notions of spatiality. (Smalley, 'Space-form and the Acousmatic Image', p. 55.) Briefly these are:
Source-bonded - "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."
Perspectival – "The relations of spatial position, movement and scale among spectromorphologies, viewed from the listener's vantage point."
Spectral – "The impression of space and spaciousness produced by occupancy of, and motion within, the range of audible frequencies."

feelings and emotions.[110] Furthermore, as suggested by Kendall, by evoking physical behaviours and objects, the sonic experience also entails contexts characterised by spatial qualities. Hearing the passing of a distant train at night immediately transports my mind to the railway setting. As the train disappears into the distance, my mind attends to the depth of space that exists beyond my ears' reach. I may begin to wonder about the destination of the train, the distance covered by its journey, its distance from me, etc. In short, through sound alone my awareness of the surrounding spatial context is enriched, stretching from the intimacy of my bedroom to the extra-personal space 'out there'. Thus spatiality plays a crucial part in how we experience sounds as full of meaning and feeling in everyday life.[111]

As implied in the second chapter, listeners also experience spatial qualities in the context of less familiar sounds that do not establish explicit real-world inferences.[112] No matter how 'abstract', sounds are mentally structured in conformity with our embodied spatial cognition: they are experienced as belonging to spatial forms and contexts. The difference is that less overtly source-bonded sounds elicit a shift of listening-focus from extrinsic identities towards intrinsic spectromorphological details.[113] Here spectral spatiality surfaces as an integral facet of sense-making:

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[110] See Smalley's "Gestural Space", a subcategory of source-bonded space that describes the "intimate or personal, source-bonded zone, produced by the energy of causal gesture moving through space, as with performer and instrument, or agent and sound-making apparatus." Smalley, 'Space-form and the Acousmatic Image', p. 55.

[111] Kendall, op.cit., p. 229

[112] Kendall, op.cit., p. 229

[113] According to Carello and colleagues "[…] when listeners are unable to identify the source of a sound […] they resort to reporting its sensory aspects, in effect converting from everyday to musical listening".

spectromorphological configurations attain perceptual qualities such as elevation, depth, volume, texture and motion. In this respect spectromorphologies *afford* transmodal inferences that help structure our more obscure sonic encounters into meaningful experiences. Not surprisingly, the experience of these spatial qualities influences and enriches our musical imagination.[114]

3.1.3 Emergence of Autonomous Spectromorphological Entities

The degrees of recognisability of sounds seem to have a direct relationship with the different cognitive stages involved in source/cause-recognition: is the sound immediately identified as a bird utterance? Or perhaps only on further reflection (at a later stage) can we detect certain vestiges of bird-like utterances in its spectromorphological content. On the other hand, the sound's apparent motion through, and occupancy of, spectral space may evoke the *behaviour* of a bird-like *entity* on a multimodal level. In this context the spectromorphology itself becomes the entity (bird). Here spectromorphologies are perceived as spatial entities that populate or occupy the vertical spectral dimension (as well as perspectival space in general). Thus the ontological notions of 'sound' and 'source' become

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[114] Note the significance of listening habit in the context of music. The sonic context can encourage listeners to pay close attention to the intrinsic spectromorphological structures by obscuring obvious real-world references. Nevertheless, the cognitive state in which spectromorphologies evoke transmodal spatial qualities is to an extent actively stimulated or encouraged by the listener. Some listeners may find it more difficult to accept a sonic environment free of familiar causal relationships and therefore fall back onto technological listening or invent other 'real' causal associations. After all, in an acousmatic context the sound is always physically produced by speakers, which can be considered as point-sources in listening space. As Gary Kendall suggests:

> Importantly, in the context of electroacoustic art, the listener must [or *can*] relax the tight grip of plausibility to accommodate potential artistic meanings that arise from unexpected or novel spatial relationships. This is the same way that we relax our framework of spatial relationships when viewing a painting that stretches and distorts space for expressive purposes. Kendall, Gary (2010), 'Spatial Perception and Cognition in Multichannel Audio for Electroacoustic Music', p. 229.

blurred: more abstract sounds can evoke visuo-spatial entities with real-world characteristics.

An example from the coda section of Risset's *Songes*[115] (see sound example 3 and 4 for stereo and quadraphonic versions respectively) may help clarify this idea. Here spectral space is reduced to its bare skeletal frame - a low, sustained drone supporting more animated higher-frequency materials. The manner in which the higher spectromorphology articulates spectral and perspectival spaces evokes the flight or drift motion of a birdlike creature. The animated sky-bound entity contrasts with the inanimate and more voluminous drone of the root. The inherent characteristic of a bird is revealed over the course of the passage, which is broken into distinct phrases of varying lengths with predominantly graduated-continuant morphologies. Note the intrinsic spectral structure, pitch modulation and occasional chirp-like quality of the sound that at times resembles bird-like utterances. The bird is not merely an imagined source of the sound, *it is* the sound itself as *it* hovers through spectral and perspectival spaces: the signifier and the signified have merged on a perceptual level.

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[115] Risset, Jean-Claude, *Songes / Passages / Computer Suite from Music for Little Boy / Sud (Music with Computers)*, Wergo, WER2013-50.

Here morphology goes beyond the immediate temporal structure of sonic events and highlights the presence of an overall character or *personage* (to borrow a term from Chion[116]) which reveals the manner of energy-expenditure and motion of a spatial being, thus moving into the realm of space-form where time is collapsed into a *form* with spatial qualities.[117] In this sense morphology becomes synonymous with the character or form of the bird's inner-life - the apparent autonomous energy that *animates* the entity. Indeed, often the identity of an entity is deduced from chains of morphological units (such as an iterative sound that can be analysed into a sequence of short impulses). Nevertheless, one's perception is not necessarily that of many entities but of a single entity with a persistent mode of energy injection.[118]

Despite its simplicity, the coda passage from *Songes* beautifully demonstrates the tight integration between spectral and perspectival spaces (*motion* appears in both) as well as the source-bonded nature of spectral spatiality. Indeed the line between directly source-bonded and autonomous entities is often blurred in acousmatic music. On the one hand source-bonded vestiges influence the perceived characteristics of autonomous

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[116] In his notes on Pierre Henry's *Le Voyage* Chion refers to the notion of 'personage', which refers to the apparent identity of a *being* that is evoked by a particular sonic behaviour or context: "…at the same time sound is both a sound object and the sound of a thing." Chion goes on to describe the manner in which sounds may evoke 'an imaginary body occupying the three spatial dimensions'. This spatial form therefore has 'volume, walls, mass, density, and speed'. It may also suggest some kind of life-form, a living being. He refers to a characteristic personage as 'êtricule', a term that can be roughly translated as 'small being' – "…a living organism of small dimension, always changing and always identical, heard against a background of the cosmos …". (Delalande, op.cit., p. 51.)

[117] See Smalley, 'Space-form and the Acousmatic Image', pp. 37-38.

[118] This seems to correspond with Delalande's third mode of listening – "figurativisation" - according to which the musical work can be viewed as a "stage" for "living" entities: in this listening approach listeners tend "to think that certain sounds evoke something that moves, ultimately living". This mode of listening behaviour is also characterised by what Delalande calls the "metaphorisation of [morphological] chains". Thus morphological units are often grouped into coherent streams which are perceived as living entities characterised by certain 'behaviours'. (Delalande, op.cit., p. 51.)

entities (as the chirp-like quality of the entity in *Songes*). On the other hand the spatial qualities of entities, even if they result from transmodal linkage, can themselves be seen as forms of source bonding.

The notion of energy injection, which is discussed in the next part, should be considered an important attribute of the entitative state. An isolated spectromorphology that dissipates quickly fails to establish any sense of autonomy. Thus an entitative state is often established through the consistent injection/reinjection or animation of spectral energy - as if the sound is maintaining itself and causing itself to 'move'.[119] In short, 'autonomous' refers to the apparent independence of spectromorphologies from external causes and sources, while 'entitative' refers to the perceived spatial qualities of autonomous spectromorphological identities as spatial *beings*.[120]

3.1.4 Timescales and the Establishment of Entitative Identities

It is clear by now that entities are not the same as morphological units or events. An entity, although revealed in time, is experienced as a spatial form. This is not to say that the entitative state eliminates the felt directionality of time. On the contrary, it is often influential in establishing listening expectations in time, both on smaller scales and on the larger scale of form. (This will be discussed in the final chapter.) However, entities are

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[119] A study of the psychological relationship between spectromorphologies that are seemingly self-propelled (autonomous) and those that appear to be invoked by external human gestures remains the topic of a future investigation. (For instance, to what extent is this influenced by listening attitude and cultural habituation?)

[120] In as far as we aim to shed some light on aspects of meaning-making in acousmatic music, it would be misleading to reduce the musical context to a catalogue of spectromorphological entities. Rather, in the context of this study our attention should be directed towards the state of consciousness in which spectromorphologies evoke spatial forms: I refer to this as the *entitative state*, which denotes both the listener's mental state and the sonic context involved.

perceptually characterised by a shift of focus from time (event) to space (object).[121]

An important question one must ask is, on what structural level do spectromorphologies reveal entitative characteristics? This is a question of how long is needed to establish a temporally consistent behavioural state, which depends on musical context, listening habits, and the nature of human cognition. Some spectromorphologies reveal characteristic patterns of 'behaviour' more rapidly (on a smaller timescale) whereas others may take longer to establish behavioural identities.[122] Thus the timescale on which an entity's behaviour is perceptually pertinent is variable depending on context. For instance, despite having a perceptible impact on larger-level structures, micro-level variations are not necessarily directly perceived in "surface activity".[123] On the other hand, more textural entities can have an aggregate nature that is typified by the coexistence of perceptually pertinent activity on different timescales: internal textural behaviour is seemingly nested inside larger-scale structures or the overall shape of a textural aggregate. As it will soon become apparent, even simpler entitative identities, such as the bird in *Songes,* are often perceptually characterised by coexisting morphological behaviours on different time-scales.

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[121] See Smalley, 'Space-form and the Acousmatic Image', pp. 37-38.

[122] Note that the full behavioural potential of an entity is often exposed over larger-scale structures and is subject to transformations over time.

[123] Budon, Osvaldo, 'Composing with Objects, Networks, and Time Scales: An Interview with Horacio Vaggione', *Computer Music Journal*, Volume 24, No. 3, The MIT Press (Autumn, 2000), p. 13.

3.2 Attributes of Entities – Energy-expenditure

3.2.1 Overview

Autonomous entities are characterised by their motion in and occupancy of spectral space, which are both primarily dependent on the injection, maintenance and expenditure of spectral energy. Therefore it seems essential to define the relationship between spectromorphological energy-variation and the establishment of entitative identities before delving into 'motion' and 'spectral space occupancy', which are more explicitly concerned with aspects of spectral spatiality. Entities are formed from 'spectral matter', which is nothing but varying patterns of energy variation that articulate the continuum of spectral frequencies. The autonomous identity of entities is therefore dependent on how entities appear to 'inject' and 'maintain' their inherent spectral energy, and the manner in which this energy may 'dissipate' (or 'flow' in an effortless fashion).

However, in practice the lines between spectral occupancy, motion and energy-expenditure are blurred. Occupancy refers to the manner of distribution of spectral energy in spectral space, which often varies in correlation with the perceived qualities of energy injection/dissipation. On the other hand, a spectromorphology may appear to 'move' in perspectival space or evolve in spectral space as a result of spectral energy-variation alone (in the absence of vertical motion). Similarly, depending on its patterns of energy-expenditure, one may experience the same vertical movement as possessing different qualities: an entity may fall/glide, descend steadily, or forcefully pull away from an apparent force of attraction placed higher up in spectral space.

It therefore appears that on a phenomenological level we cannot easily discuss the entitative state in terms of completely independent criteria. Indeed, the criteria presented here should not be considered as isolated categories; rather, as different perspectives on the entitative context. With this in mind I shall outline the basic characteristics of energy-expenditure in this section, before continuing to discuss motion and rootedness. The next chapter is dedicated to a discussion of spectral space occupancy and texture, which are particularly relevant in the context of more complex or compound entitative states.

3.2.2 Defining Energy-expenditure

The difficulty of dealing with different timescales becomes relevant when examining the apparent energy-expenditure of entities (as well as motion in general). Energy-expenditure defines the patterns of spectral energy injection, maintenance, dissipation or micro-variation with which an entity is identified. Note that spectral energy variation[124] is directly related to aspects of spectral space occupancy and motion. Energy may, for example, appear to increase through the accumulation of textural density or mass, as well as the growth in magnitude or rate of spectral motion. (More detailed discussion is reserved for the corresponding sections.) Indeed, energy injection is typically indicated by the simultaneous increase in intensity and

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[124] I use the term 'variation' to refer to the neutral (more objective) spectro-temporal energy-structures. On the other hand, 'expenditure' refers to energy-variation as observed within the entitative context. In this sense, this section discusses aspects of morphological onset-continuation-termination in the context of entities.

spectral richness (or brightness): in the context of compound or aggregate textural entities this is experienced as an increase in textural density.

Energy-expenditure can potentially be observed on different timescales. For example, in the case of single morphological units, energy-expenditure may be discussed in terms of onset, continuation and termination, as well as micro-variations in pitch, dynamic or spectral make-up, whereas larger-scale structures could be made up of chains of smaller morphological units. For this reason we must use a terminological framework that does not by default encourage the analysis of energy-profile of single morphological units, although, when perceptually pertinent, the manner of articulation of individual units needs to be considered in detail. In short, depending on the particular analytical task at hand, one must carefully judge the direct perceptual pertinence of different structural levels on the basis of empirical observation.

3.2.3 Energy Injection and Impetus

‘Energy injection’ is used to refer to the manner(s) of inputting of spectral energy that characterises an entitative identity. Energy injection ranges from *impulsive* to *graduated*: is energy fed into the sound steadily or by means of impulsive bursts? The increase in spectral energy is felt as the *impetus* with which spectromorphologies ‘move forward’ through time - as well as space, as will be discussed in the context of motion. A graduated energy injection therefore creates a sense of spectromorphological impetus which is felt more strongly as the magnitude and speed of injection (energy/time trajectory) increases: if energy is injected too slowly into a spectromorphology the sense of impetus can be lost altogether. Impetus is therefore an important qualifier of an entity's apparent autonomous life-force.

The manner of launching of spectromorphologies is an important qualifier of injection (the onset of a sound event is always characterised by a type of energy injection), but energy injection is not limited to morphological onsets. More energy may be fed into a sound after the initial onset phase and a morphological unit may even terminate with a sense of impetus through a rapidly rising input-energy. In addition, the notion of injection is applicable to micro-morphologies as well as to larger-scale structures such as phrases or textures. However, the manner of energy injection of an entity is not necessarily recognised as such on all timescales. For instance, the energy-expenditure of a texture is often identified with global rather than sub-textural activity, although lower-level textural activity may come to the fore if there is little macro variation or if textural density is sufficiently scant.

An entity is often characterised by a variety of *methods* of injection that may coexist at different timescales, in a sequence, or in nested sequential patterns. As was shown with the bird in *Songes*, a single entity may comprise chains of morphological units with different onset/termination characteristics. Moreover, each chain (or phrase) can be characterised by an overall sense of energy injection. Through time, a *method* of energy injection is established by the perceptual unification of recurrent morphological variations, sequential patterns and relationships among different timescales into one 'behaviour type' - a state of activity that persists in the listener's imagination and beyond the temporal limits of the individual sound-events.

3.2.4 Energy Maintenance, Flow and Dissipation

Listeners are sensitive to the manner of maintenance of spectral energy, which reveals the character of an energy-producing source.[125] The concept of energy maintenance is not to be confused with the sustainment of the sound per se. Maintenance implies a sense of maintained impetus or effort that may be sustained or iterative.

The simplest form of maintenance is through a more or less constant *hold* of energy-level (as characterised by a sustained sound). Impetus may also be maintained by means of reinjection in a more or less periodic or intermittent fashion. Rather than maintaining energy level, an *iterative* entity is characterised by the maintenance of *a method of injection*. Naturally, higher rates of iteration lead towards the perception of more sustained sounds, while low iteration rates are perceived as a form of reinjection (recurrence).[126] Certain granular textures can also be classed as iterative aggregates: again, the individual sonic particles may be directly perceived at lower densities. One can view iterative sounds as nested patterns of energy injection. On the one hand, the iteration itself requires a source of energy (re)injection that operates recursively on a lower timescale. (This may be further characterised by patterns of variation in pitch, dynamic, duration or time interval that divide the iterations into

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[125] see *facture,* footnote 9.

[126] See Smalley, 'Spectromorphology: explaining sound-shapes', pp. 117-118.

groups.) On the other hand, energy-profile on the phrase-level may appear to be somewhat independently governed and, often, directly accountable for the experience of impetus. Interesting ambiguities can be created by finding the borderlines between sustained, iterative and reinjective behaviours: at what point does iterative maintenance transform into explicit energy reinjection, thus shifting the perceptual identification of impetus from one timescale to another?[127]

In the context of more compound[128] or aggregate textural entities, energy appears to be actively maintained when spectromorphologies are maintained without corrosion in their internal spectral make-up or textural density. In many cases spectromorphologies can be maintained with little energy loss and no apparent sense of effort. This is, for example, evident when spectral energy and textural mass decline rapidly immediately after an initial surge of input energy, but remain more or less constant, or *dissipate* over an extensive period of time (a quasi steady-state residual tail). An example from the start of my piece *Convergences* demonstrates this (sound example 5). In this example spectral mass diminishes in congruence with energy loss, which clearly demonstrates the interdependence of the criteria of energy-expenditure on spectral space occupancy. The tail of the sound evokes a weightless quality by means of which spectral energy *flows* effortlessly. Also note that here the residual tail of the spectromorphology has been freed from the earthbound rootedness

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[127] This depends on musical context (that can encourage one's listening focus on patterns of behaviour on a particular structural level), as well as on acoustical and cognitive limitations.

[128] The term 'compound' is defined in the final chapter when discussing textural entities. In short, this refers to sounds that have a more explicit sense of spectral body and extent in their occupancy of spectral space.

of the initial injective phase, which evokes a sense of weightlessness: spectral matter appears to be *pushed* up by a strongly earthbound surge of energy, by means of which the spectromorphology is freed from the bounds of gravity and continues to slowly flow/dissipate at a higher altitude.

3.2.5 Internal Animation

Iteration can be seen as a form of internal micro-motion, but a sustained sound may also be internally animated by means of micro-fluctuations in pitch, energy and spectral makeup.[129] The internal animation of a spectromorphology can be more or less continuous. On one extreme there is iterative and granular behaviour and on the other, continuous variations such as vibrato. Moreover, one may identify two modes of micro-variation with which entities are animated: *fluctuating* and *recursive*. Energy may be said to fluctuate if energy/pitch varies more or less irregularly. When fluctuating patterns become more regular one begins to perceive a sense of recursive periodicity.

Both fluctuating and recursive animation can of course vary in rate and magnitude. The slower the rate of variation, the smaller the magnitude of change needs to be in order for the variation to be perceived as internal animation: slower and/or higher magnitude variations in energy level are perceived as overall injection/dissipation rather than as micro-animation. (Similarly, slower and wider pitch variations are perceived as global motion, rather than as micro-motion.) The perceptual continuum between

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[129] Texture motion can also be considered as a complex form of animation but this will not be discussed until the final chapter. Animation as discussed here may also occur within more textural states as a quality of sub-textural elements.

micro and macro motion is often explored in acousmatic music: this is encountered in the *Songes* example where the pitch modulation slows down and expands in its spectral extent, at which point the entity appears to take flight. Note that the overall impetus behind the motion of the *bird* also grows directly out of the trajectory established by the internal animation pattern.

In general, increase in the rate and magnitude of animation implies more input energy and is often accompanied by energy injection. Indeed, micro-animation can have a variety of different functions depending on the accompanying patterns of energy injection/maintenance and dissipation. An energy injection phase can, for instance, be animated by means of rapid internal variations, which helps exaggerate the sense of impetus (as in a crescendoing sound that increases in its rate and depth of vibrato).[130] Internal animation may continue with a sense of impetus or it may function as a sudden catalyst that appears to terminate a sustained morphology. On the other hand, animation may function as a transient disruption of stability or it may appear as a form of *reflex motion*, which describes a recursive pattern of internal animation that is preceded by a surge of energy injection and a gradual decline. This is often, but not always, accompanied by an overall dissipative state.

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[130] This may also be of a discontinuous character (e.g. iterative), in which case it may be perceived as a morphological chain with nested patterns of energy-expenditure.

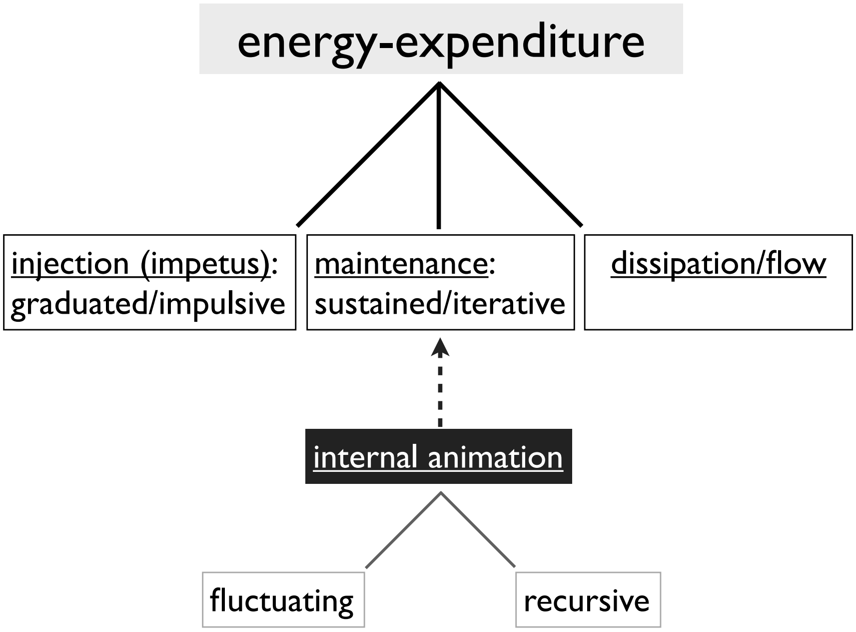

Figure 4. Qualifiers of energy-expenditure

3.3 Attributes of Entities – Motion

3.3.1 Defining Motion

The term ‘motion’ is used to describe the manner in which entities are felt to *move through* spectral space.[131] The repertoire of acousmatic music reveals recurring types of motion: Smalley highlights seven characteristic motions of *push/drag*, *flow*, *rise*, *throw/fling, drift*, *float*, and *fly*.[132] In Chapter Two we asserted that the experience of musical motion is characterised by source-bonded and embodied qualities, rather than being merely about moving up or down spectral space. Thus motion must be seen

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[131] Internal animation can perhaps be better defined as ‘micro-motion’.

