

Multi-channel formats in electroacoustic composition: Acoustic space as a carrier of musical structure

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Abstract—The purpose of this paper is to examine and compare multi-channel compositional practices in the scope of electroacoustic music and discuss arising issues regarding compositional methodology, rationale, performance and dissemination of multi-channel works with examples drawn from the author's compositional output. The paper describes principal theories of musical space and draws parallels between those and compositional practices whilst discussing the articulation of acoustic space as another expressive dimension in the musical language with reference to specific multi-channel formats.

I. SPACE IN TIME

The arrangement of music constituent elements in space has always been an element of musical practice, from antiphonal singing to instrument grouping and positioning on stage in the orchestral tradition. However audiences, and to some extent performers and composers, remain unaware of space as an element of musical expression. Since there is spatial information in every musical experience, acoustic space seems to be taken for granted and does not usually challenge auditory perception during the listening process unless it is dramatically articulated and/or is integral to structural processes.

The idea of using acoustic space for musical purposes pre-dates electroacoustic music practice by at least a few centuries. The earliest published evidence of intentional organisation of acoustic space dates from the mid-16th century. Adrian Willaert the *maestro di cappella* of St. Mark's Basilica in Venice positioned small choirs in opposite galleries in the church. These choirs were used to sing in succession alternate musical phrases. This technique of polychoral spatialisation develops further the notion of antiphony: a practice that appears in the early Christian church and carries on in the Renaissance and the Baroque era. This technique, known as *corri spezzati*, brings together compositional technique and organization of acoustic space.

Following the shift from contrapuntal polyphony to homophonic textures, and harmonised melodic lines in western art music, spatial organisation of sound sources gradually disappears from the compositional agenda as practitioners concentrate their attention to develop a more elaborate tonal language and the art of orchestration. During this time the musical argument develops exclusively to the frontal perspective, independent of notions of space. Evidently, spatial perception is present in any acoustic experience but in this case, it is independent of any musical considerations and only subject

to room acoustics and the relative position of the listener to sound sources. The notable exception during this time is a large number of works that make use of acoustic space to create a theatrical effect. Again in this case there is no evidence of a relationship between musical structure and the positioning of sound in space.

Spatial articulation returns to the foreground of compositional deliberation with the invention of recording technology, proclaimed as the single most significant event in twentieth century musical development [3]. In the new approaches to compositional practice, that emerged as a result of this technological development, the musical work is created and exists in a fixed medium and is mediated by the loudspeaker. In the early 1950's the first performances of *Musique Concrete* in Paris and John Cage's project *Music for Magnetic Tape* in the US were making use of the first multi-channel systems for the projection of music to an audience in concert conditions. These systems consisted of different configurations of sets of mono tape recorder, amplifier and single speaker. Through these sets, arranged around the audience in circular formations, the work was taking form in the listening space as the sum of a number of discrete audio channels. To the author's knowledge, there is not enough evidence to suggest that the speaker formations used during the performances of the works were mirrored in the studio during the compositional process. Regardless of this fact, it is clear that from an early stage multi-channel sound projection becomes integral to the performance practice of early electroacoustic music, suggesting issues of compositional methodology.

Stockhausen's *Gesang de Junglinge*, from 1955 – 56, is widely considered to be the first multi-channel work. Here the acoustic spatial cues were considered alongside the rest of the organised parameters of the work and are fixed on a five channel format. Although compositional intention regarding spatial organisation is demonstrated in this work there is some discrepancy regarding the composer's original plan and the way the work was presented during performance. Stockhausen's original idea was for the fifth channel to be projected by a speaker suspended above the audience but contemporary descriptions of the work refer to it as a multi-channel work for five speaker groups positioned around the audience and the first performance featured a panoramic arrangement of speakers in the frontal perspective [12].

Following *Gesang de Junglinge*, Stockhausen's next multi-

channel composition *Kontakte* in 1960 makes use of a four-channel arrangement. Around that time, four discretely composed channels are used in works from Luciano Berio, Luigi Nono and Milton Babbitt. Although a standardised practice begins to emerge with the use of four channels, quadraphonic projection arrangements in space vary from Front, Left, Right and Back in Stockhausen's work, to square, where speakers are positioned to all four corners of the listening space, in other composer's work and in commercial applications.

Following the developments in two channel stereophonic sound and the commercial failure of the Quadraphonic format in the 70's, composers of electroacoustic music find sanctuary in the stereo format. New stereo technologies allow control over spatial positioning and spatial trajectories over a frontal perspective within a standardised format with universal specification and widespread appeal.

