Frequency structure in electroacoustic music: ideology, function and perception

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This paper explores the relationship between how we use and theorise frequency as musicians and how frequency is perceived by listeners within the technological and ideological context of electroacoustic music. With reference to work in perception, music theory and aesthetics, it is argued that thinking about frequency is still dominated by the idea of music's abstract significance. It is suggested that although electroacoustic music presents a challenge to such ideology, this challenge is not reflected in current musical research, leading to a peculiar dislocation between practice and theory. In conclusion, it is proposed that studying the ways in which frequency structure contributes to meaning might provide a better understanding of the production and perception of electroacoustic music than studying frequency structure in itself.

1. INTRODUCTION

The frequency domain is a rich source of information for listeners, a domain in which composers may not only create 'abstract' structures, but directly specify events and objects, despite the increasingly disembodied nature of much current musical activity. Such a suggestion is, of course, nothing new to more narratively minded composers (e.g. Norman 1994), those that talk of 'telling tales', or 'landscape' (Wishart 1986) or the perception of sound sources, however generalised or 'surrogate' these might be (e.g. Smalley 1986, 1992, 1994, Ten Hoopen 1994). However, there is a temptation to consider the practice of electroacoustic music, and responses to it, according to the commonplace opposition of terms such as 'abstract' and 'concrete', or even to proscribe and 'reduce' listening such that only the 'abstract' remains the proper domain of composition (Schaeffer 1966). I have elsewhere suggested that the relationship between the self-referential, 'syntactical' aspects of music, and its representational or mimetic aspects, is a dialectical one, and that our efforts to ignore the tendency of our own ears to ascribe or attribute sources are motivated by a partial and traditionalist view of musical history and aesthetics (Windsor 1995). Even amongst supporters of a less 'autonomous' view of music there is still a residual belief that structures are either musical (pitch, rhythm, timbre) or *extra-musical*. According to this view, music may signify outside of itself, but it does so through its structure, which is primary and implicitly superior to any meaning that the music might have.

In electroacoustic music, which has constantly played a dangerous game with the relationship between internal musical significance and representational, or re-presentational modes of discourse, it becomes hard to maintain a distinction between the two. If we hear two sounds and perceive their sources then such a perception may not only dominate the story they might tell, but also provide the motivation for perceiving them as structurally connected within the piece. For example, hearing the sound of a valve being opened prior to the sound of steam escaping may not only be primarily informative about some potential external world, but could also be interpreted as motivating a connection *within* an acousmatic piece. Likewise, it is reasonable to assert (*a la* Smalley 1986) that types of causation can be a prime force in structuring a piece regardless of their narrative exploitation on the part of listener or composer. This tendency for extrinsic significance of sounds to engender intrinsic structural connections is not however confined to the use of found sounds in electroacoustic music. Musical sounds, whether made up from pitches or timbral configurations, originate in the environment with which we are familiar, an environment which is undeniably musical. The so-called self-referential nature of music signification, whether asserted by the most up-to-date of semiologists (e.g. Monelle 1992: 58) or the most reactionary of aestheticians (e.g. Scruton 1983), is in fact mediated by the real music that we hear and play. The musical significance of any sound rests upon our familiarity with the musical environment to which our perceptual systems have become attuned. We can choose to ignore the mediate nature of 'musical' structures, but to do so artificially polarises the 'everyday' and the 'musical'. Such a polarised view of sonic material can lead to either a belief that only traditional musical structures or their analogues will do (e.g. Lerdahl 1988), or conversely, a polemic rejection of such structures (e.g. Wishart 1985) and their domination of musical discourse. Accepting that musical and everyday sounds are merely labels for

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how we *use* or *hear* sounds rather than epistemological categories allows for a rather more flexible approach: it is not sound material alone which determines this, but our approach to it, and the context in which it is placed.

2. FREQUENCY AS STRUCTURED INFORMATION

Stating that frequency can be viewed as a structured form of auditory information *about* the world (see Gibson 1966, Gaver 1993) does not at first seem so revolutionary. Obviously, when we hear sounds, they may inform us about events or objects in the environment. Consider, however, the concentration amongst acousticians, psychologists and musical researchers upon harmonic complex tones, upon pitch and timbre, and compare this with the rare attempts of researchers to consider the structure of inharmonic, noisy, real world sounds. Since Helmholtz (and before him, Pythagorus) the sounds of musical instruments and the human voice have been the objects of scientific scrutiny to such an extent that our ability to recognise and act upon everyday sounds (which are rarely so 'orderly') has always been regarded as a side-show (see Gaver 1993). Experimental psychology itself is often more concerned with behaviour in controlled and impoverished environments, and our responses to controlled and impoverished stimuli, than in how we get along in the real environment (Gibson 1966). This approach to auditory perception suits those who wish to study instrumental and vocal music, but seems a curious starting point for research which might benefit the larger acoustic palette of the electroacoustic composer. Timbre and pitch perception are studied by psychologists, theorists and psychoacousticians as if the discrete pitches and (largely) harmonic spectra of Western music were still largely the matter of music, rather than the ever-expanding sound resources which are actually employed in both 'popular' and 'high culture' musical traditions. The approaches of Krumhansl (1983) or Lerdahl and Jackendoff (1983) to pitch structure, and attempts to extend such work to timbral structure (e.g. Wessel 1979, Lerdahl 1987, McAdams and Cunibile 1992) are curiously tangential to the practice of contemporary music, just as is the concentration of rhythm research upon the metrical and segmentational structures of tonal music.

