Spectromorphology: explaining sound-shapes

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1. INTRODUCTION

The art of music is no longer limited to the sounding models of instruments and voices. Electroacoustic music opens access to all sounds, a bewildering sonic array ranging from the real to the surreal and beyond. For listeners the traditional links with physical sound-making are frequently ruptured: electroacoustic sound-shapes and qualities frequently do not indicate known sources and causes. Gone are the familiar articulations of instruments and vocal utterance; gone is the stability of note and interval; gone too is the reference of beat and metre. Composers also have problems: how to cut an aesthetic path and discover a stability in a wide-open sound world, how to develop appropriate sound-making methods, how to select technologies and software.

How are we to explain and understand electroacoustic music? Music is not created from nothing. If a group of listeners finds a piece of electroacoustic music 'rewarding' it is because there is some shared experiential basis both inside and behind that music. We need to be able to discuss musical experiences, to describe the features we hear and explain how they work in the context of the music.

2. DEFINITIONS AND CONTEXTS

2.1. Definition

I have developed the concepts and terminology of *spectromorphology*[1] as tools for describing and analysing listening experience. The two parts of the term refer to the interaction between sound spectra (*spectro-*) and the ways they change and are shaped through time (*-morphology*). The spectro- cannot exist without the -morphology and *vice versa*: something has to be shaped, and a shape must have sonic content. Although spectral content and temporal shaping are indissolubly linked, we need conceptually to be able to separate them for discursive purposes – we cannot in the same breath describe what is shaped and the shapes themselves. The term may be rather jargonistic and it is perhaps an ungainly word, but I have not managed to invent an alternative which encapsulates the interactive components so accurately. Each component of the term belongs to other disciplines (visual, linguistic, biological, geological), which is fitting since musical experience radiates across disciplines. But the combination is unique: in music we often need words which are invented specially for defining sonic phenomena.

A spectromorphological approach sets out spectral and morphological models and processes, and provides a framework for understanding structural relations and behaviours as experienced in the temporal flux of the music.

2.2. The relationship to compositional method

Spectromorphology is not a compositional theory or method, but a descriptive tool based on aural perception. It is intended to aid listening, and seeks to help explain what can be apprehended in over four decades of electroacoustic repertory. How composers conceive musical content and form – their aims, models, systems, techniques, and structural plans – is not the same as what listeners perceive in that same music. What the composer has to say (in programme notes, talks, sleeve notes) is not unimportant, and it undoubtedly influences (both helping and impeding) the listener's appreciation of music and musical ideas, but it is not always perceptually informative or relevant.

Although spectromorphology is not a compositional theory, it can influence compositional methods since once the composer becomes conscious of concepts and words to diagnose and describe, then compositional thinking can be influenced, as I am sure my own composing has been. In the confusing, wide-open sound-world, composers need criteria for selecting sound materials and understanding structural relationships. So descriptive and conceptual tools which classify and relate sounds and structures can be valuable compositional aids. Spectromorphological

[1] This essay was first published in French in 1995, and has since appeared in Italian (Smalley 1995, 1996). It is an extensive rewriting of my 'Spectromorphology and structuring processes' in *The Language of Electroacoustic Music* (Smalley 1986). The development of spectromorphological thinking owes most to Pierre Schaeffer's *Traite des objets musicaux* (Schaeffer 1966).

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awareness may therefore help the composing process but it will not necessarily make a better composer. Although spectromorphological ideas can help perceivers to focus on the imagination and craft of the composer, they will not help the composer to become more imaginative or to improve craft.

2.3. About scores and sonograms

In electroacoustic music there are three types of score which *might* contain perceptually relevant information. The first type is intended to be used by a performer (in mixed works, live electronic music) and may contain graphic transcriptions of acousmatic material. The second, rarer type, is the realisation score, usually technical to a degree, intended as a record of how a work was produced. It represents content and form in some way, although this may not be perceptually very relevant. We could also include composers' (private?) form-plans and similar representations in this category. The third type is the diffusion score of an acousmatic work, often a free, sketchy, graphic representation of the sounding context produced primarily as a timing and memory aid for the person diffusing a work in concert. This third type, and also any transcription of acousmatic material in the first type of score, is usually concerned with spectromorphological information: events and textures are given shapes whose vertical dimension represents spectral space, while the horizontal plane shows change over time. These transcriptive scores at the very least usually give a sense of the broad structural outlines, and they can be aurally interesting since the transcriber *chooses* to represent certain criteria and not others. On the other hand this may not be a free and considered choice since transcription is often done quite quickly and spontaneously, and is limited by what can be easily represented on paper in two dimensions. It is a score with a particular purpose and only needs to be accurate enough for its task – a list of timings might do just as well. The transcriptive score, or a more thoughtful, developed version of it, is sometimes used as a listening aid.

The sonogram, a graphic spectral analysis by computer, has been regarded as a solution to the visual representation of electroacoustic music. I regard it as a very useful aid rather than a solution. A sonogram is a type of literal spectral analysis at a chosen visual resolution: at too high a resolution detail becomes lost in a blur; at too low a resolution there is insufficient detail. But a sonogram is not a representation of the music as perceived by a human ear – in a sense it is too objective. Its shapes therefore have to be interpreted and reduced to perceptual essentials. In other words, someone has to decide what to retain and discard from the representation, and more particularly, try and determine how much detail is pertinent to the alert listener. For the analyst this question of the degree of detail is a problem since recordings (CDs) allow one to listen repeatedly to the briefest passages in a work, discovering much more detail than it is possible to hear in the course of normal musical flow. How much is too much, and how much is not enough? There is no objective method of achieving a visual spectromorphological representation, and the analyst hopefully becomes only too aware of subjective decision-making and alternative 'readings'. This is as it should be.

It is undoubtedly true that the task of preparing a full, relevant, graphic spectromorphological transcription is vexatious both because of transcription problems and the tedium of the task. Even the sonogram presents difficult, time-consuming decisions. Considering the dedication required, it is no wonder that exhaustive analyses are few. The problems of representation combined with the lack of consistent, thorough and fairly universally applicable analytical tools have undoubtedly inhibited electroacoustic music's acceptance in more intellectual, musicological circles. But we must be cautious about putting too much faith in written representations because writing freezes the experience of temporal flux. It is a device for counteracting the fleeting and selective nature of wayward aural attentiveness and memory during the sounding flow of music. Electroacoustic music's strength is that unlike traditional Western art music it cannot so easily suffer by being reduced to a notation system, thereby courting the danger that music writing might be regarded as a separate entity, a substitute for perceptual experience. In this regard, electroacoustic music has more in common with much orally transmitted music than with the heritage of Western art music.

Is a score an obligatory aid to spectromorphological description and analysis? Certainly for the analyst some kind of representation is necessary but what this should be is determined by the purpose of the analysis: whether something exhaustive and detailed is intended or whether only a particular aspect of the music is to be examined. Anything from a diagram (representing some of the criteria presented in this chapter) to a graphic representation might be appropriate, accompanied by sound examples. For other types of listener, however, perhaps a bundle of conceptual tools will be enough to enable useful discussion.

2.4. Ignoring technology

In spectromorphological thinking we must try to ignore the electroacoustic and computer technology used in the music's making. Surrendering the natural desire to uncover the mysteries of electroacoustic sound-making is a difficult but necessary and logical sacrifice. The desire to know is natural because, traditionally, all cultures have considerable knowledge about how sounds are made as a result of continuing visual observation and listening. Once we can grasp the relationship between the sounding body and the cause of the sound we feel we have captured a certain understanding: intuitive knowledge of the human physical gesture involved is inextricably bound up with our knowledge of music as an *activity*.

Electroacoustic music composition in its acousmatic forms is not the same kind of activity. A sound-texture or event in its finished guise is rarely the result of a single, quasi-instrumental, real-time, physical gesture. There may be no real sounding body involved nor any aurally identifiable causal action supposedly responsible for making the sound. Information about the synthesis method, computer program, treatment device, etc., is not a substitute for knowledge of source–cause interaction: the 'working gestures' of the acousmatic compositional process do not carry perceptual information equivalent to an intuitive knowledge of the physical gestures of traditional sound-making. Therefore, while in traditional music, sound-making and the perception of sound are interwoven, in electroacoustic music they are often not connected. Not that gesture, sources and causes are unimportant in electroacoustic music. On the contrary they are very important, as we shall discover.

The composer, or other listeners conversant with technology and techniques, cannot easily brush aside a particular listening mode which I call *technological listening*. Technological listening occurs when a listener 'perceives' the technology or technique behind the music rather than the music itself, perhaps to such an extent that true musical meaning is blocked. Many methods and devices easily impose their own spectromorphological character and cliches on the music. Ideally the technology should be transparent, or at least the music needs to be composed in such a way that the qualities of its invention override any tendency to listen primarily in a technological manner. It is difficult for the composer to adopt a 'purer' spectromorphological ear untainted by technological listening when there are so many technical preoccupations which interfere with the creative stream, clouding perceptual judgement.

Spectromorphological thinking is based on criteria which can potentially be apprehended by all listeners. In electroacoustic music, the separation between the act of sound-making and perception, combined with the specialised nature, proliferation and transience of methods and devices, indicate that technological knowledge cannot be part of any method founded on perceptual consensus.

2.5. Which musics?

I intend spectromorphological thinking to be applicable to a wide variety of electroacoustic musics, cutting across national boundaries and individual styles. However, it is intended to account for types of electroacoustic music which are more concerned with spectral qualities than actual notes, more concerned with varieties of motion and flexible fluctuations in time rather than metrical time, more concerned to account for sounds whose sources and causes are relatively mysterious or ambiguous rather than blatantly obvious. If a particular style of electroacoustic music is more traditionally note-based or metrically organised, then a spectromorphological approach will not be very helpful. Of course notes and intervallic relationships are often very important in electroacoustic music, though they may be covertly hidden in the fabric. In such cases a knowledge of tonal tradition and meaning in (Western?) culture will also be needed as a descriptive aid.