The requirement to communicate the acoustic space of the work to a number of listeners larger than the stereo image "sweet spot" can accommodate when presenting electroacoustic works in stereo format in large performance spaces gave rise to sound diffusion, the performance practice of electroacoustic music. Sound diffusion fulfils the demand of analogous enlargement of the spatial cues in the stereo field, to avoid loss of spatial detail in large halls [4]. This is achieved by mapping the two channels of stereo to a number of pairs of speakers positioned strategically in the performance space. The performer can control the amplitude of the original stereo signal that arrives to combinations of those pairs. At this stage in the history of electroacoustic music it is evident that preserving the spatial particulars of the composition is essential to perception of musical argument. Accessibility on detailed control over this aspect of sound attributed temporal shaping of spatial parameters to be of equal structural importance to the shaping of timbre, pitch, amplitude and duration, contributing towards a complete syntax and vocabulary in order to communicate effectively musical structures. Although the performance practice of sound diffusion answered some of the questions posed by the problematic of presenting stereo works in large spaces, it has not entirely unravelled the challenge of spatial sound control. This lies mainly in the limitations of stereo, the imposing expansion of diffusion systems, to the extent where the control by one performer is a very ambitious endeavour, and mistaken or arbitrary interpretation of spatial cues in the music by the performer. Nonetheless, the experience of sound diffusion raised practitioners awareness of the use of space by bringing to the foreground its structural function and potential.

II. MULTI-CHANNEL FORMATS

Since the mid 90's a growing number of electroacoustic music practitioners have shifted towards a compositional practice that makes use of more than two discrete channels either by composing exclusively for multi-channel formats or embracing this practice in some of their compositional output. During that time, and in many cases today, eight discrete channels appeared to be the most popular choice of format

as it allowed much more detailed spatial control than the stereo and quadraphonic formats and was supported by digital hardware for recording and playback, i.e. A-DAT, DTRS and so on. Octaphonic systems appeared to amply accommodate the requirements of spatial articulation in electroacoustic composition and proved effective when it came to presenting the works in concert halls, as they retained more detail of the space composed in the studio. The configuration of the speakers in the space followed on from the practices of sound diffusion. The absence of a standardised format in diffusion system setups, different conventions applied to different groups with practices varying not only globally but even nationally, reflected on the octaphonic approach.

The Birmingham Electroacoustic Sound Theatre diffusion system was based on a minimum of four pairs of speakers: The main stereo pair, the wide pair that supported a wider frontal perspective, the rear pair positioned at the back of the hall and the distant pair positioned behind the main pair and angled inwards [8]. The system overall constituted by a large number of speakers, varying on occasion, but the main eight described above were regarded as the fundamental backbone. Consequently, the octaphonic works that came out of the Birmingham studios used that configuration in contrast with octaphonic works from other UK institutions that used an eight in a circle configuration, still employing the main wide and rear pairs of the BEAST system but using the remaining two channels for a pair on the side of the audience. Across the Atlantic an octaphonic circle could mean something different again: speakers positioned successively at 45° degrees starting with a speaker directly in the front of the audience. Such discrepancies in octaphonic practice, combined with the absence of a standardised format for recording and playback, proved the dissemination of multi-channel works problematic.

Recent years have seen the publication and broadcasting of electroacoustic multi-channel works in the 5.1 surround format on commercially produced media such as the DVD-Audio and Super Audio Compact Disk. New works have been composed specifically for that format and composers have been re-mixing octaphonic multi-channel works for 5.1. The use of 5.1 has not been without problems. A number of issues arose, as this format was developed to accommodate the particular needs of the film industry and not those of electroacoustic composition. The absence of speakers at either side of the listening position resulted in a compromised representation of the image in that particular area. This not only makes it very difficult to accurately position sounds to the sides but also disturbs the continuity of material that is moving from the front to the back of the space. Although not unduly problematic in the case of standard 5.1 arrays in small spaces, this particular problem becomes evident in performance spaces where the array has to cover a larger area and the distance between the front and the back speakers is greater. It is the author's experience that issues concerning the presentation of 5.1 electroacoustic works in concert could be addressed by mapping tactically the 6 channels of the 5.1 format to the diffusion system and utilise diffusion techniques during performance to adjust the

image accordingly.

III. THEORIES OF MUSICAL SPACE

Following the developments in sound diffusion and compositional output in multi-channel formats, electroacoustic music researchers investigate sound spatial movement and positioning as musical phenomenon and significant portions of the literature are dedicated to this subject. Trevor Wishart [11] suggests that we may look on spatial articulation to emphasise or even create relationships between different sonic events.

...spatial motion of one sound-object might relate to the spatial motion of others and thus build up a concept of counterpoint of spatial gestures.[11]

Denis Smalley describes acoustic space considered and implemented by the composer as composed space and identifies spatial imaging as a way to enhance inherent sound properties and their dynamic temporal shaping. He goes on to suggest how this is applicable to the notions of gesture and texture, the primary distinction between the different characters of the elements that constitute structure in electroacoustic composition.