It is one thing, of course, to perform a critique of the efforts of others, another to offer an alternative perspective. If one views frequency as a source of potentially rich information about the environment, then a rather different attitude to its structure might emerge. Rather than concerning ourselves about whether pitches or timbres have, in themselves, convincing or interesting relationships, we might begin to consider whether attention to the *significance* of different frequency configurations might be appropriate. Such significance might derive from a sound's relationship to a particular existing musical system (such as tonality), a property of the human auditory system (such as roughness), a mathematically interesting property (see, for example, the work of Shepard 1982 or Balzano 1980), or to the predictable physical properties of everyday environment (see Repp 1987, Freed 1990, Gaver 1993). None of these relationships is abstract, and all are constrained in some way, whether by cultural convention (in the case of tonality) or some more concrete constraint (such as the properties of the lower auditory system). This is not just a call for more attention to the perceptual results of compositional procedures: electroacoustic composers are most often the least guilty of ignoring the aural. Rather it is a call for more attention amongst theorists and technicians to acknowledge the fact that frequency is more than just 'number', that it is used and manipulated to create meaning through human agency. Moreover, as will have hopefully become clear, it is not a call for electroacoustic musicians to listen to theorists, especially those concerned with perception, since their concerns may be as much to do with maintaining a musical status quo which seems largely anachronistic. Much 'music psychology' is in fact dominated by an ideology which is scientistic and conservative, rather than scientific and radical.

3. FREQUENCY, FUNCTION AND PERCEPTION

At this stage it is important to return to the sounds of electroacoustic music itself and consider where technological and ideological forces might be leading us in terms of frequency structures, and to what end. Obviously, frequency is used in many ways by composers of electroacoustic music, and it is useful at this point to distinguish between two ways in which one might consider such a variety of approaches. Following Delalande (1986) one can make an analytical distinction between functional and perceptual concerns, and attempt to consider (a) how a piece functions, or how it is made, and (b) how a piece might be perceived. The way in which a piece is made may well have an effect upon how it is heard, but the relationship between the two is often unpredictable. For example, does knowing that a particular souce sound was used have any bearing upon what is heard after that source is manipulated to conceal its original provenance? What then are the forces which impinge upon (a) the electroacoustic composer and (b) the listener and, perhaps more importantly, what might this tell us about the relationship between listeners' and composers' worlds?

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4. COMPOSITION, TECHNOLOGY AND IDEOLOGY

Firstly then, what kinds of forces are at play in the realm of electroacoustic composition, and how do they influence our attitudes to frequency manipulation? From the earliest days of electronic and tape music two tendencies can be clearly observed: (a) the desire to control frequency at a finer-grained level and with more accuracy, and (b) to expand the available spectral palette. The conflict between these two desires still operates today and can be seen in the huge numbers of methods of synthesis and sound manipulation, and the correspondingly huge numbers of environments within which frequency may be controlled. The paradox here is, of course, that the ever-expanding palette implies ever-expanding complexity to be controlled, leaving practitioners in a state of continual confusion as to how they might balance these twin desires. Add to this paradox the commercial and educational dominance of MIDI, which satisfies neither desire, and one can begin to understand the frustrations of many composers. In fact, I would argue that such paradoxical desires will always remain unsatisfied: indeed they provide much of electroacoustic and computer music's motive force. It is often observed that the solution of technological problems has become the dominant area of composition with electroacoustic media, but one must remember that technical concerns have always dominated and stimulated compositional activity: did not J. S. Bach respond to new tuning systems with as much vigour as we now display in our attempts to grapple with new methods of sound manipulation and synthesis?