[132] Smalley, ‘Spectromorphology: explaining sound-shapes’, p. 117.

in conjunction with energy-expenditure, rootedness, spectral space occupancy and texture in general. Firstly, motion describes the manner of change in spectral space occupancy, which is in turn experienced within the gravitational framework of our embodied earthbound existence. Secondly, motion cannot exist without spectral energy: forms of animation and maintenance are themselves evocative of certain types of physical motion, even in the absence of vertical traversing. Similarly, texture-motion is an inherent characteristic of textural entities, which are formed by the collective motion of sub-textural elements that determine behavioural states. (This is discussed in Chapter Four.) In this sense, motion is better defined as the character of evolution of entities in space, rather than simply their *up* or *down* movement.

The formulation of a taxonomy of characteristic motions in acousmatic music is beyond the limits of this study. Here I will constrain myself to sketching out the pertinent criteria involved in defining the experience of different types of motion. These criteria can then be utilised to highlight and discuss properties of motion in specific musical contexts.

3.3.2 Vertical Direction of Motion

The most obvious aspect of motion is the manner in which spectromorphologies move through the vertical dimension of spectral space. Smalley has classified motion direction into the four categories of unidirectional, reciprocal, cyclic/centric, bi/multidimensional.[133] (The category bi/multidimensional belongs to growth processes and will be

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[133] Smalley, ‘Spectromorphology: explaining sound-shapes’, p. 116.

discussed in the next chapter). Using Smalley's classification as a basis I propose the following qualifiers of vertical directionality.

Path - This category highlights motion that articulates direct, indirect or changing paths through the vertical dimension of spectral space. Directional motion may be goal-oriented in that it can lead to the creation of temporal processes that anticipate completion (for instance moving towards a goal, disappearing out of range or receding into the distance). Directional motion may also be typified by changing direction and therefore have more than one direction. Directional tendencies often draw our attention to a higher or lower spectral region and may even suggest the presence of a goal that is not physically present.

Errant/Erratic - If change of direction persists over time then motion loses its sense of directionality and can be categorised as errant. Such motion can also become erratic if directional change and speed becomes completely unpredictable. When present on a lower structural level, local erratic motion may also have an overall sense of direction over a longer period of time, for instance by undertaking a global ascending or descending tendency or by varying its extent of spectral space occupancy over time.

Planar – Planar motion is stable in spectral space with no or limited vertical mobility. Naturally stability requires a certain length of time in order to be established. Examples include *flowing* or *floating* spectromorphologies as well as sustained *lines*. Planes often act as points of departure or arrival for directional spectromorphologies.

Recursive – This describes all motion characterised by recycling or repeating patterns or directional tendencies. This encompasses all that Smalley has previously classified under cyclic/centric as well as *oscillation* and *undulation*. Recursion need not be exact or precise as long as there is a general sense of recycling in spectral space.

3.3.3 Combinatorial Forms

In many cases the motion types defined above exist in combinatorial forms. For instance, a recursive pattern may have an overall sense of direction in spectral space. In this sense *spiral* motion may be seen as a combination of directional and recursive motion. We can, for example, imagine planar forms with recursive internal texture motions. Directionality itself can be embedded within a recursive pattern, such as recycling ascent or descent (e.g. *vortex*). Likewise, planar motion may possess subtle directional motion around a 'mean' spectral region. Similarly, a chain of planar spectromorphologies may display global directional or errant/erratic tendencies.

It would be misleading to conceive of the above motion categories as quantifiable classes. Rather, they are simple schemas that are rarely experienced in a clear-cut fashion in a musical context. For instance, how much vertical change is needed to differentiate errant/erratic from planar motion? And at what point does an errant/erratic motion become regular enough to be perceived as an undulation? What distinguishes between a changing directional motion and erratic motion? The most important factor is what directionality is perceptually pertinent to the experience of motion in a musical passage. The answer to the above questions is therefore dependant on context as well as the structural level in focus.

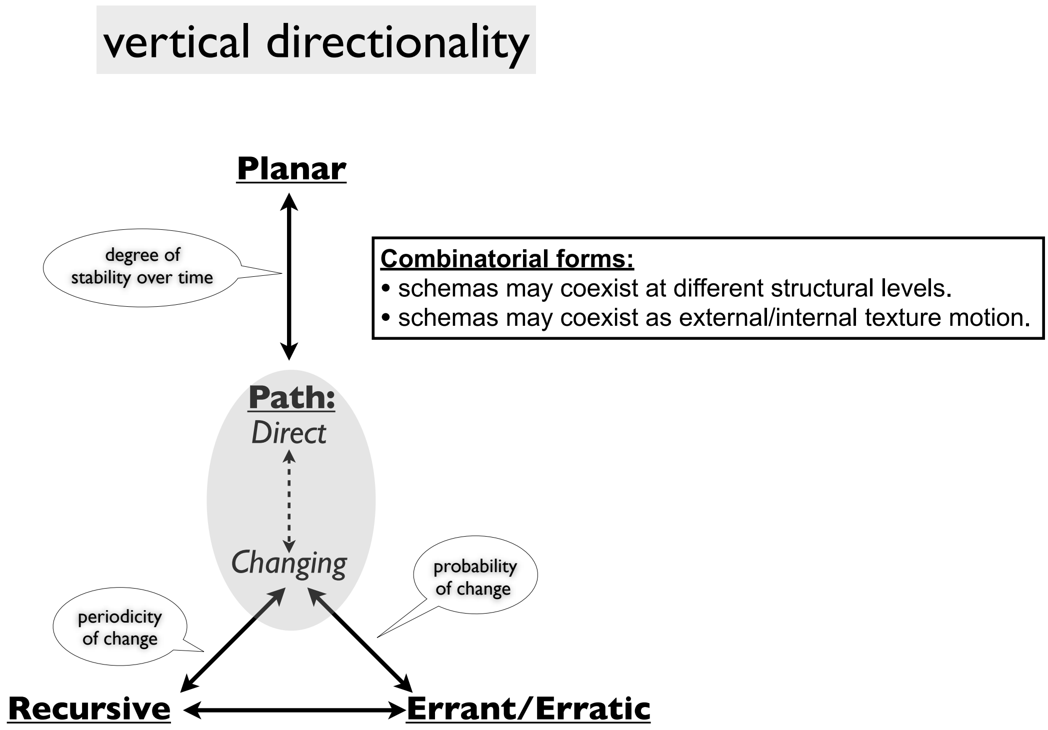

Figure 5. Qualifiers of motion directionality

3.3.4 Motion and Energy-expenditure

Motion is also characterised by the manner in which vertical traversing (or lack of it) is coordinated with energy-expenditure. Energy can be felt to be the driving force behind the vertical movement of entities. For instance, an ascending directional motion may be experienced as rising, flinging, drifting or flying, depending on the overall energy-expenditure of a sound.[134] Is motion instigated with a more or less impulsive injection of energy? Is energy sustained in a constant or animated fashion? Does it increase or dissipate relative to vertical change?

Vertical (spectral) traversing can be interpreted in terms of *motion impetus* and *gravitation-levitation*. These criteria are produced through the interaction of energy-expenditure and velocity (the rate and direction of motion) and are applicable to texture motion as well as to the motion of individual entities.

Motion impetus refers to the apparent capacity of spectromorphologies to cause or effect self-motion. We have already identified energy injection as a measure of impetus, which can also lend a sense of goal orientation to vertical trajectories. An example of motion impetus caused by injected energy is pushing motion that is launched through a rapidly forceful graduated energy injection – this is often also coupled with a coordinated growth in spectral mass. We might also imagine the graduated onset to be accompanied by an exponential acceleration of vertical trajectory, which will heighten the initial sense of impetus. An entity may continue its directional motion in an effortless manner if energy

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[134] Ibid., p. 117.

injection is followed by a dissipative expenditure: the injected energy is thus transformed into *kinetic* energy that keeps the entity in motion. The entity may then move out of sight or it may gradually lose momentum (for example by slowing down), or else be further influenced by additional injected energy and/or gravitation/levitation.

With decreasing impetus, spectral motion appears to become progressively liable to the influence of gravity and levitation. Gravitation can be regarded as a source-bonded characteristic of spectral space. Sounds often require more effort to move away (in upward direction) from the real or imaginary 'root', whereas descending motion can be activated in a seemingly effortless manner. Falling motion, for example, implies a spectromorphology that has given in to the pull of gravity. However, gravitational pull may also be part-resisted or aided through the increase and decrease of internal energy. In acousmatic music, falling spectromorphologies rarely collide with the ground. Rather, they tend to settle on a plane, merge into existing textures, or disappear out of sight through a graduated termination. In Bayle's *Grandeur Nature*[135] (the descending glissandi at 45 seconds into sound example 6) we encounter this latter case where entities fall towards the ground, but instead of coming closer to the listener's earth-bound vantage point they disappear out of sight. Does this perhaps suggest a change of vantage point in spectral space (i.e. looking down)? A freely-falling entity is therefore constructed through the combination of constant energy or dissipative energy-expenditure and a

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[135] Bayle, François, *Son Vitesse-lumière* (1997), Volumes 9-10, Magison, MGCB 91097.

relatively quick linear motion velocity. The slower the fall, the lighter the apparent weight of the entity, while slower descending motion of larger spectral masses is experienced as being self-controlled (gravitational force partly counteracted by means of input energy maintenance). At the other extreme, levitation describes the quality by means of which spectromorphologies can elevate effortlessly through the loss of weight. Certain motions such as fall are elicited by gravitation, whereas others are characterised by varying amounts of levitation (as encountered in example 1 from Liszt).

Here we must also mention recursive motion, which can be seen as an energy-generating behaviour that helps maintain the mean position of entities in spectral space. Recursive patterning in spectral space functions in a similar fashion to iteration by enabling entities to maintain themselves in place through their internally recursive activity. In this sense recursive motion can be viewed as creating a sense of kinetic energy.

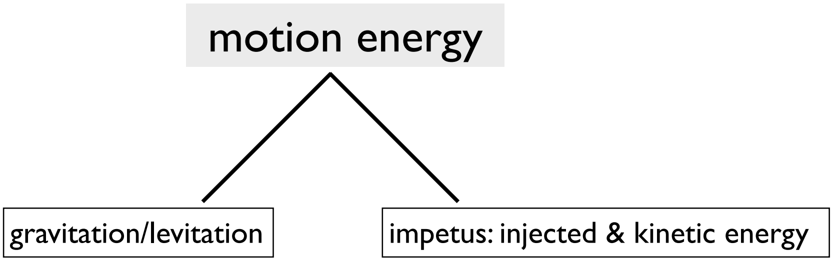

Figure 6. Qualifiers of motion energy-expenditure

3.3.5 Perspectival Motion

It is important to recognise the distinction between changes that are perceived as patterns of energy-expenditure and those experienced as perspectival motion (moving in and out of *sight*). At times, entities appear to continue their motion beyond the listener's view. (Entities can also move out of sight through vertical traversing.) The *Songes* passage is a case in point: the 'bird' recedes perspectivally, disappearing out of view, before it re-emerges from the distance.[136] The receding motion of the bird is evoked by the fact that spectral motion and micro-animation do not appear to be affected by changes in intensity (energy therefore is not felt to dissipate). Also note the consistency with which the bird always recedes with an upward tendency, as if also moving upwards beyond our ears' reach.[137]

Another example is illustrated by Christian Zanési's *Stop! l'horizon* (sound example 7). Here a flock-like entity[138] (swarm) 'flies' in and out of the acousmatic 'frame', at times possibly suggesting front-to-back exit motion. Although this can be exaggerated in diffusion, the perspectival motion is imaginary and implied by the dynamic changes in the sound as well as variations in spectral mass. Here the boundary between energy-expenditure and perspectival motion becomes blurred, particularly as the inferred motion is apparently governed by the energy-expenditure of a self-

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[136] In the original 4 channel version the perspectival motion of the bird is a combination of over-head flight and an expanding/ contracting circular path around the audience.

[137] We must also note that in terms of its intrinsic spectral structure the changes in intensity are applied uniformly to the spectrum of the sound. In a natural context energy is varied in congruence with spectral richness (a sound can therefore decrease in intensity and still have a sense of energy impetus). One could mention the added reverberation as the bird recedes but this is in fact no more than a superfluous 'cue', which would not be pertinent if it was not for the inherent motion characteristic of the entity.

[138] Textural aggregate will be discussed in the final chapter.

propelled entitative form – that is, the entity appears to move through space (both spectral and perspectival) with impetus.

A more ambiguous example appears in Bayle's *Grandeur Nature* (sound example 6). Here the lower-frequency spectromorphology may be interpreted as a relatively voluminous *orbiting* object (resulting from the combination of low frequency and spectral mass), produced largely by the graduated manner of energy injection and a seemingly controlled decrease in energy level during its sustainment. Here the steady graduated termination can be perceptually interpreted as a receding motion.[139]

All three examples above (Risset, Zanési and Bayle) are also typified by spectral motion. As far as the listening experience is concerned, it is the general sense of spatial motion that is important. In other words, spectral and perspectival motions are perceived in a unified fashion: the *up/down* directionality comprises a dimension of perspective so the theoretical distinction between perspectival and spectral motions is merely for analytical purposes and must not be seen as a pertinent aspect of the listening experience. In any case, the perspectival motion of an acousmatic entity is at best an illusion that is largely constructed in the listener's mind. That is, virtual 'sources' are not physically moved in listening space; rather, the sense of motion is manufactured by the composer who must have an intuitive grasp of the psychoacoustics and cognitive factors involved in human spatial hearing. Furthermore, the sense of spatial motion can also be afforded through spectral motion and energy-expenditure alone: a spectromorphologically inanimate planar entity does not afford the same

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[139] Note that the slow cyclical character of this orbiting motion takes some time to be established. More on this in the final chapter.

perspectival mobility as an agile flying entity. The experience of perspectival motion can therefore be theoretically dealt with only in reference to spectral (as well as more source-bonded) spatiality.[140]

3.4 Attributes of Entities – Rootedness and Weight

As suggested in Chapter Two, spectromorphologies with lower spectral components are experienced as being more voluminous and weighty (rooted in earthbound gravity), while spectrally elevated entities are often seemingly lighter, more agile and smaller in dimensions. On the other hand, a pure bass frequency[141] can suggest a sense of subterranean depth or presence rather than evoking an entity as such. Note that although the apparent volume and weight of an object depends on its spectral elevation, the ease (see motion energy) with which a lower entity moves or elevates in spectral space also influences the perception of its weight. In this sense a lower object may not seem particularly heavy if it 'hovers' effortlessly without much internal energy (as for instance characterised by the orbiting object in the Bayle example on sound example 6).[142] Likewise, rooted entities often accumulate spectral energy or move through spectral space in a more sluggish manner. A lower entity that moves or surfaces with a rapid or impulsive character often entails higher levels of input energy that

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[140] This is discussed in more detail in chapter four.

[141] Here we avoid giving exact frequency values for what constitutes the extreme highs or lows since this is highly context dependent.

[142] Later we will define the attribute of 'mass' which is pertinent in some contexts, influencing the apparent weight and dimensions of entities.

implies an overcoming of the gravitational pull of the earth (such as pushing or dragging).

Here it is important to note that although bass is experienced as a spectral space root, this root does not necessarily anchor higher entities that may be present in a musical context: it is possible for elevated materials to be more or less rooted in the bass. This was, for instance, encountered in *Songes* where the bass drone added a sense of rootedness to the passage but the bird entity itself was rather free from this root. A similar situation was discussed in the Liszt example offered in Chapter One. A spectromorphology only appears to be rooted when it corresponds harmonically (or when it spectrally integrates) with the bass component, that is when the bass acts as a fundamental frequency for higher spectromorphologies. As an example, consider a passage from my piece *Convergences* (sound example 8). Here the bass adds a sense of subterranean depth and volume (spaciousness) to spectral space, but the higher-altitude textures in this passage are far from rooted in the bass. The uppermost *plane* flows, completely free from any sense of rootedness or gravity, while the dense noise-based textures fly overhead with some effort that appears to prevent them from collapsing into the *deep space* below. Compare this with another passage from the same work (sound example 9) which starts with a strongly rooted state: the more sustained upper materials are rooted in the bass. (Here the bass acts as a harmonic root.) Note that a sense of instability emerges as these higher materials become more animated and depart from established pitch centres: listening attention is then diverted from the root towards these more animated higher materials: consciousness no longer reads a root at the bottom of the texture.

3.5 Summary

In this chapter we discussed the inherent spatiality of sound(ing) events and introduced the notion of entities. We defined the three qualifiers of energy-expenditure (injection/impetus, maintenance, dissipation/flow and animation), motion (vertical directionality and motion energy), and rootedness, which can be used to discuss aspects of entities' behaviour and states. For the sake of clarity I have reserved a discussion of spectral space occupancy and texture - which become particularly apparent in the context of more complex entitative identities - for the next chapter. However, as will become clear, texture, occupancy, energy-expenditure and motion are inherently bound to one another and must be viewed together.

CHAPTER 4

Spectral Space Texture & States

4.1 Prelude - Simple, Aggregate and Compound Forms

> "…from fumes or winds (which are nothing else but Air in Motion) being coagulated, Water is produced, & from Water mixed with earth all minerals & metals do proceed. And even these last are said to consist of & be immediately coagulated from fumes..."[143]
>
> — Michael Maier (1618)

Entities can be described as 'simple forms' when they have little or no perceived spectral extent or internal detail.[144] For instance, the entity in *Songes* may be viewed as a simple biomorphic form that 'moves' through space as a quasi point-source while retaining its apparent intrinsic shape. Such entities are typically characterised by a single pitched auditory stream[145] but they may also result from noise-based or inharmonic spectra that are animated with rapid patterns of energy-expenditure (such as a pulse-train), which will inhibit the discernment of internal spectral detail.

Simple entities may be grouped together to form complex textural aggregates as, for instance, is evident in the higher-frequency materials from Bayle's *Grandeur Nature* (sound example 6): we may refer to the lower-level entities of an aggregate texture as micro-entities. The accumulation of micro-entities can also be implied by the global motion of

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[143] Maier, Michael (1618), *Atalanta fvgiens, hoc est, Emblemata nova de secretis naturae chymica*, the University of Michigan (13 Jul 2007).

[144] The exception of planes, which are spectrally narrow but conceptually have a sense of perspectival spread, will be discussed later.

[145] Bregman, Albert, *Auditory Scene Analysis*, (MIT Press 1990).

a texture, rather than being directly observable: the swarm-like formation from *Stop! l'horizon* is a case in point (sound example 7). Here the internal texture of the swarm entity (not the global texture of the passage) is far too dense for its individual sub-elements to stand out, but the overall behaviour (motion and energy-expenditure) and the grainy consistency of the texture imply the amalgamated behaviour of sky-bound micro-entities. On the other hand, aggregate textures may be made up of grain-sized morphological units that are scattered in space and time in a more erratic manner (or at higher spatio-temporal densities): in such cases texture as a whole cannot be perceptually organised into sub-textural streams (individual micro-entities) and is perceived as the lowest-level entitative identity that appears to consist of individual pre-entitative *particles* whose behaviour blurs the perceptual boundary between space and time.[146]

Aggregate formations often occupy a certain spectral space extent, but spectromorphologies that are perceptually more fused can also reveal a conspicuous spectral width and be experienced as compound masses of spectral matter. I refer to these as *substances*, which are more integrated and perceptually fused in their internal structure than aggregates. Substances may also be morphologically less continuous if they comprise higher-density granular iterations that are fused into a compound but somewhat ‘grainy’ textural consistency. In other words, at more extreme densities sub-entitative particles are fused together to produce a more

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[146] One can metaphorically imagine the behaviour of such textures as the sonic equivalent of the activity of subatomic particles: due to the principle of uncertainty each particle can potentially exist in multiple positions in space at any given point in time. Similarly, the behaviour of the sub-elements of such textures is perceived in a probabilistic fashion that blurs the perceptual boundary between time and space.

compound *substance* with a certain spectral space spread and internal consistency.[147] In this context the shorter the duration of the grains, the less density is required to establish a sense of compoundness: the lack of distinguishable detail on the grain-level encourages listening focus towards the higher-level structure of the texture.

In terms of spectral space occupancy, more densely packed compound textures appear as *solid* masses whose internal structure holds together much more firmly, in contrast to internally less stable and spectrally diffused *fluid* substances. As an example consider the sustained fluctuating resonances in Smalley's *Base Metals*, which can be described as semi-fluid in their make-up (sound example 10): this results from the relatively dispersed spectral energy and effortless internal fluctuations of the sound. Compare this with the continuant material in *Valley Flow* (sound example 11) which demonstrates a gasoide substance (particularly as spectral spread increases) of more extreme fluidity due to the diffused nature of its spectral energy.

Interestingly, solid masses often transform into more fluid substances as they dissipate (as discussed with regard to sound example 5). Indeed it is possible for an entity to transmute into different forms: we can imagine an iterative entity that multiplies into an aggregate, which may in turn become denser and exhibit fluid or solid substance-like characteristics. In this sense it is better to think of textures in terms of their degree of compoundness (or fusion[148]), fluidity and mass, as opposed to clearly-defined categories.

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[147] Consistency is a measure of temporal density and grain-size.

[148] This is discussed later.