Spectromorphological thinking is primarily concerned with music which is partly or wholly *acousmatic*, that is, music where (in live performance) the sources and causes of the sounds are invisible – a music for loudspeakers alone, or music which mixes live performance with an acousmatic, loudspeaker element.[2] However, what is and is not acousmatic is not clear-cut, since even music where live performers are involved can become acousmatic when the listener cannot connect the sounds heard with the observed physical activity which supposedly produces them. This can happen in live electronic music performance, and is a category of music I call *live acousmatic music*. The distinction between what is and is not acousmatic becomes blurred even further in a CD recording where everything becomes invisible.

Some contemporary instrumental music can also be approached spectromorphologically – for example, the music of Xenakis and of younger composers like Grisey, Saariaho, Murail, Dillon and many others concerned with spectral and textural complexity. In this music there is often a loss of instrumental identity as the orchestra is 'resynthesised' into a kind of spectromorphological hyper-instrument. While we may sometimes be conscious of instrumental identity, we can equally be persuaded to forget individual note-gestures as these individuals are subsumed in streams and collective motions. Even though this music is represented and achieved through musical writing, the score itself is a very inadequate representation of perceptual qualities. An aural approach which treats recordings of such works in the manner of an acousmatic tape work is often much more fruitful.

A spectromorphological approach cannot deal adequately with electroacoustic music which is very strongly anecdotal or programmatic, that is, music where a very wide palette of sonic references may be employed – recordings of cultural events and behaviour, musical quotation and pastiche, and so on. In

[2] For further reading refer to *Vous avez dit acousmatique*? (see Smalley 1991a).

this type of electroacoustic music, meaning is closely allied to recognising the sources, identifying with them, knowing which context they have been drawn from, and reinterpreting their meaning in their new musical context. Such music is therefore *transcontextual* or *intertextual*. Much acousmatic music strays in and out of transcontextual suggestions – the sounds of nature, the elements and environment are particularly common. More often than not a mixture of spectromorphological and transcontextual insights is required. Spectromorphological qualities can often help qualify the power of a transcontextual message.

2.6. Intrinsic–extrinsic threads

Spectromorphology concentrates on *intrinsic* features. That is, it is an aid to describing sound events and their relationships as they exist within a piece of music. However, a piece of music is not a closed, autonomous artefact: it does not refer only to itself but relies on relating to a range of experiences outside the context of the work. Music is a cultural construct, and an *extrinsic* foundation in culture is necessary so that the intrinsic can have meaning. The intrinsic and extrinsic are interactive.[3]

In transcontextual music, intrinsic qualities and relations as created by the composer determine the impact of extrinsic messages. But there is a sort of transcontextuality throughout electroacoustic music, though not of the *intentionally encoded* varieties which in authentic *trans-contexts* are so strongly reliant on source identification. The wide-open sonic world of electroacoustic music encourages imaginative and imagined extrinsic connections because of the variety and ambiguity of its materials, because of its reliance on the motion of colourful spectral energies, its emphasis on the acousmatic, and not least through its exploration of spatial perspective. There is quite a difference in identification level between a statement which says of a texture, 'It is stones falling', a second which says, 'It sounds like stones falling', and a third which says, 'It sounds as if it's behaving like falling stones'. All three statements are extrinsic connections but in increasing stages of uncertainty and remoteness from reality. If a listener, elaborating on either statements two or three, comments on qualities and features of the texture as heard within the musical context, then attention turns away from the primarily extrinsic towards special intrinsic features and therefore moves more deeply into the particular musical experience. It is thus that this listener starts to engage in spectromorphology.

[3] The intrinsic and extrinsic aspects of music are discussed fairly fully in *Music and Discourse*: *Towards a Semiology of Music* (Nattiez 1990: 102–29). (The French edition, which is not the same as the English edition, was published by Christian Bourgois in 1987, under the title *Musicologie generale et semiologie*.)

Extrinsic–intrinsic threads of the 'as if' variety need not refer only to *sounding* experience. Non-sounding extrinsic links are also possible, whether based on human physical movement (see the section on gesture) or environmental experience. For example, spectromorphology is concerned with motion and growth processes, which are not exclusively or even primarily sonic phenomena: sonic motion can suggest real or imagined motions of shapes in free space. Spatial experience itself can involve sounds or not. Energy, which is inherent in spectral motion, is part of both sounding and non-sounding experience, linked not only to motion in general but to human gesture as well – the energetic impact of an implement hitting a sounding body, for example, has spectromorphological consequences.

I have invented the term *source bonding* to represent the intrinsic-to-extrinsic link, from inside the work to the sounding world outside. I define source bonding as:

> the *natural* tendency to relate sounds to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins.

The word 'bonding' seems particularly appropriate since it evokes a binding, inescapable engagement or kinship between listener and musical context. The bondings involve all types of sounding matter and sound-making, whether in nature or in culture, whether they arise as a result of human agency or not. Source bondings may be actual or imagined – in other words they can be constructs created by the listener; different listeners may share bondings when they listen to the same music, but they may equally have different, individual, personalised bondings; the bondings may never have been envisaged by the composer and can occur in what might be considered the most abstract of works; wide-ranging bondings are inevitable in musics which are not primarily weighted towards fixed pitches and intervals. *Bonding play* is an inherent perceptual activity.

2.7. Instrumental and vocal source bonding

One might think that in more 'abstract' instrumental music, source bondings do not exist, but they are there in force, revealed through gesture and other physical activity involved in sound-making. The bonding of instrumental activity to human gesture is somewhat ignored not only because it is invariably expected in music, but also possibly because much music study has tended to concentrate on music writing (notation), theory and analysis, which tend to distance a work from the gestural activity of its performance. Vocal presence, whether revealed through stylised singing or direct utterance, has direct human, physical, and therefore psychological links. In electroacoustic music the instrumental and vocal are included, but unlike traditional music where instrumental and vocal presence are assumed and known in advance, in acousmatic electroacoustic music they are both to be encountered (unexpectedly) and inferred. Electroacoustic music, then, subsumes instrumental and vocal experience: instrumental and vocal resources are a 'subset' of the wide-open sound world which is electroacoustic music's territory.

Identifying intrinsic–extrinsic threads is one thing. Interpreting their meanings, expressivity, and psychological significance is a more distant but ultimate goal, a study of which is beyond the scope of this essay. Some of the concepts and language or spectromorphology have formalist tendencies, but ideally, intrinsic spectromorphological description, although not directly interpretative, should be capable of helping a listener to pinpoint those musical qualities which are carriers of meaning.

2.8. The composer's ear

Attention has already been drawn to technological listening as a listening mode where the composer's perceptions can be different from those of other listeners. But the composer also has to combat another specialised listening mode – that of *reduced listening* (*ecoute reduite*).[4] Reduced listening comes about through concentrated, repeated listening to a sound event, a common activity in the electroacoustic composing process. It is an investigative process whereby detailed spectromorphological attributes and relationships are uncovered. This requires that the 'distractions' of source bonding and intrinsic–extrinsic threads be blocked out in order to concentrate on refining spectromorphological detail and sound quality. Reduced listening is therefore an abstract, relatively objective process, a microscopic, intrinsic listening.

Outside the creative process outlined above, many composers regard reduced listening as an ultimate mode of perceptual contemplation. But it is as dangerous as it is useful for two reasons. Firstly, once one has discovered an aural interest in the more detailed spectromorphological features, it becomes very difficult to restore the extrinsic threads to their rightful place. Secondly, microscopic perceptual scanning tends to highlight less pertinent, low-level, intrinsic detail such that the composer–listener can easily focus too much on background at the expense of foreground. Therefore, while the focal changes permitted by repetition have the advantage of encouraging deeper exploration, they also cause perceptual distortions. My experience of teaching composers has often revealed to me that such distortions are frequent.

As far as the spectromorphological approach to electroacoustic music is concerned, reduced listening mechanisms lie behind the development of concepts. They are a necessary aid to any full analysis, particularly at the lowest levels of structure, and they are necessary to any investigation which seeks to reveal those intrinsic features which invest the extrinsic threads with their psychological power. The CD player now, for the first time, through its flexible repetition processes, offers listeners other than the composer of the work the opportunity for investigating what were previously but fleeting moments. Retaining a realistic perceptual focus is, finally, a precarious balancing act.

3. GESTURE AND ITS SURROGATES

Until the electroacoustic medium arrived, all music was created either through forms of vocal utterance[5] or through instrumental gesture. Sound-making gesture is concerned with human, physical activity which has spectromorphological consequences: a chain of activity links a cause to a source. A human *agent* produces spectromorphologies via the motion of gesture, using the sense of touch or an implement to apply *energy* to a *sounding body*. A gesture is therefore an *energy–motion trajectory* which excites the sounding body, creating spectromorphological life. From the viewpoint of both agent and watching listener, the musical gesture-process is tactile and visual as well as aural. Moreover, it is proprioceptive: that is, it is concerned with the tension and relaxation of muscles, with effort and resistance. In this way sound-making is linked to more comprehensive sensorimotor and psychological experience.