Another interesting factor at play is the attempts of those working in the empirical sciences to influence compositional approaches to pitch and timbre, often by collapsing the two categories into similar 'parameters' which might be structured in pseudo-tonal ways: Wessel's 'timbre space' (Wessel 1979) and Lerdahl's 'timbral hierarchies' (Lerdahl 1987) are but two examples. Such attempts on the one hand assume that data collected from conventional instrumental timbres might lead to scales and transpositions in timbre, and on the other, that timbre should be constrained such that it can be organised within hierarchies familiar to any student of tonal organisation. It is no surprise that many composers try to stop thinking about pitch and timbre at all, and that many turn to the organisation of auditory surroundings for clues as to how to organise their sound material. This seems to happen in two ways: through spatial analogies, through more direct appeal to the causation or apparent causation of sounds (see Smalley 1986) or through using sound for narrative ends and hence avoiding the issue of frequency organisation as a problem in itself. It may also help to explain why simply focusing upon a particular mathematical model (such as 'fractals') or upon the idiosyncrasies of a particular composition system or synthesis tool may be a more valid alternative to more empirically grounded exploration than those who damn the 'coldness' of computer music might have us believe. Relying upon abstract models, or conversely upon the ear, may prove rather more productive than attempting to derive any inspiration from current empirical work on frequency, which merely restates the constraints of the tonal conception of musical structure in a new form.

6. LISTENING AND THE STRUCTURED ENVIRONMENT

Turning now to the listener (of course, composers are also listeners), the consideration of how frequency structure is perceived looms large in the light of the collapse of the lattice-like (Wishart 1985) discretisation of frequency. If we are no longer dealing with the twelve-fold division of the octave into discrete pitches, and not only wish to structure our music using a continuum of pitch but also wish to exploit the full range of both harmonic and inharmonic complex tones, then what will the perceptual results be? Again, turning to current perceptual work we find little of help: timbral research, as we have seen, does little to escape from instrumental notions of timbre, and work on pitch structure rarely leaves the domain of standard western tunings. However, listeners do make sense of the least conventionally structured electroacoustic works, and I would argue that they do so in two ways, and that these two ways reflect general properties of human perception. First, listeners interpret sounds in terms of known environmental sources, be these 'musical' or 'everyday'. This is not just a case of listeners *imposing* structure upon their auditory surroundings: a mutual relationship exists between listener and environment such that acoustic structures, whether temporal or frequency based, may specify certain excitatory sources, or more general provenance, and the listener explores these acoustic structures in such a way as to construct a meaningful interpretation based upon this information. Listening to music is a search for meaning, and this search is constrained by our familiarity with the physical and cultural invariances of the world. In the case of much electroacoustic music, unfamiliar juxtapositions of familiar and identifiable events may be perceived, or *vice versa*, familiar sounding structurings of material using surprising sonic material. In such cases the listener is faced with an acoustic scene which may partly specify the familiar, yet also contradict the familiar, creating an interpretative tension

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which, it could be argued, is required for all aesthetic phenomena.

To give a concrete example from the domain of frequency invariances, it is known that listeners tend to categorise hand-claps according to their frequency structure, in a manner that can be predicted by the physical relationship between manner of clapping and the acoustic result: palm-to-palm has a 'darker' spectrum than palm-to-fingertip. Certain aspects of the frequency structure are invariant given a particular style of clapping, whereas others may change without affecting our perception of this style. Given, however, only such acoustic information, listeners can do more than just attribute style of clapping to such spectral change, they are quite willing to attempt to identify the gender of the clapper. Such, however, is not specified by spectral information alone, since women and men may choose to clap in many different styles other than those regarded as archetypically gender-specific (Repp 1987). The listeners are making a best guess, albeit encouraged in this case by the researcher, and such best guesses, part-based upon the predictability of the natural environment, part-based upon the predictability of our cultural environment, may nonetheless be rather creative. Even when we hear music which aims toward self-referentiality through the avoidance of either familiar environmental sounds (whether recorded or synthesised) or familiar musical sounds, such music is perceived within the broader context of all we have heard and expect to hear. Electronic music, to many listeners, merely sounds electronic, just as to most people, high art music merely sounds classical. This is no criticism of current or past musical practice, but reveals the source-oriented nature of almost all our listening: it is vitally important to us where our music originates, whether on the level of individual sounds or whole compositions. People may buy music because they like its sound, but they are at least as likely to do so because it originates from a source with which they feel familiar and comfortable. If aesthetic value has anything at all to do with mediating between merely copying or reproducing what already exists (mimesis) and interpreting or reordering the existing (rationality) (Adorno 1984), then technology gives us the means to either widen the gulf between these two polarities, or find new ways of mediating them.