Transmutation between different entitative states is not only possible but also desirable from a compositional perspective and is often present as a guiding principle in the creation of musical form.[149]

In the light of the above discussion it seems appropriate to develop a more detailed terminological framework for discussing those spectromorphological attributes by means of which complex entitative identities are established. What is it that characterises an entity as compound, solid or fluid and how does this influence the configuration and behaviour of the entity in spectral space? After providing a working definition of texture I shall highlight a set of criteria that can be used to describe the spatial qualities of complex entitative states in acousmatic music. A full investigation of textural structures is beyond the bounds of this study so here I have kept the discussion confined to aspects of texture that are directly related to the deployment of spectral space.

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149 In this sense I believe acousmatic art-forms to be symbolically related to alchemy. The very process of physically transforming raw sound-materials into entitative identities seems to me to be psychologically analogous to the transmutation of base metals into gold. This is reflected in Wishart's suggestion that: our "principal metaphor for musical composition must change from one of architecture to one of chemistry." (Wishart, Trevor, *Audible Design*, York: Orpheus the Pantomime (1994), p. 12)

Also notable is alchemy's notion of the ontological fluidity between natural elements and beings (both animate and inanimate) as, for instance, expressed by Maier. (Maier, Michael (1618), *Atalanta fvgiens, hoc est, Emblemata nova de secretis naturae chymica*, the University of Michigan (13 Jul 2007).) The term 'cognitive fluidity' is used to describe the connection between different cognitive domains (capacity of metaphorical and cross-domain mental processing) that characterises the modern human mind. This mental capacity is historically associated with the emergence of art and religion somewhere in the time-period 60,000-30,000 years ago. Cognitive fluidity can, for instance, be observed in the 'anthropomorphism' and 'totemism' of the Paleolithic cave-paintings (half human, half animal mythological figures), the mental conception of which, according to Mithen, entails "fluidity between social and natural history intelligence". In other words the evolution of the human mind seems to be characterised by the integration of the different mental modules (present as isolated modules in 'lower' primates) to allow for the emergence of cross-domain imagination that, for example, contributed to the advancement of tool-making in the prehistoric hunter-gatherer society. (Mithen, Steven, *The Prehistory of the Mind*, Phoenix (1998), pp. 170-210.) See footnote 72 for some detail on Previc's discussion of the neurological basis of human abstract thinking. Also see Werner Herzog's film *Cave of Forgotten Dreams* (2010) for a rare documentation of the Chauvet cave-paintings in the south of France (available on DVD, ASIN: B0051ULCCO).

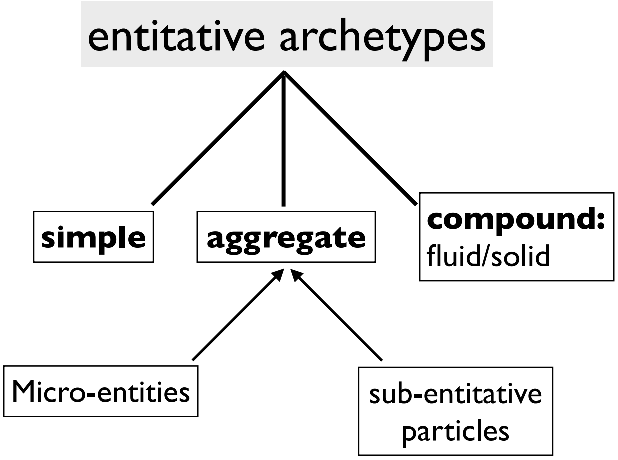

Figure 7. Entitative Archetypes

4.2 Texture

4.2.1 Texture – A Definition

The term 'texture' comes from the Latin *textura* referring to weaving, and is originally used in English to denote woven fabric. In cognitive sciences the term refers to "the *microstructure* of *surfaces*" and its perception is understood to follow three sense modalities: haptics, vision and audition.[150] In music, texture is in part a metaphor, and therefore its systematic usage is somewhat ambiguous. Musical textures can be described as rough, smooth, dense, transparent, grainy, etc. - all visual and/or tactile analogies that can be applied to the description of sonic experience - and yet, we have an almost intuitive understanding of textural qualities in music. For instance, it

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[150] Susan J. Lederman & Roberta L. Klatky, 'Multisensory Texture Perception', *The Handbook of Multisensory Processes*, ed. Gemma A. Calvert, Charles Spence & Barry E. Stein (The MIT Press: Cambridge, Massachusetts, 2004), p. 107.

would be relatively easy for an experienced listener to imagine a grainy but transparent texture, without referring to any specific sound-producing sources.

In tonal music, textural design is a byproduct of melodic, harmonic and rhythmic constructs, and is present as a cognitive aspect of the musical structure. As Erickson states:

> Masses, clouds, and other composite textural effects are by no means a recent invention. Debussy, Strauss, Wagner, Berlioz and their contemporaries developed and vigorously exploited the potential of orchestral texture.[151]

In many 20th-century and contemporary instrumental works (e.g. Varèse, Xenakis, Murail, Boulez) the role of texture as a perceptually salient structuring factor comes to the fore, highlighting spectral space as an important dimension of the listening experience. In acousmatic music in particular, both listeners and composers are aware of the importance of textural structures as the means of defining and articulating spectral space. Aspects of texture can be formulated into at least four characteristics:

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[151] Erickson, Robert, *Sound Structure in Music*, University of California Press (London: 1975), p. 139

1- Texture is perceived and is materialised within the spectral space framework; textural quality is attributed to the manner in which musical materials occupy spectral space and evolve through it.
2- Texture is cumulative; it is constructed through the gathering of sub-textural elements - discrete microsounds, continuous strata or variations/combinations of the two.
3- Textural elements demonstrate behavioural tendencies and relationships amongst one another. Depending on the type of texture it may be more or less difficult to pinpoint the individual sub-elements.
4- Overall textural quality and behaviour results from the intrinsic behavioural tendencies and relationships of the sub-textural elements.

This can be summed up in one statement that defines texture as:

> *The perceptible accumulation of more or less distinct spectromorphological elements into a coherent and holistic spatio-temporal entity whose structure is characterised by the behavioural tendencies and relationships that exist amongst its sub-elements.*

4.2.2 Texture Motion and Behavioural Relationships

Aspects of motion discussed in Chapter Three can also be used in relation to the internal and global behaviour of textures.[152] Textures can be described in terms of their global motion in spectral space as well as their internal behaviour that may display different motion tendencies. A texture may for instance be internally characterised by recursive motion, while also having a global sense of directionality. However, note that the overall directionality of a texture is not necessarily continuous and may result from collective behaviour of sub-textural elements that together establish a global directional tendency in spectral pace. An excerpt from *Songes* (sound example 12) demonstrates the manner in which vertical directionality can result from the collective behaviour of materials rather than being inherent in the behaviour of the individual elements themselves. Also note the gradual densification of the texture (discussed later) by means of agglomeration of elements which is followed by a rapid upward clearing of spectral space extent towards the end of the example. Thus when discussing textural identities we must consider the manner in which sub-textural elements *behave together.*[153] Do they seemingly collaborate to establish particular directional tendencies or processes of densification/disintegration? Is the collective behaviour of sub-textural elements more erratic or chaotic? (For example *convolution* or *turbulence*.[154]) Naturally in

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152 Of course, motion and energy-expenditure are interdependent.

153 Smalley, Denis, “Spectromorophology: explaining sound-shapes”, pp. 117-118.

154 Ibid., p. 118.

more complex situations different behavioural tendencies may also exist in combinatorial forms.

On the other hand the motion of more fused substances is not felt as resulting from the internal behavioural relationship among elements, but rather as a general sense of animation that propagates in spectral space (as well as perspectival space as it will later be suggested). Example 13[155] shows a compound entitative state that can be analysed into three substances: an inharmonic fluctuating semi-fluid substance (not unlike that encountered in *Base Metals*), higher-frequency graduated-continuant resonances, and diffused and slowly-dissipating gasoide (fluid) substances. Note that the last two elements grow directly out of the fluctuating inharmonic mass and are not experienced as independent entities as such (the concept of fusion/fission will be discussed later). Here the inharmonic material is characterised by continuous fluctuations in spectral energy that appear to propagate within its spectral space extent in an undulating fashion. Thus we can discuss the internal behaviour of this compound texture as patterns of propagation that are dispersed in spectral (and perspectival) space: the texture is animated in a quasi-decorrelated fashion across its spectral extent but without losing its fused character.

4.2.3 Texture and Energy-expenditure

All aspects of energy-expenditure discussed in Chapter Three can be applied to micro-entities in aggregate textures. How do they inject energy into the texture? Is there any apparent micro-animation on the sub-textural

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[155] This short example was composed by me for the purpose of demonstrating aspects of spectral substances.

level? Do they dissipate or are they sustained/iterative? However, it must be noted that energy-expenditure is usually perceived as a global attribute of textures - particularly in the case of compound textures, which do not establish sub-textural entitative identities. Furthermore, the overall energy-expenditure of textures is governed by variations in dynamic and internal density, which in the case of aggregate textures result from the collective/propagative behaviour of sub-textural micro-entities or sub-entitative elements. For instance in sound example 14, an isolated entitative identity from my piece *Convergences,* impetus appears to increase by means of general growth in the density of lower-level activity. Similarly, textures often dissipate by means of deterioration in their structure (lessening of density), which in the case of substances means an apparent conversion into a more fluid state (as suggested in relation to sound example 5).[156]

4.2.4 Fusion/Fission

A textural context may or may not involve a multitude of entitative identities. For instance, one may perceive only one compound entity with a complex pattern of energy distribution. Here we can use the terms *fusion/fission* to discuss the degree of segregation of a spectral texture into different entities. In a sense this is a measure of compoundness of entities: an aggregate is formed by a collection of entities whereas a compound texture results from a perceptually-unified type of spectral matter (or substance) that is distributed in spectral space.

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[156] See the discussion of mass below.

4.2.5 Texture and Spectral Space States

The notion of texture as discussed above can be seen in a more general sense to denote the global entitative context as formed by the collective behaviour of spectromorphological elements, which may themselves range from simple entitative forms to more complex textural identities: a global texture can therefore be made up of nested textural structures. From this perspective we can view the entitative acousmatic state as a meta-texture or textural identity.

Here I suggest that this thesis is in fact concerned with *spectral texture* in acousmatic music, which can be defined as *the manner in which spectromorphologies occupy and pattern the extent of spectral space* – in other words, the spectral surface-structure of the acousmatic 'image'. Depending on the 'zoom-level', spectral texture may describe the motion, energy-expenditure and spectral occupancy of aggregate/compound entities as well as that of the global entitative state.

A spectral texture identity can be conceptualised as a state of spectral spatiality or a *spectral space state*. In this sense spectral space is seen as a generalised schema or class (to borrow a computer programming term) abstracted from our experiences of recurring spectromorphological behaviours and configurations that are encountered in acousmatic musical contexts. The term 'state' refers to specific spectral textural identities that may be recalled and recognised: a spectral space state or textural identity is established through spectromorphological behaviours (i.e. manner of spectral space occupancy and articulation) that remain consistent enough over a period of time to become instilled in consciousness. In object-oriented programming one would refer to ‘spectral space’ as a class with ‘spectral space states’ as instances of it.

The following section focuses on aspects of spectral space occupancy, both with regard to isolated and global entitative identities. I will present a terminological framework for highlighting attributes of spectral space occupancy by means of which textural identities are established. Naturally, motion, energy-expenditure, and rootedness must also be viewed as qualifiers of spectral texture in this context.

4.3 Spectral Space Occupancy

4.3.1 Overview

Spectromorphologies are formed by patterns of energy distribution in spectral space. In the case of simple entities this energy is seemingly ‘contained’ and perceived as the inherent impetus or life-force of a single ‘source’. However, more complex entitative identities are perceptually characterised by configurations in energy distribution across a particular extent of spectral space (or spectral space occupancy), which can be described using the criteria of *contiguity/divide*, *focus/diffuseness* and *extent*. I have attempted to present an overview of the qualifiers in the following sections and point out their prevalence in the musical context.

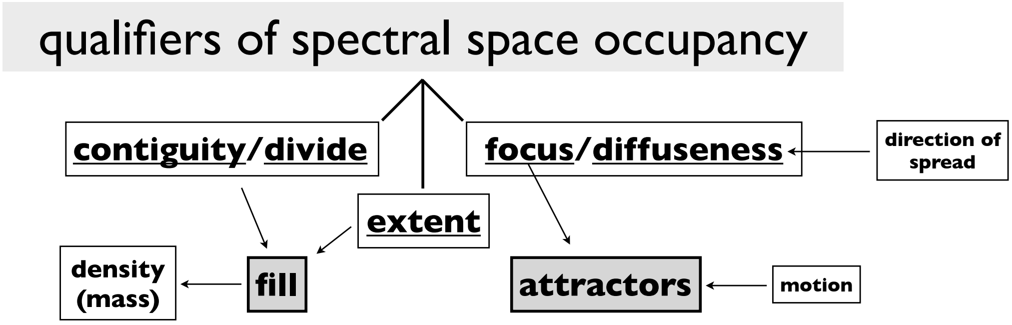

Figure 8. Qualifiers of spectral energy distribution

4.3.2 Focus/Diffuseness and Attractors

A texture can be more or less spread in its spectral space extent: spectral energy may be diffused evenly throughout this extent or it may be focused in regions as if gravitating towards *attractors* or spectral space regions that act as points of reference. Thus we can often describe spectral space occupancy in terms of one or more attractors around which spectral matter is more or less densely coagulated. Attractors may be denoted by continuant planes or by more active entities that are biased towards a general region or mean position. However, an attractor is more precisely locatable when it is denoted by pitched sounds. For example, a melodic line (in both acousmatic and non-acousmatic music) can reveal one or more points of reference or focus in pitch space as it evolves (for instance, shifting from tonic to dominant).

The qualifier 'focus/diffuseness'[157] can be used to denote the degree of uniformity of energy spread: is spectral energy equally distributed or is it focused intensely around the attractor(s)? On the other hand, spectral

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[157] Smalley, Denis, "Spectromorphology: explaining sound-shapes", p. 121.

energy may spread from an attractor in different directions: is energy concentrated in the centre (radiating outwards from an attractor) or does it spread out unidirectionally from an attractor?

If energy is diffused across a larger spectral space extent then an attractor will not be established and instead one experiences spectral texture as a state of uniform diffuseness. There are naturally many degrees of ambiguity between clearly-defined attractors and absolute uniformity. Similarly, a spectral space state may be characterised by a variety of entitative identities with different spread and focus/diffuseness. A compound entity can also denote different regions of attraction or be divided (*contiguity*/*divide* is discussed later) into more or less equally-distanced streams or pockets. In such contexts, from a global textural perspective, a dominant attractor may indeed not be present as such.

The motion of entities can also influence the perception of attractors: do entities traverse spectral space as if gravitated towards a particular region? For instance, recursive motion often revolves around a central point that can suggest the presence of a gravitational force. Likewise, errant/erratic behaviour can be more or less biased towards particular pitches or regions. As such, an attractor can also be implied (without being physically present) by means of directional motion that has a sense of impetus or goal.[158] Here the presence of an attractor can be felt more strongly in a complex texture where an aggregate of entities populates the same region(s) or collectively behaves as if attracted towards the same gravitational force(s). Similarly, the textural context of a musical passage

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[158] Smalley refers to these as diagonal forces. See Smalley, Denis, ‘Space-form and the Acousmatic Space’, p. 46.

may establish a sense of overall directionality (as discussed in relation to sound example 12) that denotes the presence of an implied attractor. In this sense an attractor may indeed exist higher up in spectral space, seemingly at an altitude that is outside our hearing range - in other words, sounds can move out of sight in an upward direction.

It must be mentioned here that in a musical context individual entities rarely traverse large (global) spectral distances and are more typically biased towards regions. This is even the case in unidirectional motion, which more often than not deviates from the *path* and therefore remains somewhat confined. Of course, entities can articulate more global spectral trajectories (sound example 12) that move towards or depart from regions of attraction with a strong sense of directionality.

Let us refer to a short passage from Smalley's *Valley Flow* to demonstrate the significant of attractors in defining the acousmatic context. Sound Example 15 is an excerpt situated 01':46" into the piece. The passage is characterised by a relatively diffused texture and an emerging high-altitude plane with an extremely focused spectral make-up. (This same pitch has already been very much a point of focus from the outset of the piece.) Initially attention is distracted away from the attractor by the more diffused textural animations and the foreground activity. (Also note the gesture at 00':07" from the start of the sound example.) At 00':17" an animated aggregate of micro-entities emerges that directs our attention up towards the planar attractor that immediately follows. At 00':24" an attack-resonance morphology (impulsive-dissipative behaviour) helps clear spectral space of the more diffused materials, leaving behind the planar entity as the main foreground element. Note that despite its pitched spectrum this plane has a sense of upward energy spread and therefore seems higher than its fundamental frequency alone would suggest.

At 00':33" a micro-gesture is launched with a gentle impetus that imparts enough kinetic energy to the spectromorphology to enable a rapid upward ascent (a 'flinging' motion). This motion encourages an upward 'gaze' towards the upper spectral region in which the plane resides, seemingly giving way to the higher micro-entitative identity that re-emerges in the distance (now in a singular form?), in turn drawing attention away from the discontinuation of the plane. Significantly the micro-entity is an octave higher from the plane (the pitch D) which perceptually smooths out leaps in spectral space. The seamless shift in register by means of octave-equivalence is even more explicit in the following phrase (00': 41") which is launched by a short-lived graduated-continuant an octave below. Despite being sustained for only a brief duration this lower morphology establishes the presence of a self-propelled planar entity in consciousness due to its steady graduated energy-variation. Indeed there is a sense that *it* continues to subsist [silently] beyond its visibility. Also note the graduated injection which appears to impart its energy (with a sense of push) to the (re)launching of the higher plane that is also accompanied by a brief high-impetus re-emergence of the micro-entity (00':41"). At this point listening-attention is drawn back towards the higher altitude as the lower plane disappears out of sight. Due to the octave relationship the lower entity acts as a supporting anchor - its absence further exaggerates the sense of rootlessness of the spectral spaces state. However, the lower-entity remains present in listening consciousness and there is a sense that it will come into sight again. One could suggest that two forces of attraction are pertinent at this stage which together denote an empty spectral extent. The distant noise-based textural aggregate at 00’:50” is a gentle reminder of the emptiness of the spectral extent of this passage, which, it must be iterated, is confined to the higher-altitudes. (The implied lower plane is in fact mid-register.)

At 00’:55” an animated descending texture is launched with a more dense (but rapidly dissipating) spectral space occupancy that fills the implied gap and expands spectral extent in a downward direction. As the texture descends, lower graduated-continuant elements are revealed (also highlighting the pitch D in different registers) that deepens the space. By the end of the phrase (01’:05”) spectral space has cleared, leaving behind the higher-altitude plane and the lower dissipating elements. Note that the plane does not dissipate as such but moves out of sight in a steady self-propelled manner. Also notice that now spectral extent has expanded (deepened). Therefore the psychological gap produced by the empty space is felt much more strongly. (More on spectral space extent later.)

At 01’:14” the micro-aggregate entity temporarily returns, this time with more impetus and higher up in spectral space (the pitch G). The planar attractor (D) is now absent while the texture become more diffused and spread in an upward direction. (Extent is now expanding upwards.) Thus a shift of focus takes place from G up to D. Instability is further increased by the internal ascending motion of the noise-based substances. However, these soon become more focused around the original attractor (D) towards which the higher materials seemingly gravitate: this is guided by an internal descending glissando at around 01':20". Note that downward tendency is present both as continuous motion of entities (glissando) and as the directional tendency articulated by the collective behaviour of sub-textural materials. The texture continues its overall descending motion, back down towards the D in the low-mid register.

The above passage demonstrates the ease with which listening focus can shift between registers (altitudes) by taking advantage of octave equivalence as well as the intricacy with which the composer directs our 'gaze', much in the same way that a painter can create visual relationships that encourage the onlooker to explore a scenery in a particular sequence or direction. It is also clear that the manner in which spectral extent is revealed and how it varies can become a guiding principle in the creation of listening focus and expectations. This is discussed in more detail in the next section.

4.3.3 Spectral Space Extent

The term 'extent' refers to the spectral space dimensions denoted by the lower and upper boundaries of a texture - the lower and upper contours of a spectromorphological context. Note that here we are concerned with the perceived spectral space extent of a sound, which may not directly correlate with the physical extent of its spectral structure. For example, a harmonic sound is often experienced as a single pitch (corresponding with the fundamental frequency) rather than the physical extent of the spectral structure. However, if such a sound remains sustained for a longer duration, attention is gradually drawn towards the internal evolution of the partials and one becomes conscious of the overall spectral extent of the sound.[159]

In a musical context spectral space extent is revealed through time and is therefore open to transformations within the temporal flow of the listening experience. The manner in which the spectral space extent of a given state is established in consciousness is an important factor in the creation of listening expectations. For instance, the establishment of an extent of 'cosmic proportions' that encompasses extreme depth and altitude imprints a strong impression in the listener's consciousness: this contextualises the experience of proceeding entitative activities and yields more or less explicit listening expectations.

Consider the start of my piece *Convergences* (sound example 16). Here the sense of extreme depth and altitude is immediately established. However, listening attention is rapidly diverted from the root towards the upper altitude occupied by the weightlessly dissipative/flowing substance. The sense of height and elevation is exaggerated in the light of the deeply rooted launching gesture by means of which energy was initially injected into the substance. Consequently as the suspended texture continues, there is an underlying expectation as to how the deeper dimension of spectral space may be subsequently revealed.

The psychological implication that the root might re-emerge explains why the recurrence of the initial gesture at 01':46" does not come as a

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[159] Naturally, the introduction of inharmonic deviation as well as decorrelated micro-animation among the partials aids the perceptual segregation of the sound into a compound texture.

surprise (perhaps a compositional weakness in the passage).[160] On the other hand, the more graduated throbbing in the bass region (starting at 02'. 58”) that is seemingly submerged beneath the surface-level threateningly echoes an apparent subterranean energy-source that is waiting to erupt. Here the extensive gap between the spectral texture root[161] and the canopied material establishes a ‘vast emptiness’. Also note that the higher-frequency textures become progressively more animated and self-propelled. Nevertheless, the behaviour of the upper materials remains somewhat receptive to the more earthbound activity, whose graduated injection seems to cause a certain level of commotion in the higher textures. (This is perhaps more explicit at 02’:07”)

Compare the sudden emergence of the full dimensions of spectral space in the passage discussed above with the beginning of Smalley’s *Valley Flow* (sound example 11), which reveals the lower extent of spectral space in a meticulously slow manner. Here spectral energy is gradually spread outwards with the substance constantly reshaping itself in a fluid fashion. Note also the increase in spectral density and the apparent mass of the texture. At the same time the presence of a lower spectral region is subtly suggested (at 01’:20”), which extends spectral space downwards: this can be felt almost as a change of vantage point, as if the listener attains a glimpse of what lies beneath. There is a relatively rapid descent starting

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[160] Of course this is also a question of timing: an expected event can be surprising if it recurs at an unexpected point in time, which is not discussed here.