We should not think of the gesture process only in the one direction of cause–source–spectromorphology, but also in reverse – spectromorphology–source–cause. When we hear spectromorphologies we detect the humanity behind them by deducing gestural activity, referring back through gesture to proprioceptive and psychological experience in general. Everyone uses this *spectromorphological referral process* when listening to recordings of instrumental music. Not only do we listen to the music, but we also decode the human activity behind the spectromorphologies through which we automatically gain a wealth of psycho-physical information.

[4] Reduced listening is a Schaefferian concept. See Schaeffer (1966) and Chion (1983) for a full discussion.

[5] For reasons of space it is not possible to enter into a comprehensive discussion of the vocal sound as a spectromorphological model. The idea of gesture can, of course, be applied to the voice, where the energy as well as the sound is projected from inside the human body.

The listener's experience of listening to instruments is a cultural conditioning process based on years of (unconscious) audiovisual training. A knowledge of sounding gesture is therefore culturally very strongly imbedded. This cannot be ignored and denied when we come to electroacoustic music. It is particularly important for acousmatic music where the sources and causes of sound-making become remote or detached from known, directly experienced physical gesture and sounding sources. The process of increasing remoteness I refer to as *gestural surrogacy*.[6]

Original, *primal gesture*, on which sounding gesture is based, occurs outside music in all proprioceptive perception and its allied psychology. *First-order surrogacy* projects the primal level into sound, and is concerned with sonic object use in work and play prior to any 'instrumentalisation' or incorporation into a musical activity or structure. It is here that musical potential begins to be recognised and explored. Traditionally in art music this first level does not become music in itself: it develops into instrumental, second-order surrogacy. But for electroacoustic music it becomes an important level in its own right since many unique sound-gestures are transplanted directly into music from this level, for example gestural play with materials like wood or metal. First-order surrogacy includes recordings of sound-making not intended for musical use. On the other hand, first-order surrogacy may involve more developed gestural play purposely used as compositional material, a sort-of personalised, nascent 'instrument' which never achieves, or can never achieve full cultural, instrumental status. But we can only award such sounds first-order status if we can recognise source (the type of material) and type of gestural cause. If in the compositional process the source is transformed and either gesture or cause becomes dubious, then third-order or perhaps remote surrogacy will be invoked.

Second-order surrogacy is traditional instrumental gesture, a stage removed from the first order, where recognisable performance skill has been used to develop an extensive registral articulatory play. An acousmatic music which, for example, uses only recordings of identifiable instruments remains in the second order. Much music which uses simulation of instrumental sounds can also be regarded as second order since, although the instrument may not be real, it is perceived as the equivalent of the real. Commercial synthesizer usage is of this type when we recognise both the gesture involved and the instrumental source simulated.

[6] The number of levels has been expanded beyond those discussed in Smalley (1992).

Third-order surrogacy is where a gesture is inferred or imagined in the music. The nature of the spectromorphology makes us unsure about the reality of either the source or the cause, or both. We may not be sure about how the sound was made to behave as it does, what the sounding material might be, or perhaps about the energy–motion trajectory involved. For example, a resonant spectromorphology could sound as if excited by gestural impact of some kind (inferred cause) even though we do not know exactly what the source might be because its sound-quality is unfamiliar, or because the resonance behaves in an unexpected way (uncertain/unknown source).

Remote surrogacy is concerned with gestural vestiges. Source and cause become unknown and unknowable as any human action behind the sound disappears. The listener may instead be concerned with non-sounding extrinsic links, always, of course, based on perceived spectromorphological attributes. But some vestiges of gesture might still remain. To find them we must refer to tensile, proprioceptive properties, to those characteristics of effort and resistance perceived in the trajectory of gesture. Thus, remote surrogacy, while distanced from the basic, musical first order, can yet remain linked to the psychology of primal gesture. But in order for such a gesture to be felt, there has to be sufficient directed, propagating or reinjected energy in the spectromorphology.

Acousmatic music, therefore, can stay close to traditional, gestural cause–source relations, but at its most adventurous extends into third-order ambiguity and beyond to a music which, although remote from traditional sound-making activity, can nevertheless maintain a humanity. The access to a more basic but very rich first-order surrogacy has only become viable because of recording technology. The imagination of the third and remote orders is one of the great offerings of composition's alliance with technology. I venture to suggest that an electroacoustic music which is confined to the second order does not really explore the potential of the medium, while a music which does not take some account of the cultural imbedding of gesture will appear to most listeners a very cold, difficult, even sterile music.

4. SPECTROMORPHOLOGICAL EXPECTATION

The note is the basic gesture-unit of instrumental music. Every note-gesture, however short, has a spectral history – the energy–motion trajectory of its spectromorphology. Every note must start in some way; some may be sustained or prolonged for a time and some may not; every note stops. These three linked temporal phases I refer to as *onset*, *continuant* and *termination*. They are not distinctly separable: we cannot tell the very moment when an onset passes into a continuant phase, nor when a continuant passes into the terminal phase. Nor do all three phases have to be present in the note-gesture. There are three important spectromorphological archetypes found in instrumental usage. In all three models spectral richness is assumed to be congruent with the dynamic shape of the morphology – the louder, the more spectral energy, the brighter and/or richer the sound. These archetypes are:

(1) The *attack* alone. This is a momentary energetic impulse. Two temporal phases are merged into one – there is a sudden onset which is also the termination. We do not have sufficient time to hear any appreciable change in spectral energy as the sound moves rapidly to its termination. There is no continuant phase. Awareness is focused on the attack-energy. A dry percussive attack or a staccato sound (without resonance) are examples.
(2) The *attack-decay*. The attack is extended by a resonance. The onset and terminatory phases are present, and there may be a hint of the continuant if we feel that the sound is being prolonged at a consistent level before it decays. In this archetype an initial gesture is enough to set a spectromorphology in motion, after which there is no gestural intervention as the sound continues towards termination. A string pizzicato or a bell are examples.
(3) The *graduated continuant*. In this archetype all three phases are present. The onset starts gradually as if faded in, and the note terminates gradually as if faded out. In between, the note is sustained for a time. Examples are sustained string or wind sounds, where continuing energetic input (breath or gestural) is needed to sustain or prolong the sound. This is the most interventionist of the archetypes because we are aware of the continuing imposition of gesture. It is therefore the most open to the development of variants.

We can say that instrumental music is made up of strings of *variants* of the above archetypes, and (in ensemble music) superpositions and mergings as well. Variants are created by manipulating the durations and spectral energy of the three phases. For example, the graduated continuant archetype (which is rather idealised) could be varied in a number of ways:

(1) By compressing the onset so that it is swelled (less linear). More energy is thereby injected into the onset, giving a more pressured, pushing effect. We find this onset variant quite often in Baroque performance practice.
(2) By lengthening the continuant phase, drawing attention away from the onset towards interest in the sound's continuity, which could be stable, or more or less varied, prior to termination.
(3) By increasing the spectral energy towards termination, leading towards, and creating the expectancy of, a new note-gesture. The continuant phase is lengthened and termination is avoided, or rather the onset of the new note-gesture is also the termination of the previous note.

What the archetypes and their variants demonstrate is that the note trains us in *spectromorphological expectation*. We have a very wide experience of the circumstances in which spectral changes occur, not just in single note-gestures but in the articulation of chains of note-gestures within the larger gestures of phrase-motion. Our acquired knowledge of the contexts of spectral change provides an almost 'natural' reference-base not only for developing the wider, more imaginative spectromorphological repertory into the third-order surrogacy of electroacoustic music, but for decoding patterns of expectation in musical form. We predict or try to predict the expected tendencies of spectral change. Electroacoustic music, even when deprived of known instrumental spectromorphologies and tonal harmonic language, still relies on culturally acquired expectation patterns.

5. GESTURE AND TEXTURE AS FORMING PRINCIPLES

The basic gesture of traditional instrumental music produces the note. In tonal music notes form a consistent low-level unit, and are grouped into higher levelled gestural contours, into phraseological styles, which traditionally have been based on breath-groups. Singers and wind-players, after all, have to breathe. In electroacoustic music the scale of gestural impetus is also variable, from the smallest attack-morphology to the broad sweep of a much longer gesture, continuous in its motion and flexible in its pacing. The notion of gesture as a forming principle is concerned with propelling time forwards, with moving away from one goal towards the next goal in the structure – the energy of motion expressed through spectral and morphological change. Gestural music, then, is governed by a sense of forward motion, of linearity, of narrativity. The energy–motion trajectory of gesture is therefore not only the history of an individual event, but can also be an approach to the psychology of time.

If gestures are weak, if they become too stretched out in time, or if they become too slowly evolving, we lose the human physicality. We seem to cross a blurred border between events on a human scale and events on a more worldly, environmental scale. At the same time there is a change of listening focus – the slower the directed, gestural impetus, the more the ear seeks to concentrate on inner details (insofar as they exist). A music which is primarily textural, then, concentrates on internal activity at the expense of forward impetus.

But most musics are texture–gesture mixtures, either in that focus shifts between them, or because they exist in some kind of collaborative equilibrium. Where one or the other dominates in a work or part of a work, we can refer to the context as *gesture-carried* or *texture-carried*. Individual gestures can have textured interiors, in which case gestural motion frames the texture – we are conscious of both gesture and texture, although the gestural contour dominates, an example of *gesture-framing*. On the other hand, texture-carried structures are not always environments with democratic interiors where every (micro-) event is equal and individuals are subsumed in collective activity. Gestures can stand out in foreground relief from the texture. This is an example of *texture-setting* – texture provides a basic framework within which individual gestures act.

6. STRUCTURAL LEVELS

It is wrong to seek in electroacoustic music the same kinds of structural hierarchies as tonal music. In tonal music the note is regarded as the lowest structural level, and all tonal music is made up of note-groupings of increasing dimensions as one moves outwards through the form – from note to motive to phrase, and so on. In addition, metrical structure gives the lowest-level note a pulse which defines the minimum possible density of movement.