The second way in which listeners 'make sense' of frequency structure is through the context within which such structure is embedded. This context takes two forms, either existing within the acoustic structure of the work, or within the work's surroundings. This of course is nothing new: pitch events have always been mediated by both cultural forces and their position in relation to other pitch events and to their rhythmic organisation. The common use of the third (especially the minor third), rather than the fourth, as the next most structurally salient interval after the fifth relation, cannot be explained by acoustics and psychoacoustics alone (Parncutt 1989). Moreover, in tonal music the *relationships* between pitch events are all important, both thought of in terms of their hierarchical organisation within a particular piece and their hierarchical organisation within the system of tonality itself (see, for example, Krumhansl 1983, Lerdahl and Jackendoff 1983). Electroacoustic music opens up this contextuality: frequency structure may be heard as pitch, in relation to existing systems of organisation with which we are familiar, or as a more complex attribute, which is heard in relation to a wider set of human, animal, mechanical or natural sound sources. Moreover, within a piece, we are pushed one way or the other by the juxtapositions of sounds. Speech sounds, for example, could be organised into a familiar sequence of fundamental frequencies, encouraging us to hear them as a melody, or as a sequence of linguistically meaningful speech events, encouraging us to hear them as talking. They could be organised in such a way as to combine them, through cross-synthesis or juxtaposition, with other sounds, encouraging us to think of them in relation to other sounds and their possible meanings, or their spectral structure could be accentuated or altered to produce 'harmonic' progressions or to focus our attention upon their non-speech-like qualities. Their provenance might be concealed, or they might in fact be simulacra: we might hear a virtual source other than speech despite the source material, or hear speech where none exists.

7. TWO KINDS OF AUDITORY INFORMATION

Of course, music prides itself on going beyond the 'real', and although I am suspicious of the abstract nature of musical meaning as ideology, it must be stressed that all music plays an interesting and dialectical game between reality and the imagination. Gibson, whose theory of perception (Gibson 1966, 1979) always attempted to find explanation for meaning 'out there' before looking inwards at the workings of the mind, contrasted two kinds of information, or rather two ways of looking at, or in this case, listening to information provided by the world. The first kind, which he regarded as most common, and essential for survival, is information which has a mutual relationship with action: we hear a sound and perceive it in terms of how we should act towards it. He encapsulated this kind of information and the relationship with the world which it implies within the concept of the *affordance*. When we perceive in this way we use acoustic structure to perceive events and objects that afford us with particular courses of action. For example, we use acoustic information

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from a car engine to regulate our use of the car's gears. Such affordances are not fixed, but change with context: for example, for a car mechanic, the sounds of a faulty engine afford actions which the layperson might not be able to perceive or act upon (Gaver 1993). In musical terms this kind of information can be extended to include all the pragmatic connections we have with music: who is playing and where; what kind of music is it; do I leave or stay; should I stay and applaud or leave in disgust; what should I say about this music? Music literally affords writing and discourse, it demands engagement, or it repels: the information for our actions, whether originating within the acoustic signal, or within our broader surroundings as part of culture, is perceived in terms of action, not as an abstract phenomenon.

The second kind of information Gibson identifies he terms 'information as such': this kind of information is perceived for its own sake, as 'sensation' and is relished without assessment of pragmatic value. Timbre as colour, relished for its beauty, but not for its use as a parameter, comes into this category. This is not the timbre of Schoenberg (1973: 421), out of which structure is manufactured analogously to pitch and harmony, or the timbre of Wessel (1979), but may be closer to Schaeffer's conception of reduced listening (Schaeffer 1966) in which we are exhorted to listen without concern for cause or system. However, unlike Schaeffer, I do not believe that it is practical to do more than touch upon such disinterested and qualitative listening for fleeting moments, undisturbed by the relationship sounds normally maintain with ourselves and our surroundings. Rather, it is much more likely that sound's embedding within the environment dominates our listening, and that such sensory beauty must be disentangled from this pervasive contextuality.

8. CONCLUSIONS

In conclusion, sounds are intimately tied to action, whether natural, human or artefactual. Frequency structure is directly related to vibration, but more particularly to the vibration of particular objects, in response to the application of energy. By manipulating acoustic structures we may obscure or lie about the sources of sound, but it is hard to escape the human propensity to search for meaning in relation to the known environment, whether such meaning is 'musical' or 'everyday'. This essay is not, however, a blueprint for any approach to listening or composition above any other. Rather it aims to open up our view of the frequency domain beyond the mathematical, acoustical or psychological models which we have, and to consider again the relationship between sounds, events and actions. Music is a human product, and as such is the result of action, despite the tendency in contemporary cultural theory to downplay the relevance of the author or composer to interpretation. Conversely, music is also the subject of perception, and the listener may attribute meanings completely unpredicted by the creator of a musical work. Between these two human sources of meaning exists acoustic structure, and the exploration of such structure must surely exist at the heart of music-making, whether such exploration exploits the known or manipulates it. The frequency domain is already rich in meaning for both listeners and composers, and perhaps our future research, as listeners, composers and scholars might focus more upon how frequency structure may be exploited to create meaning, rather than upon frequency structure in itself.

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