[161] Note that as mentioned on page 77 here the upper textures are not actually ‘rooted’ as such.

at 01’:46” in the piece (sound example 17) which pulls listening attention down, towards more earthbound materials.

It can be assumed that listeners have an intuitive knowledge of the maximum extent of spectral space in acousmatic music. In the context of *Valley Flow* we know that spectral extent can potentially move beyond the limited upper register. Without this knowledge we would not have the capacity for experiencing a sense of elevation unless a bass was always present. It is this sense of a maximum spectral extent that remains potentially open to becoming ‘occupied’ that characterises spectral space as a schema, and contextualises states of spectral spatiality.

The spectral extent of a particular spectral space state is defined by what is and has been perceptually present in the context of the piece (in reference to the full potential extent of spectral space). Thus we must consider the larger context of the piece rather than simply what is experienced at a given moment in time. Moreover, given enough contrast between different textural identities in a work, one may simultaneously be aware of two or more states characterised by different spectral space extents. Similarly, a transformational state is often characterised by convergent and divergent directional motion of entities or expansion/contraction processes in the energy spread of textures that entail explicit changes in spectral extent itself.[162] Divergent motion can for instance be used to *open* spectral space *outwards*, transforming a more confined or ‘contained’ space into a vast spatial ‘void’. A concrete example will be

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[162] Smalley, Denis, “Spectromrophology: explaining sound-shapes”, p. 116.

provided in the following section but first we must discuss the notions of spectral space ‘fill’ and ‘density’.

4.3.4 Fill: Contiguity/Divide

When spectral space extent is significant, we become particularly conscious of the way in which this extent is internally structured. The term ‘fill’ can be used to refer to the manner in which the perceived extent of spectral space is patterned by spectral matter and populated by entitative identities. For instance, is spectral space extent deployed in a contiguous fashion or is it divided into streams or pockets (*contiguity/divide*) of more or less focused/diffused spectral energy? A contiguously-filled spectral extent can be viewed as a globally spread spectral texture that may be characterised by a more or less diffused spectral energy. When energy is focused more intensely in different regions one becomes conscious of a multitude of streams separated by gaps (divide). Energy may be more or less evenly distributed among these streams: in a complex context we need to view spectral fill as resulting from nested patterns of energy-distribution.

4.3.5 Density and Mass

Starting from a compound entity with a focused spectral energy we can imagine spectral matter spreading outwards, dispersing through a progressively larger extent. However, this increase in the extent of spectral space is not by definition accompanied by an increase in the apparent mass of the texture. Instead, the overall energy-level of the texture will simply be diffused over a larger area: this can be imagined as a more or less transparent sheet or fog spread in spectral space.[163] In order for the mass of a substance to increase, its overall energy-level must intensify in conjunction with an increase in extent and fill: thus mass refers to the accumulative density of a textural body. We can use the concept of mass to refer to the overall density of a spectral space state. Naturally in the context of aggregate textures this entails an *agglomeration*[164] of elements into a larger volume.

In acousmatic music, listening expectations often result from textural processes of accumulation and deterioration. These must be considered together with spectral space extent and fill: densification processes either imply the infilling of an established extent (endogeny) or an expansion of extent by means of external accumulation (exogeny), or a combination of the two.[165] Likewise, aspects of motion must be considered here: exogeny may for instance seem to be elicited by recursive motion, which appears to gather more body with each turn.[166]

An example from *Convergences* can serve to demonstrate aspects of mass in relation to the process of expansion in spectral space extent (sound example 18). Here spectral energy (and impetus) is rapidly accumulated as spectral texture gathers more body, resulting in an impulsive 'release' of energy characterised by a densely packed dissipative substance. As the texture momentarily dissipates it exposes gaps in spectral space, making

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[163] Smalley, Denis, "Spectromorphology: explaining sound-shapes", p. 121.

[164] Ibid., p. 116.

[165] Ibid., p. 116.

[166] Of course, these processes are not limited to acousmatic music.

one aware of the spectral space extent that lies underneath. Also note that here entities become more graduated in their energy injection, as if stretched out in time: space and time are both expanded. At 00':12" energy is slowly re-injected into the texture (this time in a far more graduated fashion), again with a general upward directionality that implies a sense of effort. The scale of the subsequent explosion (energy release at 00':18") matches that of the accumulation process, culminating in a voluminous and extensive textural mass. Density is then reduced, leaving behind a sparsely filled and more diffused spectral space state (this elicits a change of 'scene' or state). This large-scale spatial opening contrasts with the more introverted space of the previous section (sound example 19) which conveys an overall sense of inhibited textural growth: this is characterised by the spectrally-focused internal pulses and micro-aggregate activity that collectively move towards a more diffused (and fused) and densely filled spectral space state, but not quite passing the 'point of no return'.[167]

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[167] See Nyström, Erik, 'Thermal Crises: Aesthetic Potentials of Texture in the Entropic Continuum', unpublished paper presented at EMS12.

4.4 Spectral and Perspectival Occupancy

4.4.1 Introduction

We have established that entities are experienced as spatial forms that exist both spectrally and perspectivally. In this sense spectral spatiality can be viewed as perspective space that is inferred by the perceptually pertinent spectral configurations of sonic materials and contexts. The relationship between perspectival and spectral trajectories has already been discussed in Chapter Three. Similarly, on a phenomenological level spectral space occupancy and texturing are intertwined. Although a full discussion does not belong in this study, below I have sketched out important points of convergence between spectral and perspectival qualities, particularly as encountered in the context of entitative states.

4.4.2 Simple Entities and Point Sources

Simple entities often appear to occupy a finite position within the panoramic or circumspatial[168] fields, even if their spatial position is not precisely localisable as such. Simple higher-frequency entities evoke point-source spatial forms (of course these may be in motion) that do not conceptually lend themselves to widely-spread or dispersed perspectival configurations. However, micro-entities can be grouped together to articulate space (both spectral and perspectival) in a more extensive manner. Simple lower-frequency entities, although not clearly localisable in

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[168] Smalley defines circumspace as “the extension of prospective and panoramic space so that sound can move around the listener and through or across egocentric space”. Smalley, “Space-form and the Acousmatic Image”, p. 55.

listening-space, appear to have a larger spatial extent in their apparent dimensions. The orbiting entity in Bayle's *Grandeur Nature* (sound example 6) can be cited as an example here. Note, however, that low-bass entities appear extremely voluminous and are often experienced as more perspectivally diffused: they rarely contribute to the production of simple entitative forms.

4.4.3 Planes and Panoramic Width

Sustained invariant morphologies can impart a sense of stasis to the entitative state, as if denoting more permanent features of a landscape. In this context, sustained and elevated planar spectromorphologies with spectrally focused (pitched or nodal) structures evoke the perspectival image of a peripheral horizontal plane. Depending on the degree of spectral spread and diffuseness these may be experienced as the "line of horizon"[169] or distant substances (stratus clouds): here the boundary between substance-like identities and a non-entitative spatial presence is blurred, particularly if there is little internal animation to maintain an entitative identity. We have already encountered a good example of this at the beginning of Smalley's *Valley Flow* (sound example 11) where a sense of panoramic vastness and prospective depth is immediately established by the distant planar material. Note that although the articulation of a

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[169] In 'Space-form and the Acousmatic image' Smalley highlights this:

> High sustained, continuant morphologies can indicate to me not a morphology acting in space, but rather an aeriform presence, a means of suggesting space itself rather than anything which moves in it, something possibly atemporal, as if time is becalmed. Continuant spectromorphologies in general can produce this idea of spatial presence, creating, for example, the idea of periphery or horizon, like a sketch which, with a few lines and smudges, produces space but no identifiable content. Smalley, "Space-form and the Acousmatic Image", p. 47.

periphery can extend circumspatially, in the context of this passage it would be rather odd if the sound was diffused in the back of the listening space: this is because the material lends itself well to processes of approach and recession, which will be discussed later.

Note that here we are dealing with a highly abstracted spatial context, so the visual analogy (the line of horizon) is used merely for verbal communication. What is important is the sense of spatial vastness, height and periphery that may present themselves in different descriptive guises, depending on the listener's background and familiarity with the medium.

4.4.4 Image Dispersion

The swarm entity from *Stop! l'horizon* (sound example 7) was defined as an aggregate texture, the entirety of which moved in spectral/perspectival space. On the other hand an aggregate entity may not articulate perspectival/spectral trajectories as such but rather be revealed as a more or less expansive spatial zone (the listener may be placed inside or outside this zone) that is textured by the activity of sub-textural elements.

More fluid substances are characterised by a sense of dispersion and instability that is both spectral and perspectival: the spectral spread of substances infers a sense of perspectival image dispersion. Moreover, when in motion, more fluid substances appear to leave behind a dissipative *trace* , or contiguously propagate across broader perspectival extents.[170]

Sound Example 19, has been composed by me for the purpose of demonstrating aspects of image dispersion and texture motion in the

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[170] Naturally the possibilities are more extensive in multichannel composition.

context of substances. Here the texture clearly spreads from the front to the back (as provided by the 6-channel configuration). This is a phenomenon referred to by Kendall as “image dispersion”.[171] From a technical point of view the success of image dispersion is largely dependent on the degree of decorrelation between the front and rear materials.[172] Due to the *precedence effect*[173], dispersion is minimised or non-existent for listeners positioned towards the front or the back of a multichannel set-up: the sound is perceived to emanate from the direction of the nearer speakers rather than becoming wider in its perspectival image. However, this can be successfully overcome by means of sending subtly decorrelated copies of the same sound into the front and the rear speakers.[174] Figure 9 shows the multitrack mixing configuration of the main entitative component from sound example 13 (the fluctuating inharmonic substance). The upper stereo track is routed to the front and front-wide loudspeakers, while the second track, containing a decorrelated[175] copy of the same sound-material, is sent only to the rear loudspeakers. The sense of front/back animation is further enhanced by means of introducing different amplitude fluctuations that

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[171] Kendall, “Spatial Perception in Multichannel Audio for Electroacoustic Music”, p. 233.

[172] Kendall, Gary, “The Decorrelation of Audio Signals and Its Impact on Spatial Imagery”, *Computer Music Journal,* Volume 19, No. 4, The MIT Press (Autumn, 1995), pp. 71-78.

[173] Kendall, Gary, “Spatial Perception in Multichannel Audio for Electroacoustic Music”, p. 234.

[174] Image dispersion also occurs as a natural consequent of acoustic reflections in the listening space and can therefore be increased by the physical placement and configuration of loudspeakers (e.g. pointing speakers towards surfaces to increase reflection).

[175] The sound was processed using an unreleased software (*Sprokit,* version 0.6.0) designed by Andres Cabrera as part of his PhD thesis at Queen’s University Belfast (supervised by Gary Kendall). This tool allows the user to analyse an input sound-file (in non-real-time) into its component frequency partials. Random frequency/amplitude modulations can then be added to the partials when re-synthesising the sound. When kept subtle, these modulations introduce decorrelations that are not directly audible. I have tested the software with more noise-based sounds with good results: Cabrera has taken much care to design a partial-tracking algorithm that works for a variety of different spectromorphologies.

exaggerate the overall energy-expenditure of the spectromorphology. More precisely, phase differences in the volume automation of the two tracks create a sense of front/back motion that perspectivally animates the inherent spectral changes in the sound. The stereo image in the rear has also been reversed to further exaggerate the front/rear decorrelation. Consequently there is an enhanced front/rear image-dispersion with an animated spatial texture.[176] Note that the sound does not appear as a source moving from the front to the back or vice versa; rather, it is extended across listening-space with a sense of animation that propagates in space - echoing the inherent spectral fluctuations of the spectromorphology.

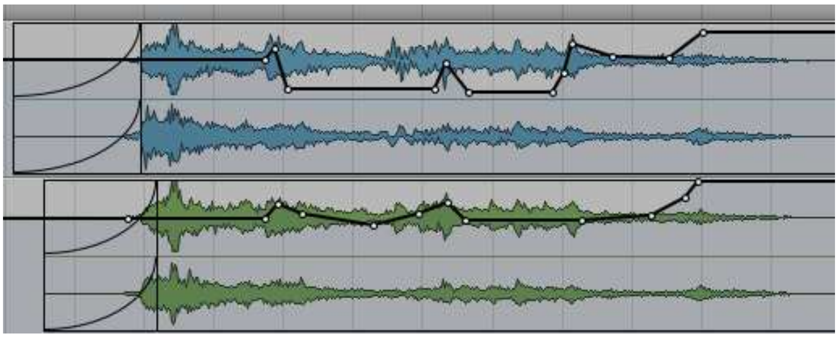

Figure 9. Two stereo tracks in Protools: the first is projected by the front and front-wide loudspeaker pairs, while the second is routed to the rear loudspeakers. The lower track contains a decorrelated version of the sound placed on the upper track (this can be observed as small differences in waveform).

4.4.5 Prospective Depth and Spectral Density

In addition to possessing a certain bodily volume (perspectival/spectral spread and thickness) textures also convey a sense of distance in relation to the listener (and to one another). Variation in spectral structure is an

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[176] Note that it is often desirable to introduce similar micro-fluctuations in diffusion in order to subtly decorrelate the rear image, thus increasing image dispersion.

important auditory cue for judging the relative distance of a sound-source: it is well known that by gradually rolling off the higher spectral frequencies of a sound we can produce the impression that the sound progressively moves into the distance.[177] In the context of simple entities (such as the bird encountered in *Songes*) we are not automatically aware of the intrinsic spectral variations of the sound but rather of the change in the apparent distance of the 'source'. However, in the context of complex entities, particularly that of compound textures, one is more directly conscious of the sound's intrinsic spectral structure. Consequently, changes in textural density explicitly influence the apparent distance of entities from the listener and their prospective relationship with one another. In this sense the manner in which spectral textures denote perspectival depth in acousmatic music is similar to *aerial perspective* in visual art, which is based on the influence of the atmosphere on the appearance of objects: as distance increases, contrast and colour difference between an object and its background decrease, along with the colour saturation of the object itself (see figure 10).

We have already discussed the sense of distant periphery that was evoked by the thinly focused stream of spectral energy at the start of Smalley's *Valley Flow* (example 11). We also noted that as the sound increased in its spread and spectral density it appeared to approach the listener. Also note that at 00':30" the texture extends upwards in a similar way in which an approaching stratus cloud would eventually end up overhead. In fact, this upward spectral expansion of textures is often

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[177] Due to their smaller wavelengths higher frequencies roll off more quickly as distance of measurement increases.

enough to create a sense of prospective approach (also demonstrated in sound example 20 from *Convergences*). Similarly, in Chapter Three we observed that the swarm entity in *Stop! l'horizon* (sound example 7) appears to seep out of the stereo frame as it increases its spectral extent and internal textural density. At times this entity momentarily fills our 'field of vision', thus obstructing other coexisting materials.

Figure 10. ***Ten thousand Li of the Yangtze River*** **by the Chinese landscape painter of the Ming Dynasty Wu Wei (1459–1508), demonstrating aspects of aerial perspective.**[178]

It should be noted here that the relationship between density and perspective is not limited to acousmatic music and can also influence the establishment of structural processes in instrumental music. As an example consider a passage from Ravel's *Lever Du Jour* from *Daphnis et Chloé*. Here a general sense of temporal directionality is created by the gradual growth of textural mass and density (sound example 21). The higher-

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[178] http://arts.cultural-china.com/en/62A222A828.html accessed 31/08/2012.

register animated flute figuration (very much an agile entitative identity) is almost blocked from view at around 01':00" but continues to persist with a strong sense of effort to penetrate through the growing textural density. Note the recursive internal motion of the aggregate/compound textural material with which mass is gathered as well as the overall fusion that results from densification.

The above sound examples demonstrate that the idea of 'fill' or saturation of the spectral extent is inconceivable without imagining the perspectival occupancy of the sound-image: a 'packed' spectral extent implies a densely-crowded perspectival frame. A texture is perceived as existing in a three-dimensional spatial field with vertical and horizontal extents as well as a certain 'thickness' or density (the apparent compactness of spectral matter). A thinly-spread texture will therefore be transparent and allow underlying materials to penetrate through; as density increases, the image-quality tends to become more opaque and, at higher densities, completely impenetrable.[179]

As Smalley suggests, prospective space can be filled "to the extent that the distal periphery will be absent or masked" (what he terms *enclosure*).[180] Thus the panoramic field will "attain maximum extension" and envelop the listener inside an enclosed space, which can of course only be fully achieved in a multichannel context.[181] On the other hand, by clearing the more proximate textural elements, space can seemingly 'open

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[179] Smalley, "Spectromorphology: explaining sound-shapes", p. 121.

[180] Smalley, "Space-form and the Acousmatic Image", p. 49.

[181] Ibid., p. 49.

up', exposing the more distal periphery of the image. (This was encountered in the change of state in sound example 18.) If the panoramic or circumspatial extent of the image is retained, this has the effect of creating a sense of open or vast ambience that immerses the listener without threatening the more proximate peripersonal spatial surroundings.[182] Note that as demonstrated in sound example 17, these processes are directly related to aspects of spectral extent fill and expansion.

A spectral space state often comprises a set of more or less distinct superimposed textural elements with varying degrees of transparency (density). In a multichannel set-up such processes can potentially be more complex since textures can be spatially configured into separate zones. A spectromorphology that has a strong masking function in a stereo context may be projected in such a way as not to overlap perspectivally with other textural materials. Of course, textures can also dynamically vary in their perspectival configurations, for example, opening up holes that reveal previously hidden materials (Here we must also consider circumspectral configurations that are discussed in the next section.)

The tight integration between spectral and perspectival dimensions can be seen as a guiding principle in acousmatic sound diffusion and composition. The task of a diffusion artist is to select perspectival configurations that can enhance the spectral/perspectival relationships that already exist in a work. Moreover, the brief discussion of the topic in this section suggests the enormous potential of acousmatic music to explore

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[182] Ibid., p. 49.

spatiality as an integral aspect of the musical ‘language’: there is musical meaning in spatial relationships and qualities.

4.4.6 Circumspectral Sound Projection

There is a more explicitly incorporated relationship between spectral and perspectival spaces that manifests itself in the experience of what Smalley refers to as ‘circumspectral spaces’. The term is a combination of ‘spectral space’ and ‘circumspace’ - how the spectral content of a sound is distributed within (and around) the listening space.[183] As he elaborates:

> How spectral space in itself is distributed contributes to the sensation of height, depth, and spatial scale and volume. I can create a more vivid sense of the physical volume of space by creating what I shall call circumspectral spaces, where the spectral space of what is perceived as a coherent or unified morphology is split and distributed spatially.[184]

It is known that distributing the partials of a single sound among a loudspeaker array does not by itself lead to the perceptual segregation of the spectral components of that sound.[185] In the context of sound synthesis one has the freedom to introduce different degrees of decorrelation (modulations or phase differences) among the partials in order to

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[183] Smalley, ‘Space-form and the Acousmatic Space’, p. 51.

[184] Ibid., p. 51.

[185] See Kendall, Gary, ‘The Decorrelation of Audio Signals and Its Impact on Spatial Imagery’.

seamlessly shift listening attention from a uniform entity towards a multitude of entitative identities: depending on the context and the degree of decorrelation, one may perceive a compound texture, a multitude of compound textures, or an aggregate of more simple entities.

Naturally in multichannel composition we have far more control over the perspectival distribution of the spectral content of spectromorphologies. Although with careful mixing one can certainly explore circumspectral configurations, it seems appropriate to take advantage of a purpose-designed computer-program that enables a more sophisticated and experimental approach: my software module ‘circumspect’[186], created with Csound’s real-time phase vocoder opcodes[187] and MaxMSP[188], is an attempt towards this. Here the user can control the circumspectral configuration of stereo sounds by means of user-defined random distributions of FFT bins within the loudspeaker array.[189] Up to eight loudspeaker channels are currently possible but theoretically there are no limits. The user can also choose between smooth distribution of the bins - whereby the adjacent frequency bands remain close to one another in terms of their panning configuration - and a more drastic scattering of spectral components that will introduce inevitable but sonically interesting

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[186] Khosravi, Peiman, ‘Circumspectral Sound Diffusion with Csound’, *Csound Journal*, Issue 15 (July 2011). A video of the paper presentation at the Csound Conference is available at http://vidgrids.com/csound-conference. Accessed 9/1/12

[187] A collection of opcode developed by Richard Dobson, Victor Lazzarini. (http://www.csounds.com/manual/html/SpectralRealTime.html, accessed 31/08/2012)

[188] http://cycling74.com/. Accessed 31/08/2012

[189] The input signal is analysed into a number of frequency bands (bins) where the surround panning ‘position’ of each band can be defined by the user.

phase distortions. One can also control the focus/diffuseness of frequency distribution in the panning 'space' by means of user-defined curves.

Circumspectral sound projection produces a distinct sonic experience that may be typified by an enhanced sense of spatial animation, volume, diffuseness or spatial enclosure. For instance, higher-frequency noise-based sounds can appear to fill listening space in a far more diffused and contiguous fashion - with an increased sense of front-back dispersion. One can create the impression of a contiguous canopied texture (a more or less dense spectral texture that is spread overhead): note that the impression of height is suggested by spectral spatiality here and does not require overhead speakers.

From a technological point of view, carefully sculpted circumspectral images tend to somewhat enlarge the size of the 'sweet spot'. Multichannel compositions often suffer when transferred from a smaller to a larger listening space: the integrity of the perspectival image can be less than perfect for listeners in proximity to individual speakers. By redistributing the spectral components of a unified sound among the speakers the composer can ensure that no single speaker reproduces the entire signal; rather, the full signal is reconstructed in the listener's mind, which means that physical proximity to a speaker will have a less detrimental impact on the experience of the perspectival image as a whole.