The discussion of gesture and texture as forming principles implied that gestures and textures could be small scale or larger scale. Electroacoustic gestures and textures cannot be reduced either to note or pulse;[7] the music is not necessarily composed of discrete elements; nor can we find that (consistent) measure of minimum movement density. Therefore it cannot be conveniently segmented, and indeed often resists segmentation. At one moment in a work one may be following discrete, short units, and at another a large-scale structure whose continuity and coherence refuse to be dissected and demand to be considered more as a whole than as the sum of minute parts. A piece could be such that the idea of anything called a 'unit' lacks relevance. There can be no '... explicit criteria for segmentation and denomination of objects...' as called for by Nattiez (1990: 80),[8] let alone the requirements expressed in the continuation of this sentence, '... and notation precise enough that a given class of sounds (which have been verbally described) will invariably and unambiguously correspond to a given symbol'.

There is no *permanent* type of hierarchical organisation for all electroacoustic music, or even within a single work.[9] Undoubtedly there are structural levels, but they do not need to remain consistent in number throughout a work, and a single level does not need to run permanently through the whole span of a work. For example, one might detect three or four levels in one part of a work and fewer or more in another part; one section of a work might comprise a neat hierarchy of small, unit-groupings, while another section might be a much larger, indivisible, higher-level whole.

It is fair to say that much electroacoustic music does not offer sufficient hierarchical variety. This occurs where the types of sounds and the structural continuity direct one to listen continuously in a global, high-level mode. With textured structures it is very easy for the composer, listening too hard to the textural material, to be deceived into thinking that there is lower-level interest within the texture when there is not. And music which deals mainly in broad, high-level, gestural sweeps with little internal interest, may not offer much to the listener on repeated hearings. A rewarding balance of perceptual interest at a variety of structural levels is unfortunately more rare than it should be.

In my spectromorphological approach, the concepts of gesture and texture, motion and growth processes, behaviour, structural functions, spectral space and density, and space and spatiomorphology may be applied to smaller or larger time-spans which may be at lower or higher levels of structure. Finding the 'right' levels or temporal dimensions to apply the attributes of these concepts must remain the perceiver's decision.

7. STRUCTURAL FUNCTIONS

Structural functions are concerned with expectation. Like other musics, electroacoustic music has its expectation patterns, and I have already suggested that these are based on our wide cultural acquaintance with the perceived spectral changes of a wide variety of sounds. During listening we attempt to predict the directionality implied in spectral change. We might ask ourselves, for example, where a gesture might be leading, whether a texture is going to continue behaving in the same way, whether change is

[7] In much contemporary instrumental music, notation can be a very misleading guide to the lowest level of structure, when the written note is not heard as a discrete unit but as part of a collective gesture or texture. Notation may show us how gestures and textures are made up, but a reading of individual 'notes' will not tell us what should be heard in them.

[8] See note 3 for the reference.

[9] The criteria for hierarchical organisation set out by Lerdahl may apply to tonal music, but they do not suit electroacoustic music. That, of course, does not mean that electroacoustic music is not hierarchical (see Lerdahl 1987: 137–8; the French version, 'Les hierarchies de timbres', appeared in *Le timbre, metaphore pour la composition*, J.-B. Barriere, ed., Christian Bourgois/IRCAM, 1991).

onsets	continuants	terminations
departure	passage	arrival
emergence	transition	disappearance
anacrusis	prolongation	closure
attack	maintenance	release
upbeat	statement	resolution
downbeat		plane

likely or not, whether change is likely to be concerned with gradual merging or sudden interruption, and so on. The ideas of onset (how something starts), continuant (how it continues) and termination (how it ends) can be expanded into a list of terms, some of them technical, some more metaphorical, which can be used to interpret the function-significance of an event or context. These functions can be applied at both higher and lower levels of musical structure, referring, for example, to a note, an object, a gesture, a texture, or a type of motion or growth process, depending on our focus of attention.

The onset terms reflect varying degrees of abruptness. What they have in common is that they are moving out from or away from a starting-point, creating expectant tensions. The continuant terms vary. Some look forward, expressing betweenness ('transition', 'passage'); others are linked backwards to the onset function ('prolongation', 'maintenance'), while 'statement' signals a more definitive, almost independent status. The terminations vary in their feelings of completion. 'Disappearance' is a weak termination without much purpose, while 'resolution' and 'release' have strong relaxant functions. 'Arrival' and 'plane' express structural goals achieved.

The attribution of a function to a particular event or context is not a simple cognitive process:

(1) *Function attribution is not normally a conscious thought-process.* We are not continually asking ourselves a reasoned series of function-questions resulting in function-decisions. Rather, function attribution is part of the intuitive expectations of psychological time.

(2) *Function attribution is a continuing, incomplete process, subject to revision.* We make interim function attributions, and may change our minds in the continuing course of a context and after it has passed by. (We cannot finally attribute a function until we know what comes afterwards.) Since we are always busy concentrating on the present, our attentions may be diverted before any final attribution can be completed – contexts slip away. And which levels of structure are we following anyway? How many levels can our attention and memory spans take in? Are we following each impending moment or broader outlines?

(3) *Function attribution may be double or ambiguous.* A context may have different, simultaneous functions. This is particularly so when events are overlapped or motion is continuous. For example, a contour which seems to resolve a motion could also form part of the anacrusis to a following peak – in this case the termination function is also an onset function on the same level.

(4) *There is no clear temporal border between the three function-types.* For example, the point at which we decide that an event has fully emerged and the point at which we decide that it has entered a transitional phase may not be a point but a process of evolving realisation.

8. MOTION AND GROWTH PROCESSES

The metaphors of motion and growth are appropriate ways of considering a time-based art like electroacoustic music. Traditional concepts of rhythm are inadequate to describe the often dramatic contours of electroacoustic gesture and the internal motion of texture which are expressed through a great variety of spectromorphologies. Quite often listeners are reminded of motion and growth processes outside music and the terms selected are intended to evoke these kinds of connections. Since motion and growth have spectral contours, they are set in spectral space.

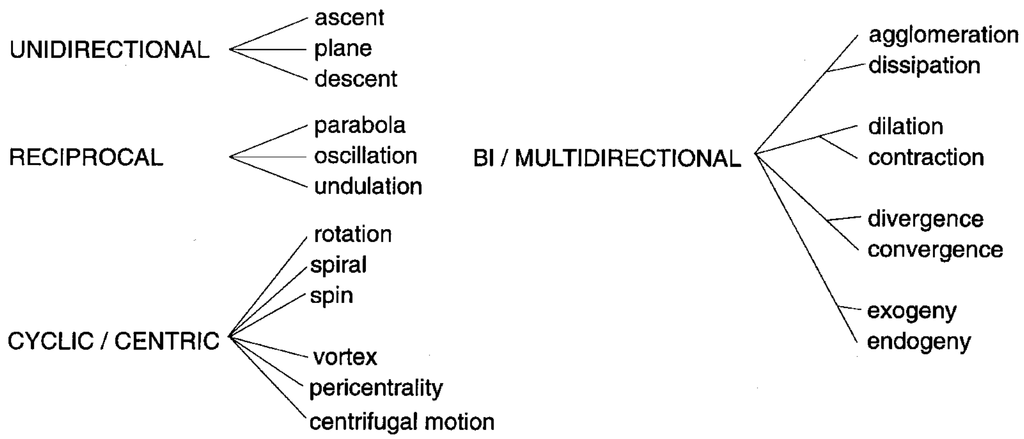

Figure 1. Motion and growth processes.

Therefore their occupancy of spectral space and their spectral density will be important additional qualifiers (see figures 6 and 7). In addition, motion and growth can be enhanced by actual spatial distribution (see figures 8 and 9). The basic reference types are set out in figure 1. The unidirectional, reciprocal and cyclic/centric groups should be regarded more as motions, while the bi/multidirectional group is more concerned with growth processes.

Motion and growth have directional tendencies which lead us to expect possible outcomes, and they are helpful guides in attributing structural functions. *Unidirectional motion* provides a simple example. If we encounter a slow, ascending contour, we could expect a variety of outcomes but not any outcome. It could ascend and fade as it goes out of 'sight'; it could increase in richness leading to an impact point; it could be joined and absorbed by other events; it could change direction, turning into a parabola; it could reach a stable ceiling. Whatever it eventually does may surprise us (if there are sudden changes) or it may do what we expect particularly if its rate of change gives us clues to its future. This hypothetical description could imply a termination function (disappearing upwards), an anacrusis (increasing in richness leading to another event), and so on. Finally, this example emphasises the gestural nature of its contour (no internal, textural interest has been referred to) even if it is stretched out in time.

In *reciprocal motion*, movement in one direction is balanced by a return movement. Oscillation and undulation, which are contour variations, could apply to internal, textural motions, as well as being descriptions of external contour. Parabolas are often more gestural, a class of curved trajectories. They are common in electroacoustic music, probably because of the dramatic possibilities of varying the duration, velocity and spectral energy of the outward and return journeys. A parabolic trajectory can move continuously through a variety of spatial locations.

Generally in music, *centric motion* is expressed by spectromorphological recycling, giving an impression of motion related to a central point. This can be achieved through spectromorphological variation alone, but is frequently aided by spatial motion. Continuing recycling, like other forms of repetition, can give an impression of structural stasis, but centric motions can also be strongly directional – vortical and spiral motions have this possibility, for example. Centric motions can also be associated with growth. For example, I can think of rotating motions which gather textural materials to them as they expand spectrally – a combination of rotation and exogenous or endogenous growth. The *spin*, *spiral* and *vortex* are rotational variations. *Centrifugal* (flung out) and *pericentral* (merely moving around a centre) are also a related group.