One can also create the impression of an animated spatial texture by more or less contiguously distributing frequency components of a spectromorphology that already suggests a sense of motion. My experiments have shown that with simpler contiguous configurations I can perceive the perspectival expansion of a sound's spectrum. Scattered random distributions produce more drastic phase decorrelations that instead increase the perceived spatial dispersion of sounds. Interesting circumspectral configurations can be created by using complex spectromorphologies and creating less straightforward circumspatial mapping of the spectral components. I have, for instance, achieved attractive results from noise-based sounds that were processed with numerous filter-sweep-like transformations to create broad spectral undulations. Even more interestingly, one can use stereo sounds where the filtering motion is coupled with panoramic trajectories in the original stereo (possibly inherent in the recording rather than resulting from any amplitude panning). The stereo sound can then be spectrally mapped to the loudspeaker array, thus circumspatially expanding the sense of spatial animation. Sound example 22, a circumspectral version of sound example 23, demonstrates this (the sound is mixed at 06':15" in the context of my piece *Vertex*). This evokes a substance-like entity that sweeps overhead. A more drastic animation is presented by example 24/25 (an unfiltered version of 22/23). Sound example 26, a circumspectral version of example 27, was create to demonstrate the sense of motion that can result when more spectrally active sounds are circumspectralised. The higher frequencies in this example are distributed towards the rear of the multichannel array which enables the spatial articulation of more transient materials. Examples 28/29, 30/31, 32/33, 34/35, and 36/37 demonstrate a variety of more or less animated semi-fluid entities as circumspectral/stereo pairs. Here circumspectral distribution is used to enhance the sense of perspectival enclosure and spatial animation of sustained fluctuating spectromorphologies.

Example 38, from the final section of *Vertex* (entering at around 10': 44"), is a mix of two differently circumspectralised sounds, which demonstrates how the combination of different circumspectral sounds can create a richer sense of animated spatial texture. Sound examples 39/40 show the circumspectral/stereo versions of the bass gesture from 04':02" in the piece. Here circumspectral distribution is used to enhance the sense of spatial volume of the sound. Sound example 41 is a circumspectral version of example 42 (mixed in at 12':43" in the piece), which creates a sense of enclosure by spreading the spectral components of the inharmonic graduated continuant morphology around the listener. Similarly, a mix of different circumspectral sounds are used near the beginning of *Vertex* to create a more vivid sense of enclosure: examples 43-51 show the individual graduated continuant resonances that are mixed together at 02':00" in sound example 52.

Examples 53 and 54 are more animated circumspectral sounds with distinct spatial trajectories (these appear between 06':40" and 07':50", as well as in the final section of the piece, starting at 12':11"). Similarly, examples 55/56 show the circumspectral and stereo versions of the animated aggregate-like entity from 04':53" in the piece. Examples 57/58 (circumspectral/stereo) demonstrate the substance-like aggregate from 02': 40", which is dispersed circumspectrally in listening space. Further discussion of circumspectral distribution and its relationship with spectral and perspectival design in a musical context is reserved for the commentary section on *Vertex* (page 144).

More detailed research about circumspectral sound projection is needed. Similarly, many possibilities remain unexplored, both compositionally and in terms of the development of software tools. For instance, how would spatial textural animation be enhanced by means of adding small amounts of delay or amplitude modulation to the spatially distributed frequency bands? Would the addition of a 'spreading' parameter for controlling the leakage of each frequency band into different loudspeakers be compositionally useful?

4.4.7 The Importance of Context

The usefulness of circumspectral distribution becomes particularly apparent in a musical context where a multitude of circumspectral sounds are mixed to create a complex sense of spatial contiguity and volume. Likewise, the manner in which circumspectral design is integrated with general spectral and perspectival textural processes and motion is of the essence in defining the experience of spatiality in acousmatic music. Therefore, here I must emphasise that the experience of spatiality is largely contextual in acousmatic music and is produced by the relationship among materials. Spectral space consciousness, and spatiality in general, become pertinent when the sonic context conspicuously reveals the articulation of the spatial dimension or extent. As we have seen, this is achieved by means of establishing structural gaps, juxtapositions in textural states, or directional and behavioural tendencies (motion and textural processes). A rich and stimulating spatial context often emerges through the coexistence, collective behaviour and dynamic relationships among elements - when mixing a multitude of sounds together to create a complex spectral/spatial texture.

The creation of perspective in acousmatic music depends on the mastery of the composer in creating a holistic impression of spatial image where the listener is not conscious of the source-point nature of the loudspeakers. (The underlying sense of spatial contiguity may of course be implied in a discontinuously textured circumspatial image.) For instance, it is notoriously difficult, if not impossible, to position and move isolated sonic entities near and around listeners' heads by means of panning technology alone: this is the case even in the 'sweet spot' of the studio. However, in a complex context where the listener is unable mentally to pin-point individual elements, either due to textural density or as a result of intricately sculpted dynamic relationships among materials, one can successfully create the impression of textural activity in the listener's immediate surroundings. Moreover, as we have seen, spectral space fill, when used skilfully in conjunction with perspectival and circumspectral configurations, can provide the means of creating a vivid sense of enclosure and envelopment. In this sense it is essential to understand and take advantage of the inherent spatiality (spectral, perspectival and source-bonded) of sounds in order to construct a more imaginative, perceptually viable, and musically meaningful spatial image.

4.5 Summary

From the discussions presented in this chapter it can be unequivocally concluded that the meaningfulness of the acousmatic experience is influenced by a rich palette of spatial qualia that can be largely attributed to the manner of deployment of the spectral domain, particularly in sonic contexts where familiar spatial settings and known source/cause relationships become obscured. Musical examples were provided to demonstrate the intricate relationship between spectral spatiality and the apparent perspectival projection of sonic materials in listening space. Furthermore, we highlighted the inherent source-bonded character of all sounds that gives rise to the entitative state in which more 'abstract' materials are experienced as spatial forms or at least contribute towards the establishment of a spatial context. However, spectral spatiality, despite being more overtly pertinent in the entitative context, is by no means limited to it. There is no reason, for instance, why one cannot refer to aspects of spectral space occupancy such as extent, fill, fusion/fission, and focus/diffuseness to discuss the felt qualities of more source-bonded or non-acousmatic musical contexts. All music can be discussed in terms of spectral space qualia or states: to what degree these are involved in the establishment of dynamic structural relationships within musically meaningful contexts is another issue. In many cases spectral spatiality may be revealed as being pertinent to perception without being perceptually pertinent.

With these ideas in mind I reluctantly move on to the concluding section, which attempts to situate the subject within the broader context of electroacoustic music and highlight certain errors of judgment that are often involved in our more conventional thinking about spatial composition.

Final Remarks

In this study I have attempted to present a comprehensive overview of the notion of spectral space and to demonstrate its contribution to the experience of spatiality in acousmatic music. It was suggested that the experience of spectral spatiality is not limited to acousmatic music and has its roots in conventional instrumental/vocal music. In a less directly source-bonded context, spectromorphologies can themselves be experienced as visuo-spatial forms with such real-world qualities as motion, density, mass, and texture. Furthermore, a number of criteria were introduced to describe the manner in which spectromorphologies 'texture' the surface-structure of spectral space (as well as perspectival space), both as individual entities and collectively within a musical context.

Despite the relatively widespread use of spectromorphological terminology in discussions of acousmatic music, the concept of spectral space is little acknowledged and is often dismissed for being a mere metaphor that is not related to the experience of 'real' space.[190] However, in the light of the literature cited in Chapter Two and the discussions that followed, it can be safely stated that spectral space is in certain contexts phenomenologically relevant as an aspect of spatiality in music. Indeed, as suggested in Chapter One, spectral space is potentially present in all sound, often sitting dormant, waiting to be drawn out by the composer and revealed as a pertinent perceptual facet, although this is not always done consciously. At other times, the pertinence of spectral space may not be

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[190] Normandeau, Robert, 'Spectromorphology of Denis Smalley', *Denis Smalley Polychrome Portraits*, Institut National de l'Audiovisuel (2010), p. 85.

obvious to the listener and may only become apparent upon further analytical investigation.

One reason for the lack of widespread acceptance of the concept of spectral space is the relative absence of an appropriate vocabulary for signifying the relevant criteria that are involved in its experience. The terminological framework proposed here (using Smalley's original categories) can hopefully serve as the basis for the development of a more exhaustive taxonomy of spectral texture qualifiers that should enable us more systematically to uncover and verbalise sonic attributes that give birth to spectral spatiality in acousmatic music. Needless to reiterate that the taxonomy discussed in this thesis has scope for further refinement and elaboration.

A second possible reason for the neglect of spectral space as an aspect of spatial experience in acousmatic music is perhaps far more alarming and therefore worth discussing.

We are often encouraged, as a result of the fairly sophisticated spatial audio technology that is available to electroacoustic composers today, into thinking that space, the final frontier, has at last been put at our disposal as a malleable compositional parameter. The possibilities are apparently endless: sound sources can move within the three-dimensional field of listening space, they can circle the audience or fly overhead (although often unconvincingly[191]), and all at the turn of a knob. As such, space appears to

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[191] See Gary Kendall and Andres Cabrera, 'Why Things Don't Work: What You Need To Know About Spatial Audio', *Proceedings of the 2011 International Computer Music Conference*.

be a parameter, and one that can be easily manipulated and quantified independently from the sonic content that is ‘spatialised’.

In contrast, attributes of spectral spatiality cannot be objectively measured, nor can they be easily visualised or placed into neat and discrete categories or controllable parameters. This, as we have seen, is due to the complex multifaceted nature of spectral spatiality that depends on the interconnection of many elements (including source-bonded and perspectival characteristics), as well as on the musical contexts in which these elements emerge and interact. (However, it must be noted that in this respect the concept of spectral spatiality is no more complex than the processes involved in the human spatial cognition in general.) Should we consider spectral spatiality as being somewhat less ‘real’ or less ‘actual’ because it is not objectively tangible and measurable? Does spectral spatiality perhaps exist only within a more abstract realm of musical interpretation and thinking that is divorced from the actual empirical experience of space? If so then the premise of this thesis is flawed.

My answer to the above question is negative, as inferred and echoed throughout this study. Sufficient evidence and musical scrutiny has been presented to argue for the potential spatiality of the spectral domain in the acousmatic listening experience. The problem lies elsewhere, namely in the erroneous credence that ‘spatialisation’ technology directly corresponds with the psychoacoustic experience of space as a single *parameter* rather than a complex multifaceted *quality*. This error seems to stem largely from a superficial and simplistic approach to the nature of spatial experience in general, and is further helped by the false sense of objectivity towards space that is implied and encouraged by the available technology. This is particularly threatening in music that does not lend itself to conventional analytical approaches, and which lacks a certain amount of tangibility due to its emphasis on sounds alone, without a mediating body such as the musical score or instrumental idioms and familiar performance gestures. In this context it is vital to remain focused on the subjective, on the sonic *experience*, whereby meaning and sense-making reside. Moreover, it is imperative to understand the particularities of sonic spatiality in order to know the limits and possibilities of spatial composition in acousmatic music. As suggested by Kendall and Cabrera:

> In everyday life, every person is able to navigate the spatial world, to think about space and even to imagine unknown spaces; spatial thinking is one of our most deeply embedded cognitive capacities. The ease with which we think about space is possibly a miscue to how easily spatial ideas can be translated into spatial audio, which has its own intrinsic nature and inherent limitations. Sonic artists need to be alert to the nuances and idiosyncratic relationship of spatial hearing to spatial thinking. Not every spatial idea can be reverse engineered into sound.[192]

The notion of ‘spatialisation’ encourages one to consider space as an empty canvas or frame within which sounds can be placed and moved. However, in the light of the current examination it is clear that source-

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[192] Gary Kendall and Andres Cabrera, ‘Why Things Don't Work: What You Need To Know About Spatial Audio’, p. 37.

bonded and spectral spaces are inherent to all sounds, and that perspectival space cannot be considered in isolation from these two facets. Sounds may be experienced as moving without the presence of directly corresponding physical 'movement' of audio-signals within listening space. This can be easily put to test by establishing dialogues with non-specialist listeners (a regular occupation of mine). In such cases one quickly ascertains that these experiences rely on aspects of source-bonding and spectral spatiality: let us not forget that the latter is inherently source-bonded in itself. Similarly, not all sounds lend themselves to all manners of perspectival projection and motion. Spectromorphologies, particularly in a musical context, are pregnant with a certain spatiality that can *suggest* perspectival settings, motions and configurations: as a composer I have learned that it is imperative to be guided by this inherent spatiality in order to accomplish a more sophisticated approach to the composition of space - an attitude that strongly contrasts with the notion of 'spatialising' sounds in a parametric manner. An investigation of space in acousmatic music must therefore be largely material-based and context-dependent. Above all, it must consider the inherent spatiality of sounds themselves, rather than divorcing space from sound in the hope of an objective, neutral approach.

In short, there is far more to the composition and experience of spatiality in acousmatic music than positioning and movement of virtual 'sources' within listening space. One could even go as far as to suggest that it is the power to explore and sculpt spatiality in a meaningful manner that marks acousmatic music as a unique form of artistic expression. An understanding of the nature of spectral spatiality is therefore critical in order to take advantage of the compositional possibilities offered by this art-form and to comprehend better its reception. I often envisage the researcher/composer as an experimenter of the occult arts, mixing and transmuting spectral matter into entitative identities that move far beyond the spatial confines of the studio, and indeed far beyond the spatial contexts encountered in our everyday lives.

CHAPTER 5

Commentaries

5.1.1 - *Formations, Flux* (stereo, 20’:19”, 2 movements)

General Considerations

The piece was originally conceived as a shorter single-movement work, which now stands as the second movement, *Flux* (starting at 10’:43”). The work aims to move away from more conventional teleological forms and towards a kind of space-form in which a spatial environment is established and viewed from different perspectives. The gradual perspectival approach in the first part tentatively reveals the ‘setting’ that is explored at closer quarters in the second movement. The context is that of a voluminous and slowly-evolving mass of spectral matter in a constant state of flux. One can imagine the homogeneous fluid surface-structure of Tarkovsky’s *Solaris* with its undulating ebb and flow. The second part attempts to zoom in and out of this evolving ‘mass’, slowly rotating around it in order to reveal it from different angles (changing vantage points).

For the most part the felt presence of a human agent has been completely removed. For instance, the use of attacks, which are often experienced as strongly source-bonded gestures, has been minimised: the first movement does not contain any attacks up until 08’:26”. From this point onwards the attack morphology becomes more prominent and eventually leads to the sudden onset (energy release) of the second movement. However, throughout the second movement, compositional interest is refocused onto the fluid activity inside the sustained resonances.

Formations, Flux also marks an important stage in my compositional activities where I was for the first time consciously and directly sculpting spectral texture. This made me fully aware of the close relationship between spectral and perspectival spaces, as well as the significance of entitative identities in the exploration of spectral space.

Poietic Considerations

Having recorded and edited the raw sound materials, it became apparent that any direct source identities carried in the sounds had to be obscured in order to bring spectral spatiality to the fore. It is this transformation of raw materials into more abstract entitative identities which necessitates the use of digital signal processing for me.

Most of the sound transformations in the piece were created using Csound.[193] Csound's score language was used to script compound textural entities by adding up instances of samples in numerous transpositions. I was particularly interested in the use of signal processing in the animation of spatial texture to achieve fluid-like behaviour, both spectrally and perspectivally. For instance, left/right spectral decorrelation was introduced by means of subtle amplitude fluctuations (different for left and right channels) among the frequency bins of an FFT signal.

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[193] see http://www.csounds.com/journal/issue7/onTheDesignOfSpectralToolsInBlue.html, Accessed 24/10/2012


0.02491 arp_left
0.02637 arp_right
6 gain
0.070... depth
0.20000 freq
0.02456 depth (amp)
0 phase_left
0.27679 phase_right
1.17592 rand depth
5.81800 min speed
19.1104 max speed
sine MODE
2048 size
512 overlap

Figure 11. A spectral transformation instrument designed with Csound and Steven Yi's front-end Blue.[194] This instrument allows the introduction of random as well as periodic arpeggiation of the frequency bins with independent control over the left and right channels.[195]

Entitative Identities in *Formations, Flux*

The entitative identities in this piece can be categorised into three main typologies:

1- Sustained semi-fluid substances with internal textural fluctuations and inharmonic spectral structures. These, which dominate the work, vary in their spectral space contiguity/divide and spread.

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[194] See http://blue.kunstmusik.com, Accessed 24/10/2012

[195] see http://www.csounds.com/journal/issue7/onTheDesignOfSpectralToolsInBlue.html, Accessed 24/10/2012

2- Semi-fluid earthbound granular activity. This is used to lend a sense of earthbound surface activity to the texture (for example the lower materials at 05':15").

3- Sky-bound aggregate entities made up of micro-entities or particles. These appear at different altitudes and with varying textural densities. For instance, the passage between 6':00" and 8':25" is a saturation process by means of the accumulation of these aggregate identities.

Recurring Ideas

There are two general 'motifs' that recur throughout the piece:

1- Periodic iteration, pulsation or fluctuations of materials. For instance, at the very start of the piece one quickly becomes aware of the internal pulsations that animate the sustained resonant materials. This pulsation is echoed in movement two in the pitched materials at 12':09". The iteration gradually slows down (e.g. 12':34") and is finally hidden within the fluctuating resonant materials 13':50".

2- Descending glissandi, which are first presented at 02':42" by the motion of a distant entity. This motion transforms into a forceful pull during the climax of the piece (16':15"-15':55").

General Considerations About Spatial Orientation

During the compositional process I viewed myself as a navigator, moving towards and around a large entitative mass or nebula, at times caught in its turbulence and at other times hovering above its surface, or observing it from a distance. Discussions with other composers/listeners revealed an interesting point of divergence: they did not experience themselves as navigating around the nebula, but rather, as observing *it* move in relation to their vantage point. (Composer's perspective versus listener's perspective?) Could one explore new spatial territories in a complex installation context where the listener *can* navigate through space and time? I strongly suspect the answer to be positive, although such an undertaking remains for a future project.

The first movement, *Formations*, can be interpreted as a 'landscape' defined by the gradual approach of, and shifting relationships between, its elements. Spectral space extent is slowly established, along with entitative identities and their behavioural relationships which remain consistent for the rest of the piece. As the materials approach the listener, one becomes conscious of being inside an environment, rather than observing it from a distance. This, in particular, characterises the second movement, *Flux*. The state of maximum enclosure is finally reached in the climactic section (16':55").

Spectral Spatiality

Here I will present my interpretation of the first passage of the first movement to give an idea of the processes by means of which spectral space is explored. The piece begins with a progressive build-up of a semi-fluid substance, which slowly reveals the spectral space extent of the piece in an upward direction. At 01':44" a higher-altitude undulating gasoid substance comes to the fore, adding a degree of downward internal tendency to the texture. As this material clears away, a thin planar stream becomes apparent that lends a sense of stability to the passage, as if the slow ascending spectral build up has reached a kind of stable upper plane. This can be thought of as an attractor formed around D#6 (also supported by a plane an octave lower at 02':03"). Here a more active (granular) compound/aggregate texture, which is placed behind the transparent sustained materials, becomes 'visible' and begins to approach the listener. Note the downward glissando at 02':20". This is too slow to be felt as a fall. Rather, it is experienced as an autonomously controlled downward glide. The glissando almost disappears at 02':36" as it reaches the pitch A#5, directing one's gaze towards the emergence of a planar substance (with the same pitch) in the distance. Also note the salience of this same pitch (attractor) near the start of the piece (for example at 01':13").

This passage is followed by a gradual increase in density (contiguity of fill and textural thickening) that is accompanied by the recurrence of the glissando and an increase in spectral diffuseness (through the emergence of more spread noise-based substances). The granular compound/ aggregate material becomes more predominant at 03':09" before receding into the distance. At 03’:29” the D# plane returns but is quickly cleared away by a faster ascending glissando which, due to its speed, functions as a pulling motion. Spectral texture then moves towards a more diffused state (03’:54”) that is in turn cleared away, leaving behind the lower sustained entities and the more granular aggregate matter.

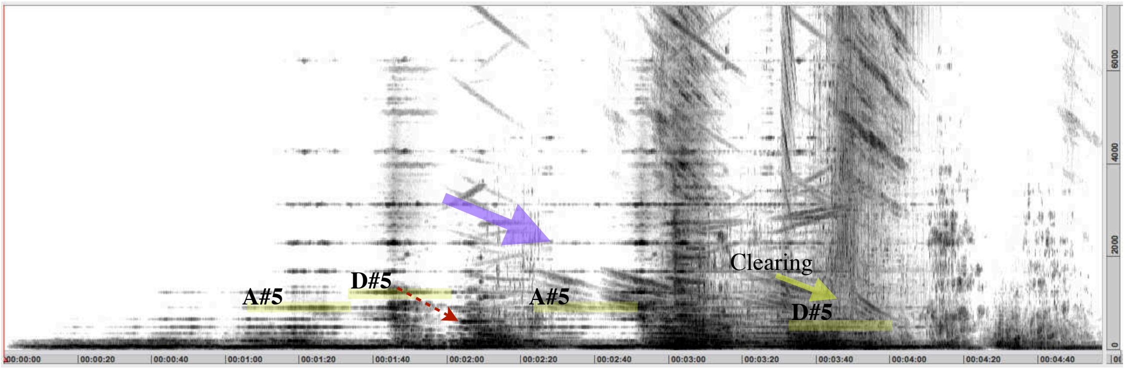

Figure 12. The sonogram display of the first 04’:40” of *Formations, Flux*

Conclusion

In the above discussion I have highlighted the pertinence of entitative identities and spectral space consciousness in *Formations, Flux*. Moreover, I suggested that the exploration of spatiality encouraged the composition of a less narrative form which was more successfully achieved in my final portfolio piece *Vertex*.