Bi/multidirectional motions create expectations, and most have a sense of directed motion. They can be regarded as having both gestural and textural tendencies, and could be large structures in themselves. *Agglomeration* (accumulating into a mass) and *dissipation* (dispersing or disintegrating) are textural processes. *Dilation* (becoming wider or larger) and *contraction* (becoming smaller) are concerned with changing dimensions and could be regarded as a different aspect of agglomeration/dissipation. *Divergence* and *convergence* are strongly directional and could be gestures or texture growths, or a simultaneous linear descent/ascent. *Exogeny* (growth by adding to the exterior) could be allied to dilation and agglomeration, while *endogeny* (growing from inside) implies some kind of frame which becomes filled, or texture which becomes thickened.

In figure 2 I have grouped together *seven characteristic motions* in order to sketch out their implications.

(1) *Motion rootedness*. Some are more likely to be 'earthbound' (push, drag) while others are not

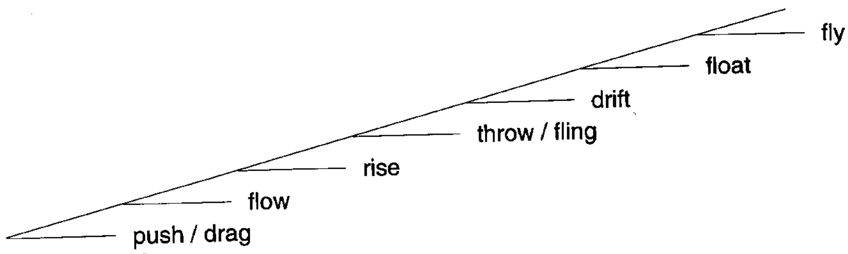

Figure 2. Seven characteristic motions.

rooted to a solid plane. Many spectromorphologies are inherently non-rooted because there is no bass anchor (fundamental note) to secure the texture. Thus analogies with flight, drift and floating can be common. Motion towards a root could be implied in a spectral descent towards termination, but a root may not be achieved if the motion fades 'in the air'.

(2) *Motion launching*. The launching of motion varies. Some may be considered as self-contained events with gesture-based, pressured onsets (drag, throw, fling) while others could be thought of as emerging as if they had always existed (flow, float, drift).

(3) *Contour energy and inflection* – the direction and energy of motion through spectral space. Some are inherently slow or evolving (flow, drift, float), needing time to establish themselves, while others imply rapid energy–motion trajectories.

(4) *Internal texturing* – continuity and discontinuity. Most of these motions imply a certain internal textural consistency in order that the type of motion may remain coherent (see below).

9. TEXTURE MOTION

Most of the bi/multidirectional motions imply internal textural change, but the other motion-groups can also be textured. Moreover, in terms of occupancy of spectral space they could vary in dimensions, and consist of more than one layer. As far as structural level is concerned, it is the motion as a whole which is the most significant perceptual unit. Texture motion does not necessarily imply that it is possible to segment the texture into lowest-level units, although it might be possible to separate out one or more spectromorphological types.

Figure 3 sets out several qualifiers of *texture motion*. The left column lists four ways in which the internal textural components may collaborate in motion. That implies a type of 'behaviour' (see below). *Streaming* refers to a combination of moving layers, and implies some way of differentiating between the layers, either through gaps in spectral space or because each layer does not have the same spectromorphological content. *Flocking* describes the loose but collective motion of micro- or small object elements whose activity and changes in density need to be considered as a whole, as if moving in a flock. One can imagine flocking motion passing through a variety of multidirectional growth processes. The interior of a stream could be flocked, and a flock could be part of a streamed texture. *Convolution* (coiling or twisting) and *turbulence* (irregulation fluctuation, possibly stormy) involve confused spectromorphological entwining, but nevertheless tend to concur in their chaos.

Texture motion may vary in internal consistency. *Continuous motion* is sustained while *discontinuous motion* may be more or less fragmented. The *continuity–discontinuity continuum* runs from sustained motion at one extreme to iterative motion at the other. If iterative repetitions become too widely spaced then separate objects will be heard. This tendency is possible with some of the multidirectional growth processes if the internal texture becomes sparser during fragmentation in the growth process. Granularity occupies an ambiguous mid-point since it could be considered either (roughly) sustained or iterative depending on how closely packed the grains are. Both continuity and discontinuity can move in a more or less periodic–aperiodic/erratic manner, with internal fluctuations in tempi. Continuous/discontinuous texture motion may need to be considered as a totality, or may follow grouping patterns if contours, fluctuations or discontinuities are subject to repetitions, cycles or pauses which imply higher-level groupings.

10. BEHAVIOUR

The metaphor of behaviour is used to elaborate relationships among the varied spectromorphologies acting within a musical context. I believe that listeners can intuitively diagnose behavioural relationships (or a lack of them) in electroacoustic music contexts and that this diagnosis affects the listener's interpretation of and reactions to the music. In this respect, behaviour is archetypal. We may be aware of behaviour in tonal instrumental and vocal music, although it is fairly circumscribed because of the nature of the harmonic system which brings with it

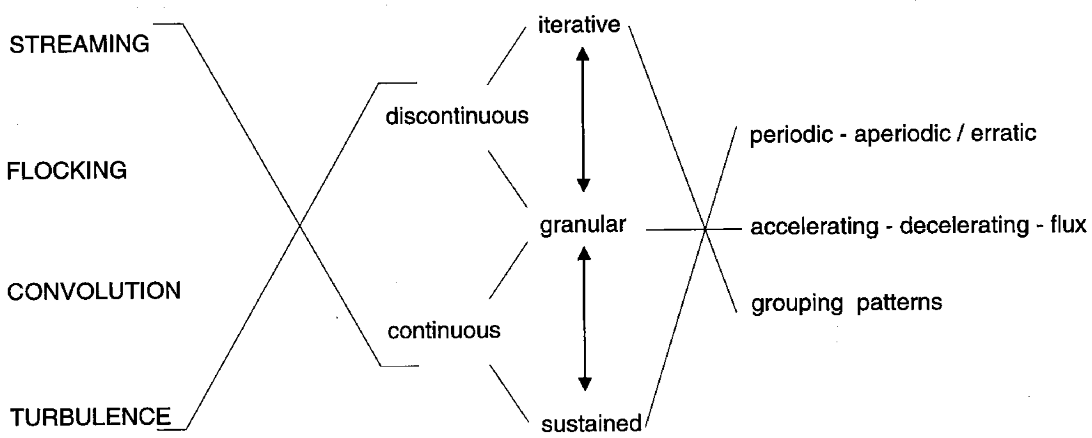

Figure 3. Texture motion.

constraints of polyphony and counterpoint. In acousmatic music the invisible freedom of spectromorphological content and motion creates a much wider and more variable pool of extrinsic, behavioural references. We hardly need reminding that in an acousmatic music behavioural relationships are carried by spectromorphology alone, and that in mixed work the perceived behavioural relationships between the visible, gesture-bearing performer and the surrounding acousmatic context will be crucial to the work's understanding.

As with other concepts, behaviour may be applied at a variety of levels, for example, discrete events, low-level texture motion, or the much higher level of relations between groups of textures or growth processes. Behaviour (figure 4) has two interactive, temporal dimensions (shown linked by the double-headed arrow), one vertical the other horizontal. The vertical dimension is concerned with *motion coordination* (concurrence or simultaneity), while the horizontal dimension is concerned with *motion passage* (passing between successive contexts).

The *loose–tight continuum* represents the degree of coordination freedom. Whereas synchronicity has been the rule in tonal art music, it is no longer the case. Today there is an extreme distance between a very tight, perhaps rigidly controlled, punctual, homorhythmic, minimal music, and the very relaxed, malleable associations found in some electroacoustic music. Indeed, spectromorphologies could be so different in their character and motion that the only relationship they seem to have is that they exist in the same space at the same time. That, of course, is in itself a behavioural relationship.

In motion passage, the *voluntary–pressured continuum* expresses how one context or event yields to the next. We are reminded that such questions as the degree of motion coordination, the energy–motion trajectory of gesture, the pressuring urgency of onset rates, and the type of motion are strong determinants. *Causality*, where one event seems to cause the onset of a successor, or alter a concurrent event in some way, is an important feature of acousmatic behaviour. The arrow leading from the voluntary–pressured continuum shows that causality can be weaker or stronger, depending on the influence or impact one spectromorphology has on another. On the whole, a strongly causal music relies on gesture, and impact-coordination points which will be regarded as goals in the structure.

The upper part of figure 4 is intended as a guide to interpreting behavioural relationships and is dependent on two oppositional pairs of concepts – dominance/subordination and conflict/coexistence – which form the basis for a group of *relationship modes* listed in the centre.

11. SPECTRA

I must now turn in more detail to the spectro- aspect of spectromorphology. I adopt the more general terms 'spectra' or 'spectral space' to represent the wide variety of sound-qualities, timbres and pitches perceived over the spectrum of audible frequencies. No doubt the reader has already been triggered into imagining types of sounds in association with motion and growth, texture motion, or behaviour, but when it comes to describing more precisely what these sounds might be we run into difficulties. Composers and researchers are used to thinking of spectra in terms of their spectral components which can be analysed, extracted, reconfigured and transformed to create new spectromorphologies and transform existing ones. This detailed, analytical approach to spectra can only be used in spectromorphological thinking if it is perceptually based and relevant to the musical context. Even then, what terminology do we use, particularly when individually perceived pitches are not

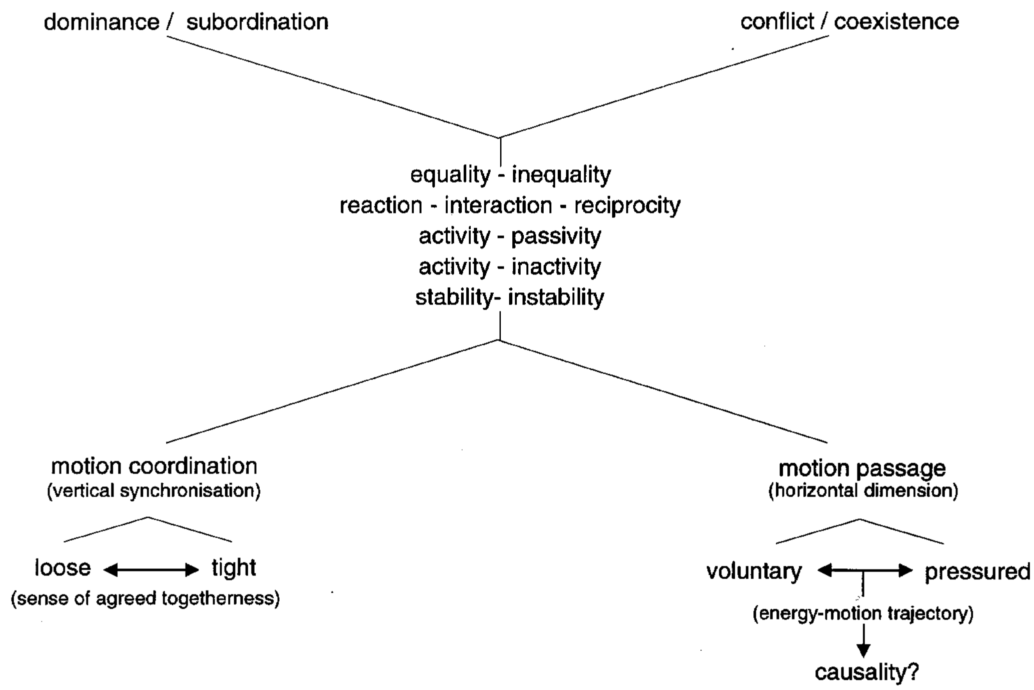

Figure 4. Behaviour.

involved? Source-bonding in itself draws attention to spectral attributes associated with the type of source: naming a real or imagined source is an act of differentiating spectral qualities. No doubt we can describe spectral attributes of the source in terms of whether the sound is bright, dull, hollow, thin, intense, and so on. We need to expand this terminology of qualitative description in order to deal more comprehensively with aspects of spectral space.

Whether pitches are heard or not is of prime importance in spectral discrimination. I must first discuss the nature of the note both as a manifestation of pitch and as a type of spectrum. That will then allow me to discuss spectra without audible note content.

11.1. The note – internal and external spectral focus

Electroacoustic music allows two *note-views*. The first is the traditional view where the pitch of a note is the most important factor and the spectral components are regarded as colouring the note. The spectral components of the note remain largely unheard, or at least ignored because it is the note itself which matters most to the context – the note and its colour are perceptually fused. An alternative view (as permitted, for example, by close recording of an instrumental note), takes the ear inside the note so that spectral components can be heard. Such a change of focus, created by actually moving inside the sound, is common in spectromorphological music. The components are then heard to have a pitch relationship, which for the most part inside the instrumental note will be a harmonic one, with varying weightings among the components of the harmonic series. So a note can be a note alone when viewed externally, or more than a single note when the interior is entered. Opportunities for internal *spectral focus* are common in electroacoustic spectra in general, not just with notes.

11.2. Note collectives – relative and intervallic pitch

When external notes move too quickly for the ear to hear precise pitch-intervals, or are piled up in densities, the note ceases to be perceptually significant as a pitch. The external note may be theoretically present (we actually *know* it is in complex instrumental textures) but perceptually absent. We must therefore differentiate the poles on a continuum between intervallic pitch and relative pitch. In *intervallic pitch* we can hear pitch-intervals, and therefore their relationship to cultural, tonal usage will become important. In *relative pitch* contexts we hear with much less precision the distance between pitches and can no longer hear exact pitches or intervals in spectral space. Instead we are inclined to follow higher-level gestures and motions – *note collectives*. Much electroacoustic music merges intervallic and relative pitch approaches. Judging which approach predominates at a given moment is a problem for the composer (whom we assume has a good ear for pitch). For listeners the borderline between the intervallic and the relative is equally important. Firstly it is not a well-defined border since it is very much influenced by the listener's perceptual skills. Secondly it is important because intervallic pitch, if obviously present, will be the prime focus of attention for most listeners.

The use of the word 'intervallic' in intervallic pitch draws attention to the fact that more than a single pitch is needed for pitch to become perceptually relevant. There are many circumstances in electroacoustic music where pitch is a recognisable attribute of a spectromorphology, but if there is no intervallic relationship with another pitch, the pitch-attribute becomes a background factor, and there may be other qualities of the particular spectromorphology which are contextually more significant. Even with a pitch-drone, the actual pitch (as opposed to the fact that it is high, low, or a stable reference-point, or its motion is textured) is unimportant if intervallic pitch relationships are absent.

11.3. From note to noise

The difference between the note (as an intervallic pitch) and noise is an extremely important spectral distinction, yet this is another border which is difficult to define. For my purposes, noise, as an extreme compared with the note, can be defined in two ways. The first definition is qualitative – non-pitched roughness, granularity or grit. Extrinsically we associate *granular noise* with sea, water textures, wind, static interference, granular friction between rubbed and scraped materials, fracturing materials (e.g. stone), unvoiced vocal consonants, and certain types of breathing and fluid congestion. Therefore a wide range of source bonding is involved, ranging from human utterance, to play with objects, to the environment. This is a rich reservoir for electroacoustic exploration. Granular noise is textured impulses, and need not be dominant in a spectromorphology. For example, it can be a decorative or subordinate strand or trace, or a pocket of added intensity.

The second definition is not distinct from the first, and is concerned with density – a saturated spectral state which cannot be resolved into intervallic or relative pitch. *Saturate noise* can be looked upon as another aspect of some of the sources mentioned above (e.g. sea), but it can also come about through spectral compression, where an area of spectral space is closely packed such that pitch awareness is impossible. In addition it can occur when spectral space becomes filled by the active contours of convoluted and turbulent motions. Thus there are certain accumulative processes which tend towards noise and can be used to create noise.

Noise is relative rather than absolute – it exists because we have a concept of pitch. Intervallic pitch is an absolute – we can perceive and name intervals precisely – whereas noise is a generality and has to be considered spectromorphologically in terms of its motion, texture, and behaviour if we are to be able to describe its riches. On the other hand, noise can occur in narrower or wider bands, and become coloured and resonant so that pitch (either relative or absolute) becomes blended in. Therefore, while intervallic pitch and noise are in one sense extremes, noise can take on a pitch identity, just as pitch can take on noise content. Although noise-based spectromorphologies have been extensively explored in electroacoustic music, their qualities have yet to be more widely appreciated, so dominant is the conditioning of the intervallic pitch heritage. Electroacoustic music, in enabling noise exploration, seeks to embrace the full spectral potential of the wide-open sound world.

11.4. Harmonicity and inharmonicity

While harmonic spectra have a specific intervallic organisation based on the vibrational properties of strings and columns of air, inharmonic spectra do not. The bell and metallic resonances are the usual examples of inharmonicity, and they suitably represent the inharmonic dilemma because inharmonic spectra can be ambiguous in that they can include some intervallic pitches. To be regarded as properly authentic, an inharmonic spectrum cannot be resolved as a single note, and its pitch-components need to be considered relative, not intervallic. As a result, continuous inharmonic spectra have a tendency to disperse into streams.

Inharmonic ambiguity allows spectral change in two directions. Firstly one can move into intervallic and harmonic (tonal) spectra. Secondly, like the spectral compression mentioned in discussing the note, inharmonic saturation – the adding of spectral components – can be a means of moving towards noise. Inharmonicity can therefore occupy a useful

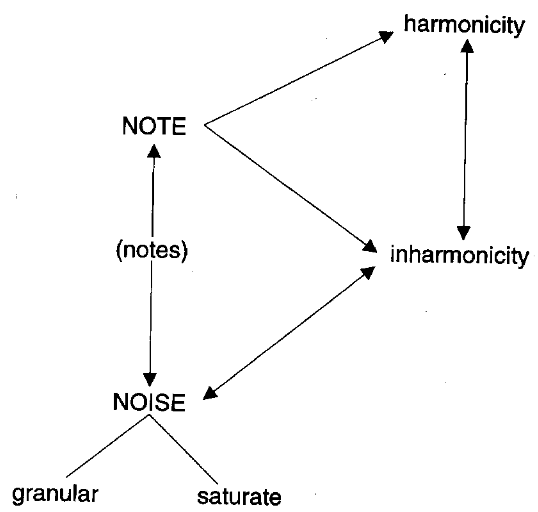

Figure 5. From note to noise.

middle ground which allows movement towards harmonicity and intervallic pitch on the one hand, and noise on the other.

In figure 5, the possibilities of transformation among note, inharmonicity and noise, are set out, along with the possibility for the note (intervallic pitch) to move in the direction of both harmonicity and inharmonicity.

11.5. Spectral space and density

Spectral space covers a distance between the lowest and highest audible sounds. In discussing motion and growth processes it was assumed that spectromorphologies move through spectral space as they change over time, and in discussing the seven characteristic motions, attention was drawn to the rootedness of certain motions and the non-rootedness of others. In other words, certain motions need to occupy spectral space in different ways.