5.1.2 *Dog Star Man* (stereo, audio/visual, 05':41")

General Considerations

Brakhage once described music as "the sound equivalent of the mind's moving". His films are unique in their attempt to achieve 'visual music', or perhaps better to say 'music by visual means': his deliberate occupation with silent filmmaking was in fact due to the desire to create the visual equivalent of the mind's moving. As he elaborates:

> "The more informed I became with aesthetics of sound, the less I began to feel any need for an audio accompaniment of the visual I was making. [...] Ironically, the more silently-orientated my creative philosophies have become, the more inspired-by-music have my photographic aesthetics and my actual editing orders become, both engendering a coming-into-being of the physiological relationship between seeing and hearing in the making of a work of art in film." (Brakhage, *Film and Music*, 1966)

Brakhage's idea seems relevant in the context of acousmatic music where sounds can be experienced as visuo-spatial entities. As suggested in Chapter Three, the lack of visual stimuli in acousmatic music can indeed enrich the visuo-spatial qualia of the sonic experience. Here I have attempted to establish a relationship between Brakhage's internalised sound and my own internalised vision: a kind of audio/visual polyphony. In doing so I have essentially reinterpreted and modified the experience of the original work.

Audio/Visual Polyphony

An example of the polyphonic approach to the audio/visual relationship can be cited from 02':24". Here the sound is almost taken away, providing a moment of 'repose' for the viewer to experience the visual element in its 'pure form'. (Naturally the experience of time is altered by the preceding sounds.) The intention is to establish a dialogue between the visual and the audio dimensions, much in the same way that in a polyphonic musical texture listening focus may wander from one part to another. Also note the spectral design of this passage by means of which the sound disappears out of sight in an upward direction (and subsequently returns by means of a descending motion).

Similarly, the placement of audio/visual 'synch points' was controlled in such a way that the sound and the image retained some of their independence. Rather than producing a forced sound-image relationship the intention was to establish a dialogue between the two mediums. (Naturally, by virtue of putting sound and image together some form of relationship is inevitably forged.)

Entitative Identities and Spatiality

The passage mentioned above demonstrates a variety of aggregate and compound entitative identities, as well as the manner in which they establish processes of textural growth and fill. As another example consider the passage between 00':27" and 02':02". Here spectral texture is characterised by a mix of aggregate entities (small granular sounds at 00’: 27”) and more diffused fluid substances (such as the noise-based materials at 00’:39”) that saturate the sonic image (both perspectivally and spectrally). Also note the perspectival superimposition of materials (echoing the superimposition of the visual elements) in this passage, and the gradual move towards saturation and fusion.

Here we must consider a point of divergence between sound and image. The visual frame remains inherently selective in what it contains. In contrast, sounds are omnipresent: they are not bound to the direction of our gaze. This is, for instance, highlighted in the passage starting at 02’:53”. Here one has visual glimpses of liquid and gasoid matter. However, sonically, these substances are continuously present throughout the passage. At times the motion of a particular sound converges with an onscreen activity, implying the existence of an offscreen visual presence. Also note the lack of aggregate textures in the visual counterpart (aggregate textures are only evoked by the sounds). The animated blue dots at 02’:58” establish a relationship between the sonic aggregates and an implied offscreen visual aggregate (of which these are a few escaped particles).

Poietic Considerations

My Csound-based tools served their function for the purpose of composing *Formations, Flux* but did not completely satisfy me as standalone and general-purpose programs. I therefore set myself the task of a more elaborate software project, with a focus on the malleability of sonic matter. This culminated in an early version of my FFTools software written with

Csound and MaxMSP. Most of the sounds in *Dog Star Man* were transformed using FFTools.

Spatiality and Audio/visual Projection

The addition of the visual element to a certain degree inhibits the work in diffusion. Audiovisual projections often suffer from a discrepancy between the two-dimensional nature of the cinema screen and the inherent three-dimensionality of sound projection. In general, the sound image (even in a carefully designed stereo configuration) is inherently three-dimensional as opposed to the visual image, which, as well as being an approximation (or representation) of three-dimensionality, is by definition selective in what it reveals. This difference is further exaggerated when sonic entities are projected and diffused within circumspace.

Thus in performing this work, the sound ‘projection’ was restrained to the stage in order to avoid any gaps between the audio and visual components. In fact, a three-channel (stereo plus a centre speaker) version of the work was created in order to better anchor the sound to the screen. However, it was later decided that the complexity introduced in the set-up (the centre speaker had to be placed behind the screen) was not justified by what was gained in terms of sound-to-image marriage.

It is interesting to note that since our spatial cognition is visually biased, the addition of image to acousmatic sounds can potentially detract from the spatial richness of the sonic image. In many ways the work is experienced more ‘visually’ in an acousmatic context, in the same way in which Brakhage suggests that silent film is experienced more ‘musically’ than sound film.

5.1.3 *Convergences* (Stereo, 11’:42”)

General Considerations

Convergences refers to processes of textural convergence/divergence in spectral space, as well as the temporal ‘coming together’ of textural materials towards the articulation of metric time. The title also refers to the convergence between spectromorphological thinking in acousmatic and dance musics. Here I extracted characteristic spectral space states from dance music and developed them within a conventional acousmatic context. I did not approach this in a systematic fashion and intentionally avoided any contact with dance music during the period in which the piece was being composed.

It is fascinating to observe the collective body language of participants on the club’s dance floor. There is a strong sense of a shared experience that is underpinned by the predominance of metric structures. However, there are moments in which the pulse is backgrounded and a more spectral consciousness appears to come to the fore. This is, for instance, prominent when textural root disappears and the pulse is moved to the upper spectral region (a kind of prolonged suspension) prior to a ‘bass drop’. Such states are also characterised by more sustained morphologies and less regulated rhythmic structures. An example is provided from *Cactus* from a berlin-based artist *Objekt* (example 59), which also shows a strong tendency toward spectral space fill. Another example from the same track demonstrates a delayed bass drop preceded by a spatial opening which is accompanied by a stretching of both time and space (example 48). I have discussed similar processes in *Convergences* on pages 100-103.

Spectral Space Design and Pulse

Pulses appear in three guises in *Convergences*:

1- Internal micro iterations. Instances include 04':19" and 09':28". The same sonic materials are also used to form iterative micro-entitative identities and aggregate textures (for example 02'56") without any sense of pulse.

2- Subdued or introverted earthbound pulses. These are either temporally stretched-out pulses, such as the graduated continuant bass activity starting at 02':56", or they emerge as internal dynamic/spectral fluctuations in sustained resonances (for instance at 04':37"). The latter is used to create ambiguities between sustainment and pulsation (by means of introducing internal animation). For instance, in section two (starting at 04': 18"), episodes of internal micro-iteration (see above) are contrasted with short periods of repose in which the pulse is only present in the internal fluctuation of the sustained resonances.

3- Blatant pulses that emerge at 09’:02”: these are accompanied by a strong earthbound drive. The gestural dimension of these pulses is previously echoed in the piece by the more source-bonded impacts (for instance in the second section starting at 04’:18”).

Regulated pulses can possess internal energy without necessarily allowing the energy to be released spectrally. Thus one can create textural states that are characterised by a sense of contained or introverted spectral energy. This is, for instance, pertinent in section two (starting at 04’:17”) where there is a tendency towards the externalisation of the pulse. Here there is also a tendency towards a more chaotic textural state: an interesting dynamic arises between internalised pulses, externalised pulses, and a complete releasing of spectral energy that leads to metric disorder. In *Covergences* there is a gradual shift towards the externalisation of the pulse and ultimately a freeing of its constrained energy. This release of energy does not occur until the final moments of the piece, in the climactic section (10’:23”). Rather than reaching some form of structured state this climax leads to a state of total disorder, further highlighted by the emergence of the noise-based material by means of which spectral energy is diffused in all directions. The substance then disappears out of sight in an upward direction. Also note the deepening of spectral space at 11’:18”, which reiterates the extent of spectral space, evoking a sense of vast emptiness.

Metric Time and the Entitative State

Convergences explores a wide range of entitative identities, particularly those with a more textural make up. (This has been discussed throughout the thesis.) On the other hand, the dominant metric pulses at 09':04" are not themselves entitative as such. Rather, they form a temporal skeletal framework within and around which entities come in and out of existence. The sense of tension in this passage results from a conflict between metric regularity and entitative behaviour. The section can be broken into five sub-sections:

<u>Subsection I (09:02")</u>

Introduction of the beat.

<u>Subsection II+III (09':18", 09':28")</u>

Gradual weakening and finally complete loss of pulse.

<u>Subsection IV (09':42")</u>

Return of the beat

<u>Subsection V (09':57")</u>

Loss of pulse, gradual introduction of pulse in the higher spectral region, 'corruption' of metric regularity.

The weakening of pulse is achieved by the omission of the bass and the fill of spectral space by means of aggregates and more fluid substances. This is often accompanied by a stretching of both time and space, much in the manner encountered in *Cactus* (sound example 60). Moreover, the use of directional force (glissando) diverts attention away from the pulse and aids the creation of a more ‘spectral’ consciousness.

Spatial Design and Form

I have discussed aspects of spectral and perspectival space design of *Convergences* elsewhere in the thesis so I shall limit myself to general observations here. With *Convergences* I began to think more carefully about the contribution of spectral space states and textural processes towards the creation of larger-scale formal relationships. The work can be classified into a number of spectral space states or episodes in which the same materials are transformed to ‘paint’ different spatial impressions:

00’:00”-04’:17” - Introductory section which sets up the entitative context and spectral space extent. This is characterised by a subterranean depth and animated high-altitude micro-entitative textures. Stretched-out pulses are introduced, as well as flowing planar substances.

04’:17”-05’:16” - Sudden change of state. Internal pulses moving towards textural saturation and a more chaotic behaviour, but energy remains ‘contained’ until the very end of this section.

05’:17”-07’:39” - After a brief bridge, space opens up to reveal a new state, mostly characterised by a sense of energy flow and floating entitative motion. Time is put on halt as a result of the cyclical behaviour of the materials. The texture is then cleared by means of a dragging gesture that pulls the materials upwards, leaving a dissipating residue behind.

07':39"-09':02" - A densely saturated spectral texture in which the upper materials are highly animated and the lower elements slowly undulate. Here pitch-structures come to the fore. Also note the instability introduced at 08':30" as the bass moves up to the dominant while the upper pitched materials move out of sight, leaving behind the more noise-based aggregate textures.

09':02" - the 'beat section' (see above).

10':23"- The climax of the piece, which can be seen as a stretched-out gesture characterised by an unending ascent and a progressive accumulation of density.

Concluding Remarks

With *Convergences* I was for the first time satisfied with my use of spatiality as a dominant musical dimension. This was further confirmed as the piece was performed on different loudspeaker systems. The work lends itself well to diffusion: in particular the processes of approach and recession can be highlighted and further sculpted in listening space.

5.1.4 *Vertex* (6 channels, 15':00")

Multichannel Configuration

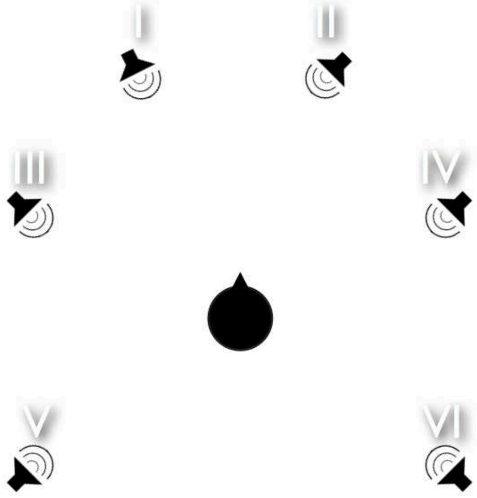

Figure 13. Multichannel configuration

General Considerations

In geometry *vertex* refers to a meeting point of two lines that form an angle. In more general usage it can mean "the highest point; the top or apex". Here the title refers both to the build-up of textural density towards a climactic 'height', and in a more literal sense, to the presence of extreme altitude as articulated by the manner in which sonic elements occupy spectral space. The presence of a high canopy prevails in the spectral texture throughout the piece. It is only at the very end of the work that the 'vertex' disappears out of sight, leaving behind an increasingly deepening bass. (This can be interpreted as the arrival of a new state whose subsequent evolution is left to the listener's imagination.)

In its form *Vertex* is highly episodic: this in part contrasts with the more teleological form of *Convergences,* or rather, it expands upon the episodic form of the latter. Formal unity is created by the consistency in the sonic material and recurrence of textural states. There is no attempt to create a sense of exposition and development of materials.

This piece is possibly the most spatial work in my portfolio, both in terms of spectral and perspectival design, helped by the multichannel format. *Vertex* is also my most 'entitative' work in that it directly deals with the establishment and transmutation of autonomous spectromorphological entities. Below I sketch out the thought processes involved in the composition of *Vertex*, as well as providing some insight into the use of technology in the realisation of the work.

Alchemical Processes in *Vertex*

The compositional processes were directly inspired by reading the alchemical writings of Michael Maier, particularly his *Atalanta Fugiens,* which is a collection of emblems, each accompanied by an epigram, a more extensive discussion, and a musical canon (Maier was also an amateur composer). The text is highly enigmatic, as if trying to preserve the secrets of alchemy: only those who 'understand' the symbolism have the privilege of unraveling the text's meaning. However, among the seemingly non-sensical statements the notion of fluidity (see footnote 149) prevails:

> All Mercury is composed of fumes, that is of Water elevating Earth together with itself into an aerial rarity or thinness, & of Earth forcing Air to return into Watery Earth or Earthy Water; for when the Elements are in it altogether & mixed throughout & mutually blended, subdued & reduced to a certain Viscous Nature, they do not easily recede from one another, but either follow the Volatile flying upwards, or remain below with those that are fixed.[196]

Note the emphasis on a cosmic setting in which the elements transmute, fuse and diffuse. Also significant is the apparent dichotomy between 'fixed' earthbound elements and flowing/elevating 'fumes' from which 'Mercury is composed'. In the context of spectral spatiality this can symbolise the earth-sky framework.

The 'elemental' approach to sonic matter is at the heart of *Vertex*. Simple biomorphic micro-entities are densified to create coagulated spectral substances (for instance the densification process starting at 04': 23"), or fluid gasoid entities reveal their low-level particle makeup (the dense noise materials at 00':52" and the high-frequency noise-based dissipative substance at 04':16"). Similarly, spectral texture moves towards a state of fusion in which the elements are "mutually blended" or transformed into a "viscous nature" (starting at 04':16" or the textural growth at 01':07") - that is, moving from fluid to solid substances.

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[196] Maier, Michael (1618), *Atalanta fugiens, hoc est, Emblemata nova de secretis naturae chymica*, the University of Michigan (13 Jul 2007).

Spatiality and the Creation of Form in *Vertex*

The form of *Vertex* is largely defined by textural processes, spatial states and relationships. There is an emphasis on the maximum clarity of states or textural processes by avoiding embellishments that divert the listener's attention. In this sense, although the sonic materials are highly varied, the piece is minimalistic in its approach to musical processes and form. Note that there are spatial ruptures and unexpected shifts in foreground/background relationships (for example the passage between 07':44" and 08':34"). However, these devices are used as clearly articulated structural processes, rather than as embellishments.

The spatial processes by means of which musical form is defined in *Vertex* are listed below:

- Fusion/fission of textures
- Spectral space fill
- Enclosure and opening
- Approach and recession
- Masking and vectorial wipe
- Establishment of attractors
-

Let us consider some of these in context.

Spectral Spatiality in Section One (00':00"-03':33")

The piece opens with an explosion of spectral energy by means of which spectral space extent is immediately defined. Energy dissipates slowly, leaving behind flowing fluid substances. One also becomes conscious of the internal fluctuations and pulsations of the sustained materials that provide the texture with a sense of self-propelled entitative identity. Spectral density decreases by means of clearing the spectral space extent, leaving behind the high plane and the lower bass drone. At 00':51" a diffused high-altitude substance reminds the listener of the upper extent of spectral space. At this point one becomes aware of an extremely focused and elevated planar entity with an upward spread tendency. (Note the emergence of a sustained and perspectivally wide upper plane that is fused with the more focused plane.) Listening consciousness is then pulled lower down as the plane becomes more overtly pitched (a high-mid C#6).

At 01':56" spectral extent is gradually filled again, towards a more fused state. The planar entity still penetrates through but it becomes less prevalent at 02':25" as the higher noise-based substances re-emerge, giving way to more animated aggregate-like entities. At this point the bass deepens, which increases the sense of vertical height. Here, the emergence of lower fluctuating noisy substances ('fumes') establish an oscillating melodic figuration (augmented fourth) centered around F#. Although this material is lower in spectral space it still has a light and weightless quality due to its diffused spectral make-up and effortless fluctuating motion. At 02':52" this substance re-emerges (accompanied by a lower and more diffused/noise-based planar entity), which gives way to a much lower fume-like substance, closer to the surface of the earth. Since most of the spectral energy (and listening consciousness) is focused higher up, this causes an apparent shift of vantage point (looking down). The fume then quickly recedes into the distance, leaving behind the sustained planar entity (or the vertex). The higher transparent aggregate entity disappears by entering a kind of spatial 'void' in the center of the panoramic field, leaving behind the slowly dissipating higher substances.

Closure, Fill and Opening in Sections Three & Four (04':02-09':20")

The third section, which follows a brief glimpse of a highly animated state heaving with micro-entitative activity, is a drawn-out process of densification by means of which textural elements are gradually accumulated, eventually filling the spectral space extent. There is also a sense of attraction towards the prominent pitch. Following the extreme sense of perspectival enclosure at 06':10", spectral space opens up to reveal a vast and empty perspectival setting. Note the mostly sustained planar makeup of this passage and the sparse and animated canopy (high-frequency micro-pulses and thin sheets of iterating spectral matter). At 07': 42" a turbulent wave of dense fluid activity momentarily interrupts the calm, wiping the underlying textural materials. However, the background materials soon reemerge, giving rise to a short-lived melodic figuration (almost visible from behind the 'fog'). The texture is then quickly infiltrated by animated particles and micro-entities that gradually become more earthbound.

Spectral Texture and Circumspace

As my first multichannel piece the process of composing *Vertex* revealed a number of issues regarding the composition of spectral texture within a circumspatial context. I became aware of how the experience of spectral space can drastically change when the panoramic field is circumspectrally extended.

For instance, the creation of textural saturation and spectral extent fill becomes far more complex as perspectival space expands, since more sonic matter is required to create a sense of spectral saturation. Moreover, the precise manner of mixing of the materials amongst the speakers is of the essence. The combination of two or more sounds may be enough to create a sense of textural saturation in a stereo context, but if the sounds are differently positioned in the circumspatial field they will fail to produce textural saturation and can clearly be pinpointed by the listeners. This also means that even in a dense textural context one can articulate spectromorphologies with far more clarity and precision in a multichannel context. This is, for example, apparent in the final section of the piece, where despite the relative density of spectral texture, there is a sense of clarity in the articulation of the materials, particularly that of the pulses.

The Multichannel Configuration for *Vertex*

Rather than being configured as a perfect circle, the 6 channel loudspeaker array was thought of as a quadraphonic set-up plus a more distant frontal stereo pair. This creates a pronounced sense of prospective depth and enables the composition of more elaborate textural processes based on approach and recession. Thus, the wide loudspeaker pair does not only provide an expanded panorama (as would be the case with a frontal arch-shape), but also a closer panoramic field. The combination of the front-wide stereo pair and the back stereo pair can therefore potentially produce a highly enclosed circumspatial image.

The decision to work in 6- as opposed to 8-channels was based on some initial experiments which suggested that the side speakers in an 8-channel configuration are only useful for ‘filling’ the gap between the front and the rear. Note that in a larger listening space the back speaker pair (channels 5 and 6) has to be doubled into the side rear speakers, in order to (a) cover the gap between the front and the rear, and (b) to provide a rear image for listeners sitting towards the front of the room.

Circumspatial Composition in *Vertex*

My initial experiments demonstrated the potential fragility of circumspatial composition. On the one hand the problem is that of conventional amplitude panning which, as discussed elsewhere (pages 105-107), does not by itself enlarge the spatial volume or width of a sound due to the proximity effect. On the other hand, the contiguity of the spatial image can be distorted when a multichannel work is translated to a larger space. (Gaps become apparent between the speakers.) Moreover, one has to deal with the fact that sitting near the loudspeakers (particularly on the sides) can have a detrimental effect on the composed perspectival space of the piece, to the extent of rendering the image musically useless in certain seating positions.

After much trial and error the notion of a ‘sweet spot’ was completely abandoned: I often changed position during the mixing of the piece and intentionally sat nearer the sides to make sure that the individual speakers did not overpower. Thus there is no perfect position for experiencing the work. There is no attempt to provide exactly the same image for every listener, as long as the contiguity and animation of spatial texture remains stable throughout the listening space.

Drawing upon my theoretical research and compositional experiments, I invested some time into expanding FFTools to create new modules that enable an intuitive and imaginative approach to the creation of circumspatial (and circumspectral) textures. This culminated in the design of two new modules: *Partikkel* and *Circumspect*. The former is based on Csound's Partikkel opcode[197], which enables the user to define per-grain parameters such as panning value and pitch transposition. For a full description of Circumspect see pages 112-117 and pages 156-171. Here it suffices to mention that the combination of Partikkel and Circumspect enabled the distribution of sonic matter amongst 6 loudspeakers in two different ways: (1) circumspectral distribution and (2) granular distribution. These are highlighted below.

Circumspectral Distibution

This method was discussed on pages 112-117. Here we can further highlight the use of this technique in a musical context. Circumspectral sound projection is present consistently throughout the work. The effect can vary drastically, depending on the nature of the input stereo sound. For instance, all the sustained sounds at the start of the piece have been independently processed, using Circumspect, with various different frequency/panning configurations (either using carefully selected biased random distributions or contiguous spreading of frequency content in

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[197] See http://www.csounds.com/manual/html/partikkel.html Accessed 25/10/2012

circumspace). The prominent drone (example 43, also mentioned on page 116), which has been processed by a variable low-pass filter, has been configured in such a way that its higher partials gradually move toward the rear. Thus as the frequency of the filter decreases, the sound becomes more confined in its panoramic image and as the frequency increases the sound extends around the listener to create a more engulfing spatial experience. The growing sense of enclosure is particularly prominent at the peak of the passage at 01':59", in which numerous graduated continuant spectromorphologies, with different circumspectral configurations, converge to highlight the apparent spatial growth of the drone. Likewise, the 'fumes' that gradually approach the listener at 02':29" have been circumspectralised to give them a sense of volume and perspectival spread. Consequently, the internal spectral fluctuations of these substances are highlighted perspectivally.