In instrumental music (if we know the instrumentation) and vocal music, we have prior knowledge of the potential spectral space not only of the ensemble but of individual instruments and voices as well, and we have expectations of the use of spectral space relative to the musical style. In electroacoustic music, spectral space boundaries are not known in advance but defined in the course of a work. The occupancy of spectral space, the impression of the space-breadth, how it unfolds, where the highs and lows are located and how they are reached, are directly related to the listener's interpretations of extrinsic factors as well as being strong formal determinants. We need a descriptive vocabulary to help define the *occupancy of spectral space*. Figure 6 shows three basic reference-points. Canopies and roots can be regarded as boundary markers which may have functions. For example, textures can be hung from canopies and use them as goals or departure points, while we already know that the drone can act as a root-reference. Together they frame spectral space, although they do not have to be heard simultaneously to do so. We are used to a central region in music, and even if this is not clearly defined in an electroacoustic work, we are nevertheless aware of where it is. A frame, of course, implies a vacant central region.

The following four qualifiers help further to describe the occupancy of spectral space, whether in part of a work or in the work as a whole:

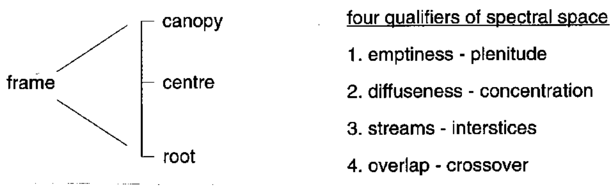

Figure 6. Occupancy of spectral space.

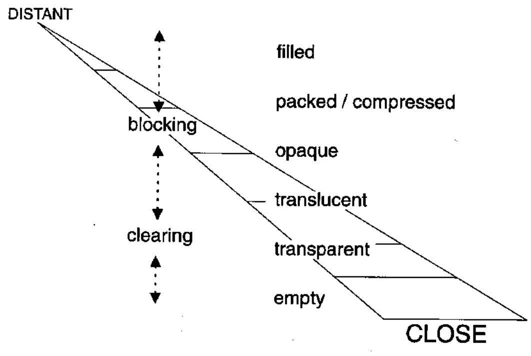

Figure 7. Spectral density.

(1) *Emptiness – plenitude* – whether the space is extensively covered and filled, or whether spectromorphologies occupy smaller areas, creating large gaps, giving an impression of emptiness and perhaps spectral isolation.
(2) *Diffuseness – concentration* – whether sound is spread or dispersed throughout spectral space or whether it is concentrated or fused in regions.
(3) *Streams – interstices* – the layering of spectral space into narrow or broad streams separated by intervening spaces.
(4) *Overlap – crossover* – how streams or spectromorphologies encroach on each other's spectral space, or move around or across each other to another region. This is directly related to motion and growth processes.

Figure 7 defines qualities of *spectral density* which can be imagined as a fog, curtain or wall of broader or narrower spread which allows sounds to penetrate or not. In other words, is the density such that other spectromorphologies, if superimposed, can or cannot stand out in relief? Thus a packed or compressed spectral space is compacted so that is suffocates and blots out other spectromorphologies. A transparent spectral space lets spectromorphologies through, while something in between (translucent, opaque) has a masking effect. Spectral density is related to distance perspective and needs to be considered along with space in general. This perspective aspect is represented by the distant–close continuum in figure 7. For example, a packed density of full spectral range, set in close foreground focus, will prevent other spectromorphologies from getting through because it creates a solid wall very close to the listener. The same density set further back will free space closer to the listener so that it can be occupied by other spectromorphologies. Of course a density need not have a fixed perspective. There are perceptual limits to how much spectromorphological information can occupy spectral and stereo space: high density is the enemy of low-level detail.

12. SPACE AND SPATIOMORPHOLOGY

The concept of spectral space is analogical: higher pitches can be thought of as spatially higher, and lower pitches as lower, but in terms of actual spatial location they are not normally 'physically' higher and lower. One reason for equating spectral height/depth with actual height/depth in electroacoustic music could be to do with the fact that high pitches are regarded as physically smaller and therefore not rooted. Another reason could be that high degrees of spectral mobility are concerned with higher registers (analogy with flight?) which can often be clearly localised compared with the vague, more spread localisation of bass sounds. Anyway, spatial perception combines these two aspects, one analogical, the other actual.

The discussion in this section is concerned with defining a grammar of localisation. Spectromorphological changes – in spectral space and density, in dynamic level, in motion and growth processes – in themselves imply spatial settings and motions, and these implications can be developed by the composer. As well as enhancing the character and impact of spectromorphologies, changes in spatial perspective are a means of delineating musical structure. Real spaces can be simulated faithfully, as is the case if a music is set in a simulated room or hall acoustic. But electroacoustic music is not limited to spatial reality, and the composer can, for example, juxtapose and rupture spaces, an impossible experience in real life. Electroacoustic music can encapsulate a wide range of spatial experience, perhaps even a life-long experience of intimate and immense spaces, both of which can be compressed into the relatively short time-span of a musical work. This makes electroacoustic music a unique art.

Spatial perception is inextricably bound up with spectromorphological content, and most listeners cannot easily appreciate space as an experience in itself. Spatial appreciation can be acquired by consciously listening to the spaces in works as distinct from regarding space only as spectromorphological enhancement. I use the term *spatiomorphology* to highlight this special concentration on exploring spatial properties and spatial change, such that they constitute a different, even separate category of sonic experience. In this case spectromorphology becomes the medium through which space can be explored and experienced. Space, heard through spectromorphology, becomes a new type of 'source' bonding.

Both the grammatical details and the psychological messages of spatial apprehension are unstable because they depend not only on space as composed, but on the relationship between the composed space and the space(s) in which listening takes place. This is the first major distinction shown in figure 8, where the double-headed arrow shows the interdependence of the *composed space* (the space as composed on to recorded media), and the *listening space* (the space in which the composed space is heard). Listening spaces themselves comprise two categories which are distinguished by the different position of the listener relative to the radiating sound sources (loudspeakers). In personal listening the listener is close to the sources of a frontal image, while in public contexts the listener could be in any one of a variety of distant or off-centre positions relative to a frontal reference-image. Furthermore, diffused space (where a multi-speaker system is used) permits a radical, expansive, multidirectional reorientation of the (composed stereo) space. Both the personal listening space and diffused listening space are open to widespread abuse which undermines spatial perception. In personal spaces, loudspeakers and listener are often casually positioned without thought for stereo imaging needs, while successfully diffused space is a complex combination of loudspeaker types, placements, and the art of diffusion itself.

I have identified five, basic, *personal/diffused space variants* which can be drastically affected, or changed for better or worse, according to listening space conditions and diffusion style. Listeners can only become really aware of the variants if they have had an opportunity to compare perceptions of the same work under different listening conditions, not a possibility which is commonly available.

The composed space itself can be divided into two categories. *Internal space* occurs when a spectromorphology itself seems to enclose a space. Resonances internal to objects (hollow wooden resonance, metallic resonance, stringed instrument pizzicato resonance, etc.) can give the impression that their vibrations are enclosed by some kind of solid material. Internal space is therefore source bonded in that one needs this sense of an actual or imagined sounding body.

External space (figure 9) is much more significant than internal space because there can be no music without it, whereas a sense of internal space need not exist at all in a work. External space, which is made apparent to us through reflections, exists outside and around spectromorphologies – outdoor/open spaces or indoor/enclosed spaces which provide settings for spectromorphological activity. External spaces are perspectival, and in the case of frontal stereo, the analogy with linear perspective vision can be striking: in looking through the 'stereo window' between the loudspeakers, the listener can apprehend spaces much broader than the real, space-breadth between the speakers, spaces which stretch beyond the confines of the listening space's actual depth. A sense of spatial intimacy occurs when spectromorphologies seem to act close to the listener as if inhabiting the same space

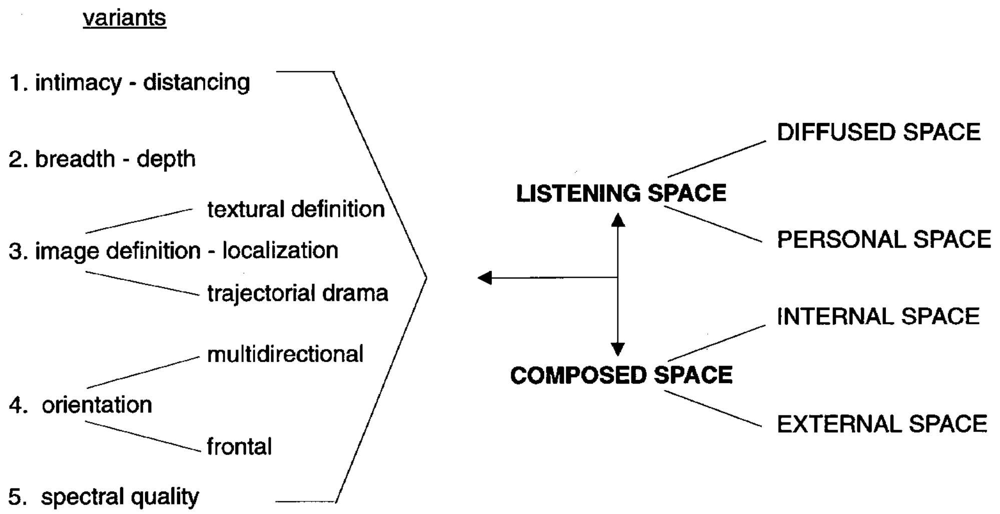

Figure 8. Composed and listening spaces.