Circumspectral configurations are also applied to more animated and noise-based spectromorphologies to produce a sense of scattered entitative behaviour or to create an overhead canopy. Examples include the transparent elevated aggregate identity at 02':43", which cannot be spatially localised due to a randomly scattered circumspectral configuration. A similar approach is used to impart an omnipresent identity to the continuous higher pitch materials in the final section of the piece (sound example 61). Despite having a planar spectral structure the scattering of the spectral components in circumspace helps radiate the sound in all directions and inhibits the localisation of a planar entity in perspectival space. This contrasts with earlier instances in the piece where the same material is indeed used to evoke a stratus-like plane approaching or receding (for instance at 01':57").

Particle Distribution

Granular synthesis is used to distribute the particles of individual spectromorphologies in circumspace. This enables a more pronounced perspectival articulation of entities. At lower densities one can create aggregate textures that articulate spatial zones or circumspatial trajectories (examples 62-64). At even lower grain-rates one can create a point-source articulation of space: this becomes particularly useful in the context of the final section where a complex spatial 'counterpoint' is created by superimposing repeating pulsed patterns that follow different circumspatial vectors denoted by isolated points in space (examples 65-71). At higher densities (using overlapping grains) granular synthesis can be used to impart a sense of spatial volume to sounds. Decorrelation can be introduced by means of scattering high-density granular streams amongst different loudspeakers. (See pages 105-107 for a full description of the use of signal decorrelation in image dispersion.) For instance, this is used to transform the granular noise-based spectromorphologies in the piece, which helps spread the sound in listening space, evoking a sense of canopied substance (examples 72-74). Note that the elevation of the sound is entirely due to its spectral space occupancy while the dispersion results from the use of signal decorrelation. Thus the result is that of an elevated sound image that extends (overhead) from the front to the rear.

Pulses in Vertex

The use of pulse in the final section is far more integrated in *Vertex* than it was in *Convergences*. Nevertheless, overtly pulse-based structures by definition create a non-entitative state in which one is more aware of the temporal articulation of space than of the presence of entitative forms. In *Vertex* I have tried to create ambiguities to bring these two worlds together. For instance, in the pulse-based section a substance-like entitative presence begins to infiltrate the texture (the mid-high waves starting at 11':53") and gradually masks it to the point of saturation. Thus there is a certain duality in this passage, which remains unresolved: for example, at 12':40" one begins to forget the presence of the beat (due to the emergence of a thick curtain of sustained materials that comes to the fore) before being quickly pulled back into the regulated temporal domain of the underlying pulse.

Conclusion

The composition of *Vertex* was more directly influenced by the ideas discussed in the thesis than my previous pieces. Indeed while working on *Vertex* I put some of my notions regarding the establishment of entitative identities to test (for example energy-expenditure, internal animation, motion, texture). Subsequently certain written topics had to be altered to more closely reflect the listening experience. In this respect *Vertex* attempts to represent the musical applications of spectral spatiality as discussed in this thesis.

Nevertheless, many circumspectral configurations remain under-explored. For example, by careful mixing of 'circumspectralised' sounds, one should be able to produce complex and yet articulate layering of canopies. Through *Vertex* I have become conscious of a rich palette of unexplored possibilities offered by circumspectral sound projection. In a sense this is reflected in the form of the piece, which, rather than ending with the completion of a 'journey', leaves us in the outskirts of a new 'land'.

5.2.1 FFTools

Installation

FFTools requires a working version of Csound 5. This can be obtained from sourceforge: http://sourceforge.net/projects/csound/files/csound5/.[198] (The current version is 5.18.031.) After running the Csound installer no additional configurations are required for Csound. FFTools is currently only running on Mac OS X and has been tested on OS X 10.6 and 10.7.

General Configuration

1. Double click on FFTools.app to open the application. This reveals the application menu, the on/off button for the DSP engine, and a small CPU metre.

Figure 14. FFTools application menu

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[198] Accessed 26/10/2012

2. If opening the application for the first time, the DSP preferences (accessed from the 'DSP' menu) must be configured before turning the sound engine on. This allows the user to change the audio interface and sampling rate, as well as the signal and I/O vector sizes. Since all the modules are demanding in terms of CPU I recommend relatively large vector sizes. Naturally this increases the output latency but since the program is designed for studio use this should not be a problem.

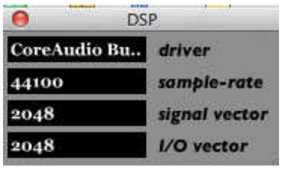
DSP
CoreAudio Bu.. driver
44100 sample-rate
2048 signal vector
2048 I/O vector

Figure 15. FFTools DSP settings

3. Once the DSP setting is configured, the engine can be turned on by pressing the 'ON' button. The different software modules can be opened from the 'modules' menu. (Modules can be opened one at a time only.)

Figure 16. FFTools modules

Shortcuts for the individual modules are documented inside each module's interface. Here I shall describe the 'circumspect' module in detail since it directly relates to the topic of this thesis.

5.2.2 Circumspect

Main Settings

Below is an annotated snapshot of Circumspect's main configuration panel.


4096 FFT
4 OL
2 Win *
Hamming WT
channel config 6

Figure 17. Main configuration panel of Circumspect

1. Drag and drop an input sound file from the finder. The file must have one of the following extensions: .aif, .aiff, or .wav. 16-, 24-, 32-bit, and 32-bit float samples are accepted. The file is generally expected to be stereo but up to 8 interleaved channels can be read: in this case the channels in the file are mixed down to stereo (see number **7** below).

2. The space-bar is used to start/stop playback of the input file. The loop mode can be turned on and off.

3. FFT size, which defines the total number of frequency bands. The Nyquist frequency (sampling rate/2) corresponds with FFT size/2+1. All the bins that fall above this are discarded. Thus with a sampling rate of 44100 Hz and an FFT size of 8192, bin number 4097 (8192/2+1) represents the frequency of 22050 (44100/2). A larger FFT size is usually desirable here since it will provide a higher frequency-resolution: a larger number of narrower frequency bands can be circumspatially distributed. The FFT size also defines the duration of the analysis window in samples. Consequently, a higher frequency-resolution (i.e. FFT size) yields a lower temporal resolution. Note that the analysis/synthesis of lower frequencies requires larger window sizes that can fit at least one cycle of the lowest frequency.

4. ‘Hop size’ (overlap) defined in divisions of the FFT size. Thus with an FFT size of 8192 and an overlap of 2, a new window will be generated every 4096 samples. It is desirable to increase this parameter as FFT size increases, in order to compensate for the decrease in the temporal resolution of the analysis.

5. This additional parameter enables the user to set the window size (in samples) independently from the FFT size. This is calculated in multiples of the FFT size. So if this is set to 2, the window size will be 16384 for an FFT size of 8192 (8192*2). For general purpose use this can be left on the default value of two.

6. The windowing function can be set to ‘Hamming’ or ‘von Hann’. The latter provides a slightly less continuous result.

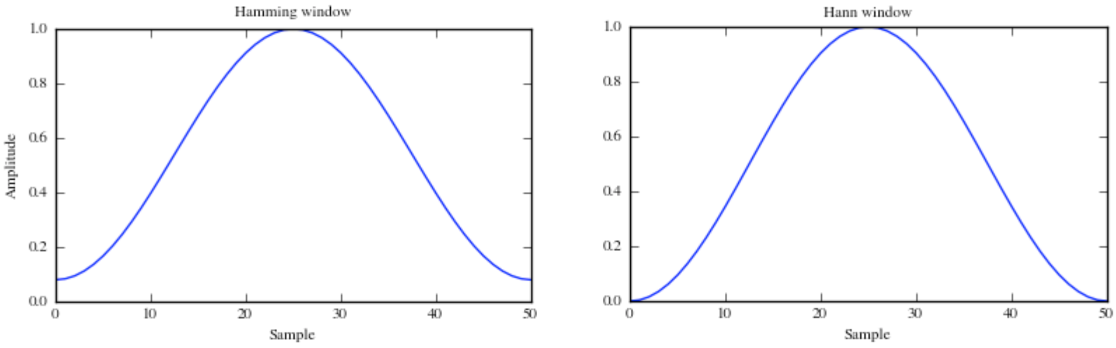

Figure 18. ***Hamming*** **and** ***von Hann*** **windowing functions**

7. The matrix allows the the user to change the many-to-two mapping for stereo mix down of multichannel input files. Note that this does not refer to the output of Circumspect. Rather, it defines the manner in which the channels in the sound file are read into the input of Circumspect. The horizontal axis represents the input channels read from the sound file. The vertical axis denotes the two-channels into which the file's channels can be routed (and mixed). With the default configuration, all the odd-numbered channels in the file (up to 8 channels) are mixed into the left input of Circumspect. Conversely, all the even-numbered channels are fed into the right input channel.

8. Enabling the ADC option will allow the user to input external signals into the programme, either directly from the audio interface (e.g. microphone) or, more usefully, via a DAW using Jack or Soundflower.[199]

9. This parameter must match the physical loudspeaker configuration in order for the circumspectral distribution table (described below) to be mapped correctly into the loudspeaker array. The drop-down menu enables the user to choose between 6 or 8 channel configurations. This defines the bin-to-speaker mapping. The studio speaker array must be configured as dac output channels 1/2 (front left/right), 3/4 (front wide left/right), 5/6 (side left/right for 8-channel set-up and rear left/right for 6-channel configuration), 7/8 (rear left/right for 8-channel configuration only). The circumspectral panning values are defined as follows for the

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[199] See http://www.jackosx.com and http://cycling74.com/products/soundflower/, accessed 05/11/2012.

left and right input channels for an 8 channel and a 6 channel configuration.

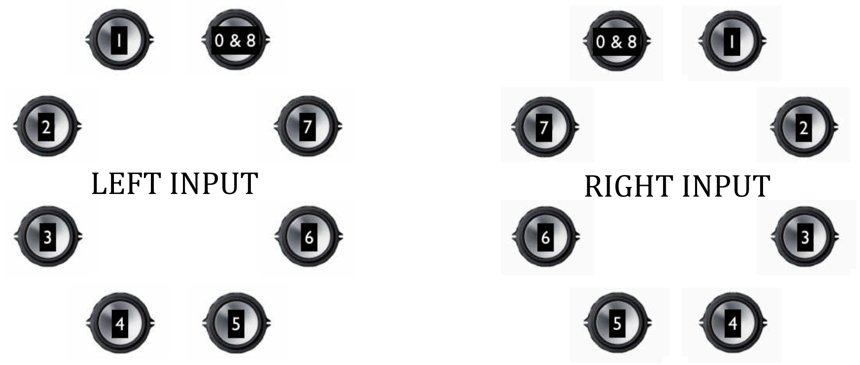

Figure 19. Loudspeaker configuration for the 8-channel setting

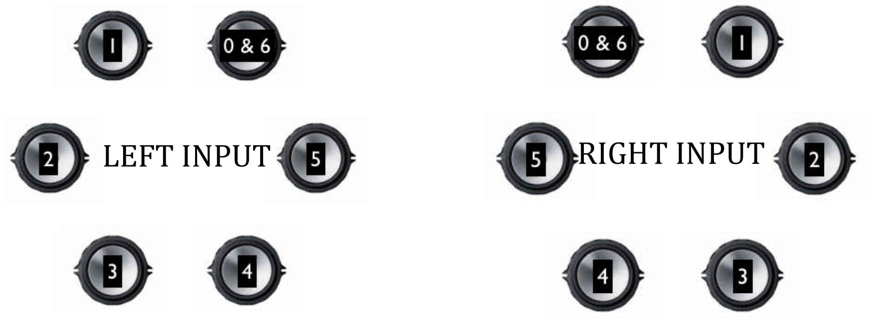

Figure 20. Loudspeaker configuration for the 6-channel setting

Spectral Panning Table Editor

The table editor positioned on the top part of the main window of Circumspect is used to manually draw the circumspatial distribution of the FFT bins (see figure 21). The *x* axis represents the frequency continuum (0-22050 Hz), and the *y* axis represents the panning 'position' at a given frequency. The panning values range from 0 to 8, corresponding with the loudspeaker mapping shown in figures 19 and 20. Thus the precise meaning (circumspatial 'position') of a value on the y axis depends on whether 6 or 8 channel setting is chosen in the main configuration panel, as well as on whether the user-drawn function is used to distribute the left or right channel of the input file: as shown in figures 19 and 20, the left and right panning positions are symmetrically arranged. Integer values correspond with single loudspeakers, while fractional values signify mixing between the speakers. Thus, a value of 0.5 mixes the synthesised frequency bin equally between channels 0 and 1.[200]

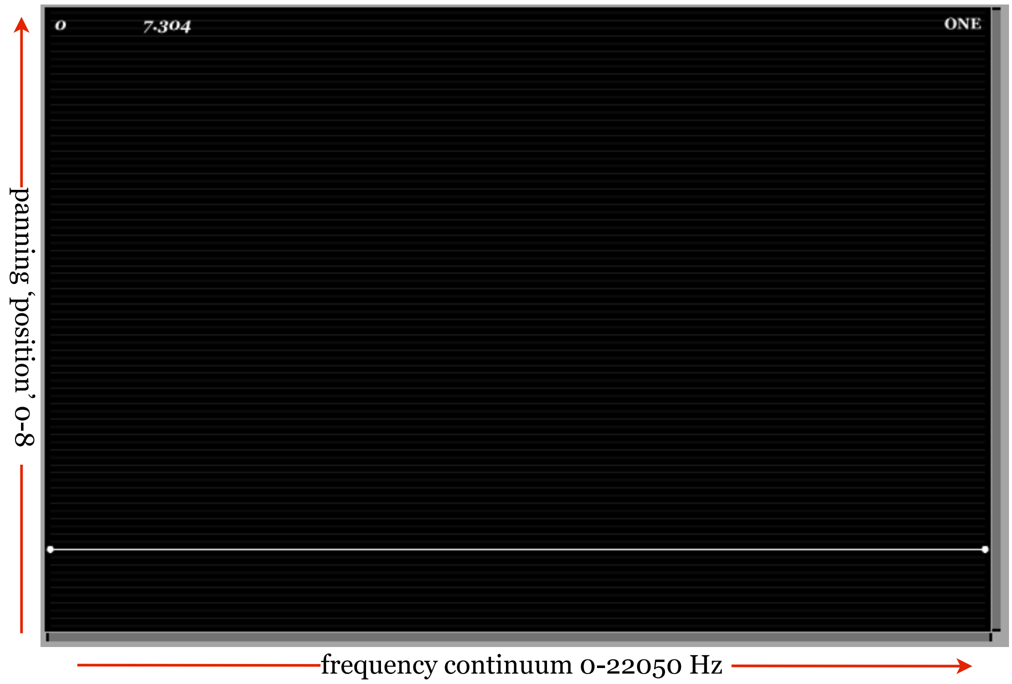

Figure 21. Table editor for the manual circumspatial distribution of FFT bins

According to the straight line displayed in figure 21, all the bins will be mapped to the same panning 'position', thus no circumspectral distribution will takes place. Clicking on the line segment will create a new point at a given frequency. This point can be freely dragged to adjust its

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[200] The formula is square root amplitude panning: with a panning value of 0.5, the signal for each speaker is scaled by the square root of 0.5 (≈ 0.7).

frequency and panning position. The values between the user-drawn points are interpolated to calculate the panning position for the frequency bins in between. Curves can be created by holding the 'alt' key and dragging a line segment (figure 22).

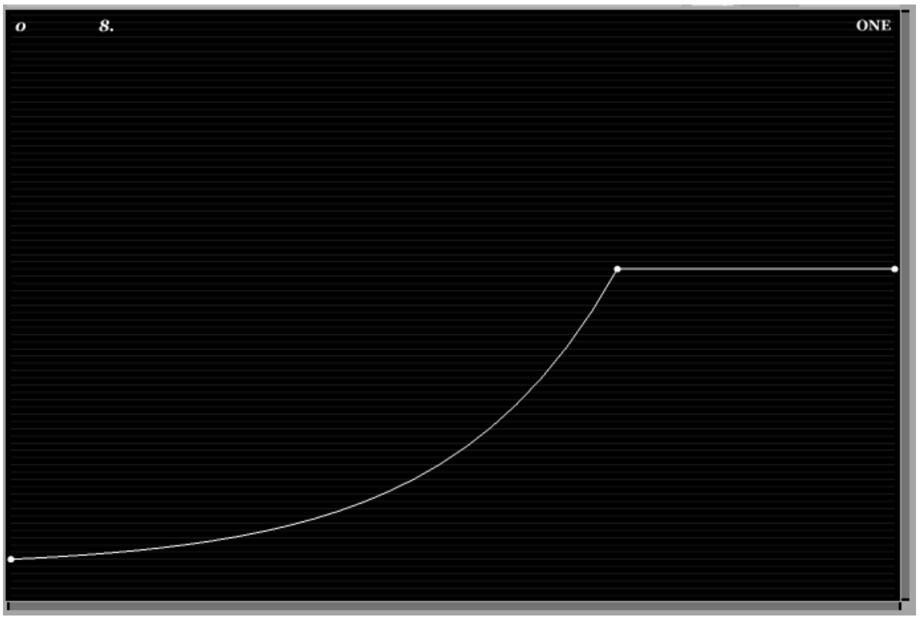

Figure 22. Table editor for the manual circumspatial distribution of FFT bins

By dragging on the sliders along the the right and bottom edges of the table editor, it is possible to zoom into the x and y axes for more detailed editing.

Rendering the Table Editor Values

In order to send the table values to the synthesis engine they must be copied into one of the four available spectral panning tables (figure 23). The spectral panning tables visualise each bin as a single point. This can be better demonstrated with an FFT size of 256 (figure 24).[201] Each table

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[201] Note that the table only displays bins that correspond to the frequency range 0-22050 Hz. Thus the index number of the panning table is calculated by the formula: (FFT size/2)/(sampling rate/22050)+1.

contains a set of two circumspectral panning functions, one for the left- and one for the right-channel content of the input sound - colour-coded as blue and red respectively.

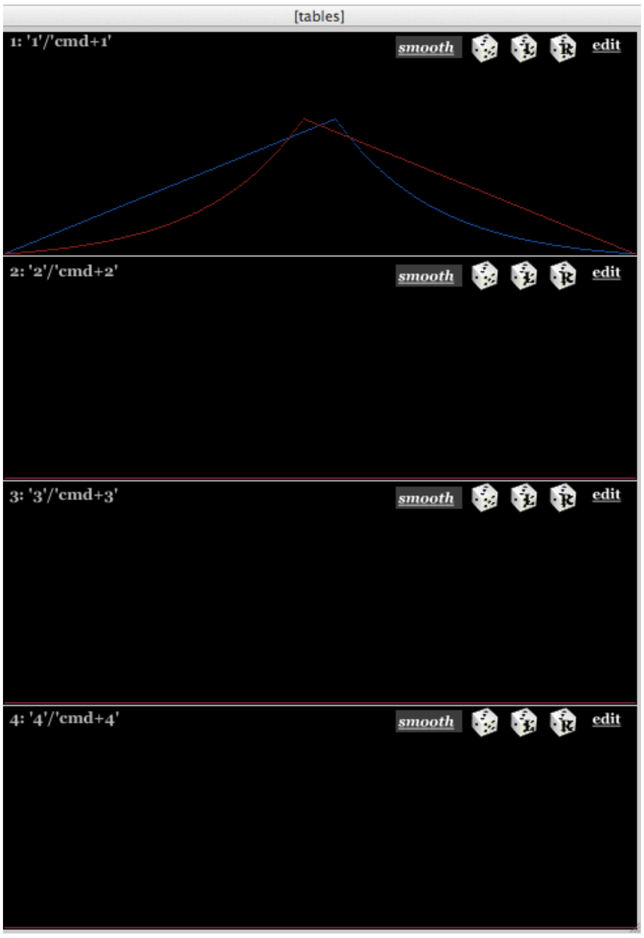

Figure 23. Spectral panning tables

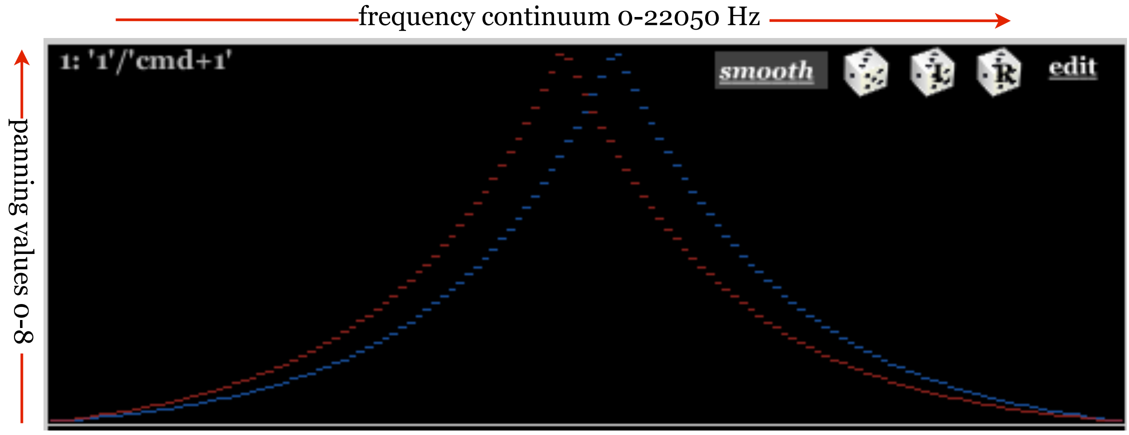

Figure 24. Spectral panning table with a FFT size of 256

To copy the content of the main function editor to the left-channel component of table one, press the number key '1' (since there are four tables, one can use the number keys 1-4). For the right-channel component press 'cmd' plus a number key that corresponds with the number of the target table. The user can choose amongst the 4 different panning configurations or interpolate between them using the two-dimensional slider 'MORPH'. This is particularly useful for quick comparisons between different circumspectral distributions.

Figure 25. Interpolate between tables

Linear and Logarithmic Mappings

The frequency axis on the user-drawn function is by default mapped linearly onto the spectral panning tables. This can be changed to two different logarithmic scales:

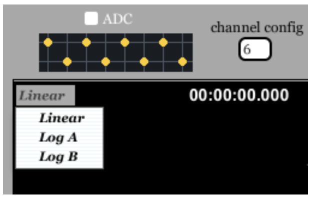

Figure 26. Linear and logarithmic mapping

These define the relationship between the horizontal axis displayed on the table editor, and the frequency continuum:

1. Linear - Denotes a simple mapping where the number of pixels displayed on the horizontal axis are scaled to fit the frequency range 0-22050.

2. *Log A* - Frequencies are displayed logarithmically along the horizontal axis of the editor. This provides a more detailed editing in the lower frequency region. The centre of the x axis of the table corresponds with the frequency of 3675 Hz.

3. *Log B* - A sharper logarithmic scaling where the centre of the x axis corresponds with the frequency of 1837 Hz, thus allowing a more detailed control of the lower frequencies. This mode is useful for input sounds that contain energy in the low-bass region.

Random Circumspatial Distribution of Frequencies

Circumspect can become a powerfull tool when the panning 'position' of the bins are randomly generated. The available functions are annotated in figure 27.

Figure 27. Generating random panning values for each bin

1. Pressing this icon generates a random value for each frequency bin.

2. By using these icons one can generate random values independently for the left and right input channels. Remember that each table contains two functions (left/right).

3. The user can choose between *smooth* or *scattered* circumspatial distribution of the frequency bins. The former eliminates large leaps in panning 'space', keeping the adjacent bins relatively close to one-another in terms of circumspatial 'positioning'. This avoids drastic smearing of transients in the input sound since it minimises phase-distortion. It is essential to bear in mind that FFT bins are not the same as partials: often the combination of two or more bins make up a single partial, in which case obvious artefacts are produced when the bins are drastically scattered. Such artefacts can be more or less useful, depending on the nature of the input sound and the desired result. Figures 28 and 29 show a smooth and scattered distribution respectively.

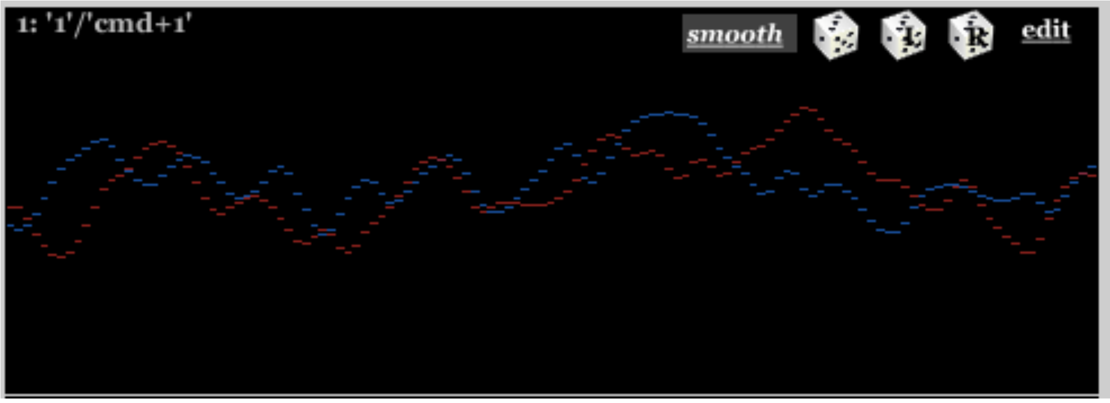

Figure 28. Smooth distribution

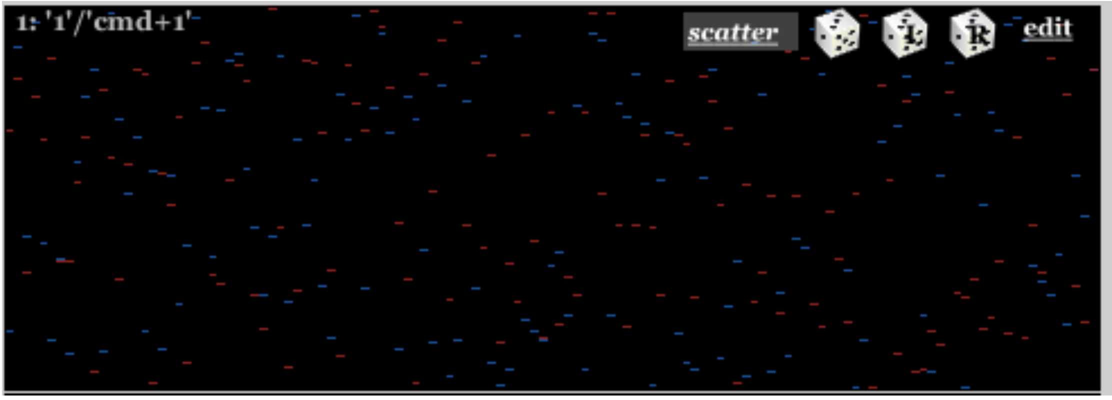

Figure 29. Scattered distribution

4. Clicking on *edit* opens an additional window which enables the user to define the type of random distribution in terms of tendencies (see below).

Controlling the Random Generator

The default configuration generates linearly distributed random (panning) values between 0 and 8. Clicking the 'edit' item above each spectral panning table opens an interface that enables the user to manually define tendencies so that the randomly generated values are more or less biased towards certain paning 'positions'. The top function-editor (figure 30) is a user-definable probability table where each panning position (visualised along the *x* axis) can have a different 'weight' (represented by the *y* axis). A user-drawn point denoting the panning value (*x*) 2 and weight (*y*) of 0 means that there is zero probability of the random generator to produce the panning value two (see figure 30).

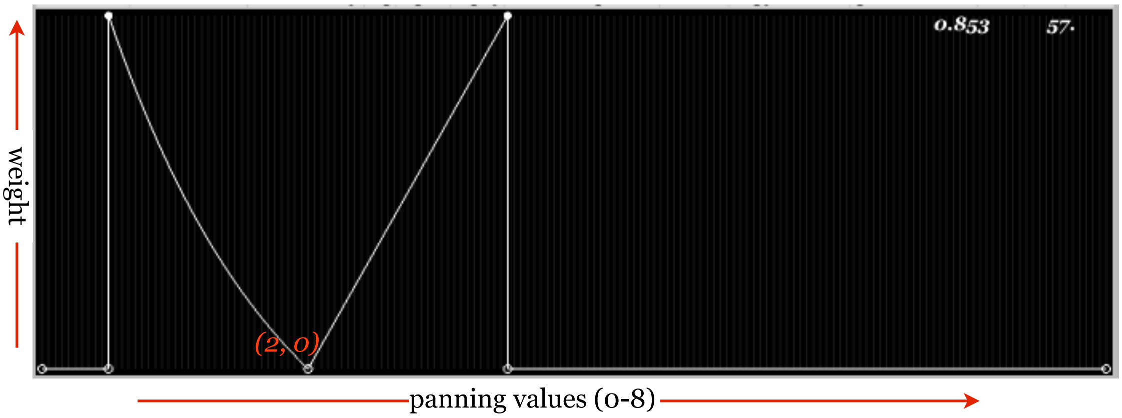

Figure 30. Tendency table editor

The configuration in figure 30 will yield the following panning table where the bins' circumspatial distribution is biased towards the front and rear of the loudspeaker array:

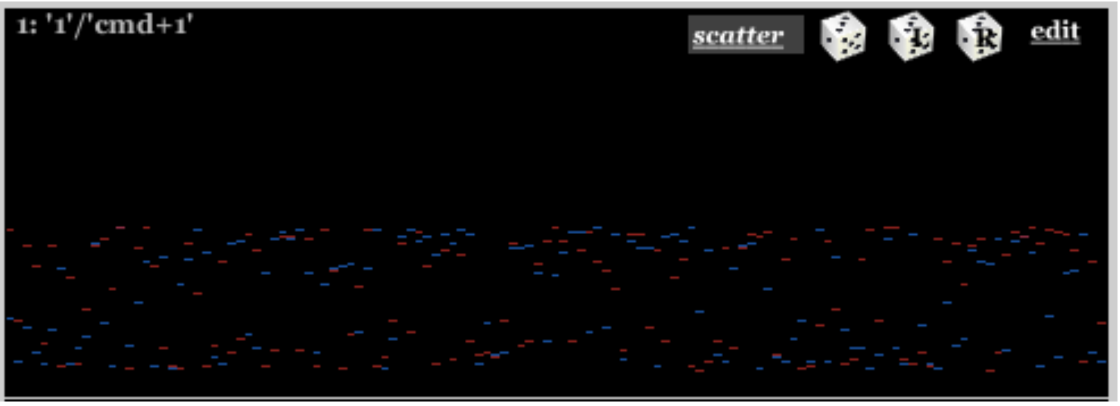

Figure 31. Randomly generated panning values biased toward the front and the rear

Masking Functions

The ‘Mask HIGH’ and ‘Mask LOW’ functions enable the user to define *frequency-dependent* upper and lower limits for the random panning values. Thus the ‘Mask HIGH’ function displayed in figure 32 will further transform the random values displayed in figure 31 so that the lower frequencies are limited to the front of the loudspeaker array, while the circumspatial distribution of the higher frequencies is more widely scattered (figure 33).

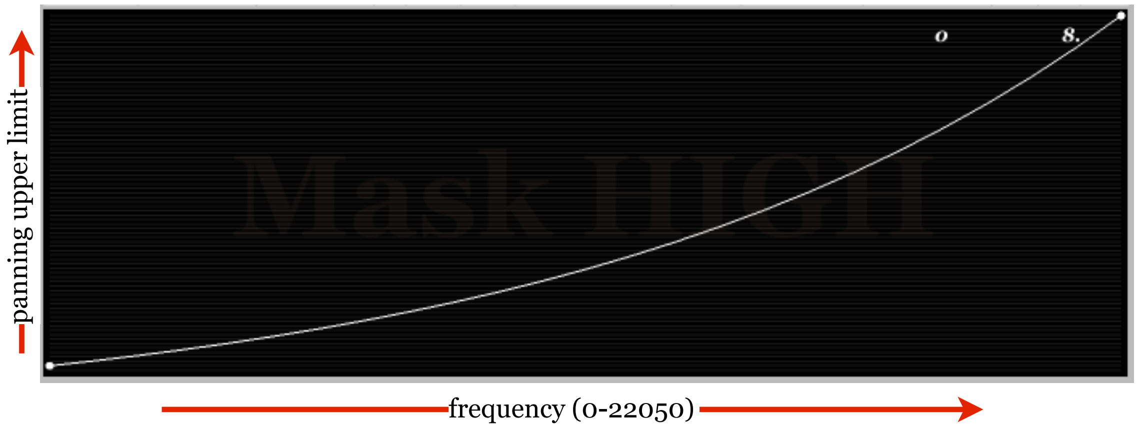

Figure 32. Frequency-dependent upper limits for the panning values

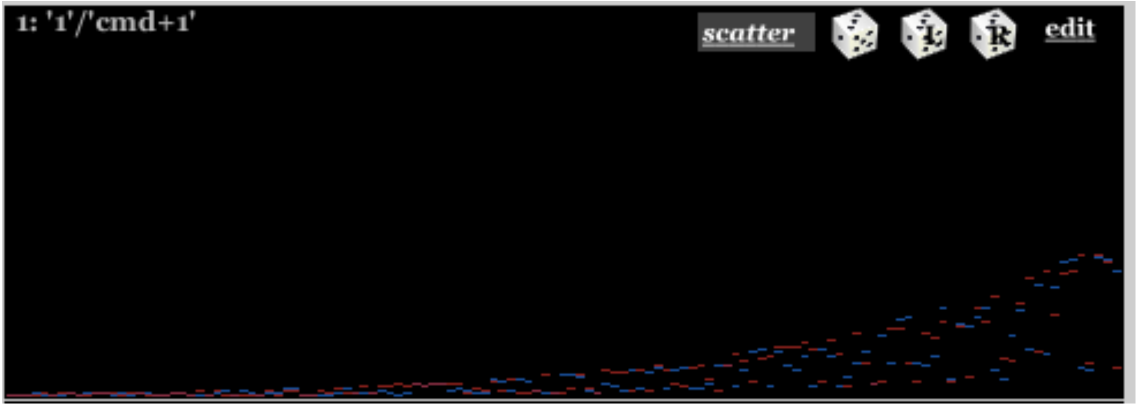

Figure 33. The panning table in figure 31 masked by the user-drawn function in figure 32

Effectively, the randomly generated panning value of each frequency bin is scaled to fall within the panning range defined by the values of corresponding indices in the low/high masking tables.

Recording the Output

The output of Circumspect can be recorded in ‘real-time’, using the ‘recorder’ tool in the ‘utilities’ menu. To record a file, first click on ‘Open a file’ box. Browse to a destination folder and type in a name for the new output file to be created. Pressing the ‘record’ button puts the recorder in ‘guard mode’. Pressing the space bar will then trigger playback and recording together. Once playback stops the recording will also stop. If the current module is in loop mode, this must be done manually by pressing the spacebar.

Appendix I - Programme Notes

Formations, Flux

2009, 20’:00”

This two-part composition attempts to evoke the sense of an autonomously-evolving environment, characterised by a seemingly organic flow of sonic energy. Conventional narrative form is abandoned in favour of setting up a state within which the listener can focus attention on different elements and their shifting relationships. I imagine this environment as a planet whose surface structure is characterised by a fluid activity, resembling that of Tarkovsky’s *Solaris*.

In the first part, *Formations,* the different aspects of the environment are slowly revealed. At first one attains fragmented glimpses of a world in which sonic matter shapes and reshapes in a fluid manner. Textures gradually become more continuous, leading to a growing mass which eventually moves out of sight with an infinite ascent.

In the second part, *Flux,* all traces of narrativity are left behind and the listener is offered a closer look inside the environment, at times caught up in its turbulent ebbs and flows.

Dog Star Man (audio/visual)

2010, 05’:41”

Brakhage once described music as "the sound equivalent of the mind's moving". Brakhage's films are both rare and unique in their attempt to achieve 'visual music', or perhaps better to say 'music by visual means'. Brakhage's deliberate occupation with silent filmmaking was in fact partly due to this desire of creating the visual equivalent of the mind's moving. He writes:

> The more informed I became with aesthetics of sound, the less I began to feel any need for an audio accompaniment of the visual I was making. [...] I ironically, the more silently-orientated my creative philosophies have become, the more inspired-by-music have my photographic aesthetics and my actual editing orders become, both engendering a coming-into-being of the physiological relationship between seeing and hearing in the making of a work of art in film. (Brakhage, *Film and Music*, 1966)

Here I have attempted to establish a relationship between Brakhage's internalised sound and my own internalised vision. In doing so I have essentially reinterpreted and modified the original work, I dare say for the worst. But I hope that the residual vestiges remaining from this destructive act make the process worthwhile. Needless to say that the original work of

Brakhage is a silent film and must be viewed in silence in order to remain true to the filmmaker's intentions and vision.

I would like to thank Marilyn Brakhage for giving me permission and encouragement to complete this project.

Convergences

2011, 11’:42”

On rare occasions I have found myself on dance floors of London’s Brick Lane bars, mesmerised by the spectromorphological detail of the often banal, regulated pulses – no doubt encouraged by the combination of alcohol and boredom! For me the most interesting parts are the short-lived transitory moments in between tracks where one song seamlessly, and sometimes dramatically, converges with another. The tricks utilised by the DJ are instinctively familiar to an electroacoustic composer – e.g. the introduction of high frequency noise that functions as a kind of ‘spectral clearing’, the use of filters to reduce the track to higher frequency components (typically the high-hat) followed by the gradual introduction of the bass (textural ground) from another track (metrically synchronised of course). Also fascinating is the use of internal pulses within a more textural setting.

Despite my interest I remain a stranger to the club sound-world, always observing it from a distance. This dichotomy, the tearing between two worlds, is apparent in the piece. There are internal pulses waiting to explode and chaotic textures converging to move towards metric regulation, as if caused by an invisible magnetic field.

I would like to thank Audrey Milheres (Flute) and Joe Browning (Shakuhachi) for allowing me to sample their instruments.

Vertex (6 channels)

2012, 15':00"

> All Mercury is composed of fumes, that is of Water elevating Earth together with itself into an aerial rarity or thinness, & of Earth forcing Air to return into Watery Earth or Earthy Water; for when the Elements are in it altogether & mixed throughout & mutually blended, subdued & reduced to a certain Viscous Nature, they do not easily recede from one another, but either follow the Volatile flying upwards, or remain below with those that are fixed.
>
> -Michael Maier, *Atalanta Fugiens* (1617)

In geometry *vertex* refers to a meeting-point of two lines that form an angle. In more general usage it can mean "the highest point, the top or apex". Here the title refers both to the build-up of textural density towards a climactic 'height', and in a more literal sense, to the presence of extreme altitude as articulated by sonic elements. The latter is explored by means of materials in the higher register that can evoke elevated planes, overhead canopies, or aggregates of scattered particles. In particular, a constant high-register layer runs through the piece, functioning as a unifying thread that binds together the fragmented sections.

The form of the piece is somewhat dictated by textural processes and states that have a strong sense of spatiality: invisible ‘entities’ approach the listener or fly overhead, spaces become vacant or fill up. There is also an overall sense that the fragmented pitch structures gradually become more consistent, until they form a continuous melodic thread towards the end of the piece. Likewise, the more earthbound gestural activities eventually emerge as insistent cyclical pulses.

Appendix II - Glossary of Terms

Circumspace - "The extension of prospective and panoramic space so that sound can move around the listener and through or across egocentric space."[202]

Circumspectral Space - "The spatial distribution or splitting up of the spectral space of what is perceived as a coherent or unified spectromorphology."[203]

Energy-expenditure - The patterns of spectral energy *injection*, *maintenance*, *dissipation* or *micro-variation* with which an entity is identified. Spectral energy variation is directly related to aspects of spectral space occupancy and motion. Energy may, for example, appear to increase through the accumulation of textural density or mass, as well as the growth in magnitude or rate of spectral motion.

Entitative State - Acousmatic contexts in which spectromorphologies themselves are experienced as spatial forms and in which the ontological 'barrier' between sound and source is removed.

Focus/Diffuseness - A texture can be more or less spread in its spectral space extent: spectral energy may be diffused evenly throughout this extent or it may be focused in regions as if gravitating towards *attractors* that act as points of reference in spectral space.

Fusion/Fission - The degree of segregation of a spectral texture into different 'entities'. This is a measure of compoundness of textures: an *aggregate* is formed by a collection of sub-entities, whereas a *compound* texture results from a perceptually-unified type of spectral matter (or substance).

Perspective - "The relations of spatial position, movement and scale among sound materials, viewed from the listener's vantage point."[204]

Rootedness - The anchoring of a higher spectromorphology in a fundamental frequency, which typically occupies the bass region. A rooted texture feels grounded and stable.

Source-bonded Spatiality - "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."[205]

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[202] Smalley, "Space-form and the Acousmatic Image", p. 55.

[203] Smalley, "Space-form and the Acousmatic Image", p. 55.

[204] Smalley, "Space-form and the Acousmatic Image", p. 56.

[205] Smalley, "Space-form and the Acousmatic Image", p. 56.

Spatiality - The felt experience of sound as occupying space or belonging to physical objects and interactions, which may invoke the dimensions and topographical features of a known or imagined environment.

Spectral Space - The apparent vertical extent that is evoked by the manner in which spectromorphologies 'occupancy', and 'move though', the domain of spectral frequencies.

Spectral Spatiality - "The impression of space and spaciousness produced by occupancy of, and motion within, the range of audible frequencies."[206]

Spectral Space Attractors - Spectral space regions that act as reference points for listening consciousness. These may result from spectral energy focus, motion, and pitch relationships that highlight tonal centres. Once established in consciousness, an attractor may continue to function as a point of reference beyond its physical presence in the texture.

Spectral Space Extent - The spectral space dimensions denoted by the lower and upper contours of a texture. In the context of a musical work or passage, spectral extent may be established over a longer duration, as well as being subject to transformations of *expansion* and *contraction*. The extremities of spectral space can also be suggested through motion that is directed towards an apparent goal, which may be beyond our 'field of vision'.

Spectral Space Fill: Contiguity/Divide - The manner in which a particular spectral space extent is 'filled' by spectral matter. Whether the extent is deployed in a contiguously packed manner, or if it is divided into 'pockets' of more or less concentrated energy.

Spectral Space State - A spectral space state is established through spectromorphological behaviours (i.e. manner(s) of spectral space occupancy and articulation) that remain consistent enough over a period of time to become instilled in consciousness. The term 'state', therefore, refers to specific spectral texture configurations or 'states of affair' that may be recalled and recognised. This concept is highly relevant when discussing *space-form*, where spatial identities are established through the consistency in which materials behave over time.

Spectral Space Motion - The manner in which entities are felt to *move through* spectral space. Motion is often characterised by the interrelationship between a multitude of factors, namely vertical directionality, energy-expenditure, spectral space occupancy, and internal textural behaviour, as well as the perspectival configuration of the material.

Spectral Texture - The manner in which spectromorphologies occupy and pattern the extent of spectral space – in other words, the spectral surface-structure of the acousmatic 'image'.

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[206] Smalley, "Space-form and the Acousmatic Image", p. 56.

Texture - The perceptible accumulation of more or less distinct spectromorphological elements into a coherent and holistic spatio-temporal entity whose structure is characterised by the behavioural tendencies and relationships that exist amongst its sub-elements.

Textural Mass - The accumulative density of a textural body in terms of its spectral space occupancy.

Weight/Volume - Spectromorphologies with lower spectral components are experienced as being more voluminous and weighty (rooted in earthbound gravity), while spectrally elevated entities are often seemingly lighter, more agile and smaller in dimensions.

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