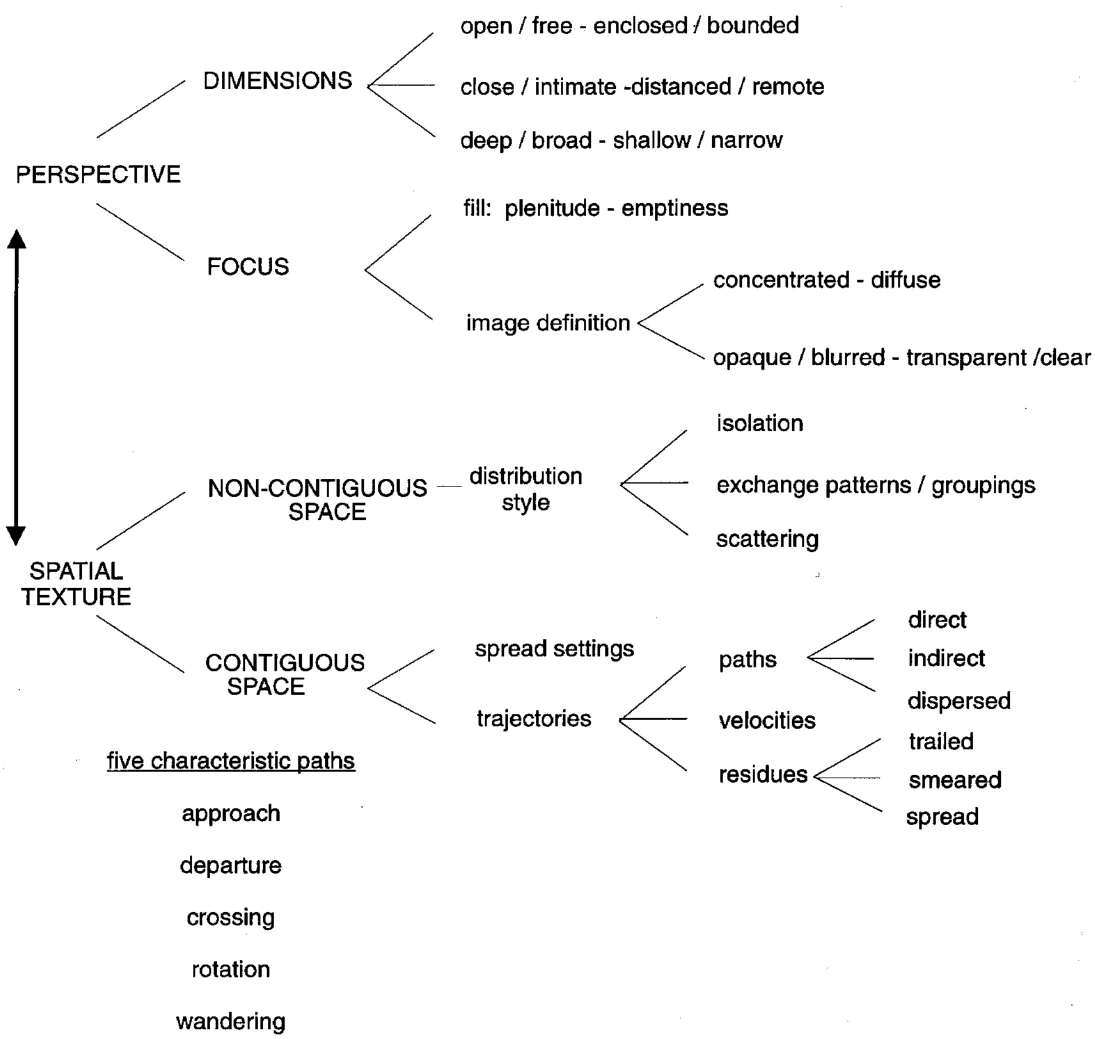

Figure 9. External space.

as the listener. (Such intimacy is easily lost in diffused listening space.)

Image definition can be elaborated in two sets of variants. Opacity and transparency have already been mentioned in discussing spectral density. Here they are repeated as attributes of spatial *focus*, but are also extended by the idea of spatially blurred or clear images – whether the occupancy of space is clearly defined or not. We should note that a distant image could be blurred or clear, as could a close image. The second variant related to image definition is concentrated/diffuse focus – whether the listener's attention focuses on a small (central) area of space or on diverse activity spread through space. This, in turn, is linked to the idea of *spatial fill* – how sparsely or densely populated the space is.

Spatial texture is concerned with how the spatial perspective is revealed through time. This is a question of *contiguity*. Space is contiguous when revealed, for example, in continuous motion through space (such as in a left–right gestural sweep), or when a spectromorphology occupies a spread setting (without spatial gaps). *Non-contiguous space* is revealed when spectromorphologies are presented in different spatial locations such that two successive events are not considered near neighbours: there is no sense that a spectromorphology occupies or moves through adjoining sectors of space. The distinction between contiguity and non-contiguity is not necessarily clear-cut. Imagine a very active, ongoing, rough texture, presented across the breadth of stereo space in many scratchy point-sources of varying intensity. These point-sources are presented non-contiguously so that attention may be drawn to any part of the horizontal space where a particular scratch stands out in relief. Thus the attentive ear (eye) darts among non-contiguous positions. Yet, taken over a sufficiently long duration, the individual non-contiguous points of this texture, perceived as a whole, cover a contiguous space. Thus this space is non-contiguously erratic at a low level but contiguous at a higher level, a characteristic spatial behaviour for active textures. Contiguity therefore differs according to the structural level considered, and is determined by the type of spectromorphology and the degree of *continuity* over time. The *distribution style* of non-contiguous space can vary between the presentation of isolated spatial points, and scatterings over smaller or larger areas. Distribution patterns may emerge as a result of recurrences of the same spatial positions or repetitions of sets of locations. For example, left–right exchange patterns are very common.

Contiguous space can be represented by a spectromorphology which is spread over an area, but gestural trajectories are particularly characteristic. They can follow direct (linear) or indirect *paths* (direction changes, or varieties of curvilinear trajectory), and even subdivide and disperse in multiple directions. Their velocity will vary according to the desired energetic profile of the trajectory relative to the distance to be covered, and will be very closely linked to changes in spectral energy. Five basic paths representing the simple breadth/depth directionalities are listed – approach, departure, crossing, rotation, and wandering. A trajectory is not necessarily a concentrated point-source. As the head or bulk of a gesture moves through space it can leave residues behind. Trajectories can therefore leave trails, can be smeared across space or be spread in a more egalitarian way through space. It may be that the establishing of a residue is part of a transformation of a gesture into a spread setting – the spread setting is introduced by a trajectory.

Finally, here are some guidelines to help define the global *spatial style* in a work as a whole:

(1) *Single spatial setting*. The single setting has two aspects. A work can be set in a single type of space of which the listener is aware at the outset. On the other hand, different aspects of a space can be revealed over time. Spatial awareness is cumulative, and the listener eventually realises that there is a global spatial topology into which the whole work fits. For example, the extremes of proximity and distance are unlikely to be known until the work has advanced somewhat.
(2) *Multiple spatial settings*. Throughout the work, the listener is aware of different types of space which cannot be resolved into a single setting.
(3) *Spatial simultaneity*. Imagine a very present granular texture directly in front of you as if actually within your listening space, while in the distance a door closes in a large reverberant space. You are aware of simultaneous spaces.
(4) *Implied spatial simultaneity*. Implied simultaneity occurs when the listener remains aware of the existence of a space in its absence. This can occur, for example, when contrasting spaces are intercut and alternated (spatial interpolation), giving the impression of simultaneity even though the spaces are presented successively. This is related to film, where in spite of the cutting between successive events, they are considered concurrent.
(5) *Spatial passage*. Passage between spaces can be sudden (*interrupted passage*), repeatedly intercut (*interpolated passage*), or more gradually merged (*graduated passage*).
(6) *Spatial equilibrium*. What is the relative balance between types of perspective and spatial texture in the work? Is one type of space emphasised more than another? Are there alternations or reciprocal exchanges between spaces?

13. FINAL REMARKS

Spectromorphology is concerned with perceiving and thinking in terms of spectral energies and shapes in space, their behaviour, their motion and growth processes, and their relative functions in a musical context. Although the detail of spectromorphological description may sometimes not be easy to follow, particularly without an extensive experience of electroacoustic music repertory, it is far from being an esoteric activity. Spectromorphological thinking is basic and easily understood in principle because it is founded on experience of sounding and non-sounding phenomena outside music, a knowledge everyone has – there is a strong extrinsic–intrinsic link. In this sense spectromorphology derives from a common, shared, natural base which provides a framework for the individual, cultural works of electroacoustic music. Discovering and defining the natural link is important for composer–listener communication because new musical 'languages' (if such a thing is really possible) or significant shifts in language are not created in a vacuum, but must have some shared natural-cultural basis if they are to make sense to listeners. No rationale or theory has to be worked out in advance of language shifts, but ultimately the workings of any 'new' language must be explicable. As a result, not only can we help explain how and why electroacoustic music is as it is, but we can also have a means of articulating problems when we react badly to a particular work (and there are plenty of electroacoustic works which are unrewarding). This is all the more important for a music which is so closely allied to a means of production – computers and technology – whose role is mysterious and unknowable to most listeners, particularly since traditional, instrumental and vocal gesture are often absent or not immediately apparent. Spectromorphology, therefore, in starting from a decoding of perception, is an attempt to make collective sense of a wide range of individual electroacoustic musics created since the birth of the medium in the 1950s.

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