...gesture can be more vividly dramatised through spatial displacement, just as texture can be 'environmental' through spatial distribution.[9]

Furthermore, Smalley asserts spatial articulation as a determinant of spectromorphology of sound objects. This is clearly demonstrated in [11] the example of the sound of a fly as a case where a spatial motion is essential to a recognisable sound morphology. Following on from this, one could argue that spatial trajectory or spatial positioning could determine audiences' perception of character and consequently structural function of the sound object, i.e. a granular sound object distributed across all the speakers of a multi channel system with a stable amplitude would be perceived as a texture, demonstrating internal behaviour without indicating direction, recycling the same energy. The same sound object articulating a spatial trajectory would exhibit application of energy with intent and indicate direction, all of which characterise a gesture.

Harrison [3] proposes a slightly different approach to space in electroacoustic composition which originates in the acoustic ethos of partnership between composer and material. He suggests the consideration of four factors:

- 1) Intrinsic musical space that has an effect on all spatial considerations (spectral, temporal, dynamic and spatial).
- 2) Notion of placement (compositional or listening).
- 3) Environment (space on the field recording).
- 4) Realisation (public performance).

A basic model of musical spaces proposed by Henriksen [5] attempts to unify the theories mentioned above and to create a hierarchy of musical space comprised of three levels:

- 1) On the highest level is the listener's interpretation of the musical space of the composition as experienced in the listening situation. This is what I call perceived space.

- 2) On the middle level there are spatial characteristics of the musical composition itself - the composed space.
- 3) On the lowest level are spatial characteristics of the individual sounds that make up the composition. These characteristics are discussed as intrinsic space, spectral space, and extrinsic space.

Multi-channel formats provide the means for more accurate control over the first two layers mentioned above, and the opportunity to underline intrinsic, spectral, and extrinsic space of sound objects. The command over broad spatial motion and immersive acoustic spaces accommodates structural relationships not only between spatial profiles of different sound objects but also by emphasising or generating dynamic spectromorphology and character of individual structural elements. Multi-channel compositional practice can contribute to a unification of structure, behaviour and character in search of a complete syntax and vocabulary to communicate effectively organic musical structures.

IV. COMPOSITIONAL METHODOLOGY

The following examples taken from the author's work *Atropos*, will try to demonstrate compositional thinking in multi-channel formats. The work was composed using the industry standard 5.1 configuration. Figure 1 is a spectrogram of the first few seconds of *Atropos*. Only five channels are presented here. The Low Frequency Effects channel, which deals with frequencies at the bottom end of the summed spectrum of the remaining five, is omitted as it displays minimal localisation. The signal of the Central speaker is positioned in the middle of the graph, followed by the Left and Right channels above and below it respectively. The Surround Left and Surround Right channels follow to the top and bottom of the graph. The same principles apply to the rest of the graphs throughout this section. The work opens with a strong gesture, which stems

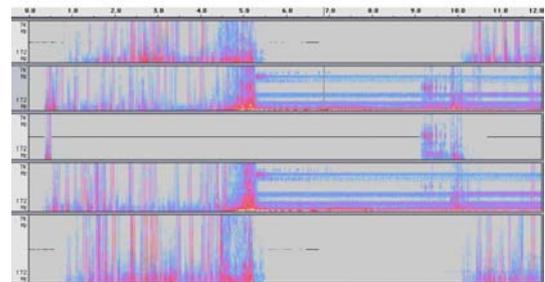


Fig. 1. *Atropos*, 0 to 12 sec, spectrogram

from the central speaker and grows rapidly to establish the composed space. The material initially moves left and right from the centre to articulate a wide frontal perspective, before moving swiftly across the performance space and to the back speakers of the array, covering all 360° degrees around the audience, before it returns emphatically to the front of the listening space. The main motif of the work and the space

within which the piece is composed is presented in the first few seconds. The sound material featuring in this gesture has been selected circumspectly due to a predominately high frequency content, and its granular nature. Contrary to sounds with only low frequency content, material that displays energy in the upper part of the spectrum, with a combination of short percussive attack, is easily localised. The granular disposition in this particular instance facilitates clear articulation of spatial trajectories as omni present short attacks continuously redefine the sound's position. This example displays Smalley's notion of vivid dramatisation [10] and the idea of spatial articulation as a determinant of character and structural function. The same sound material fixed in space would not in any case accommodate the same musical argument. The end of the first gesture instigates a sparse texture in the frontal perspective followed by a gesture similar to the opening, which this time stems from behind the audience (variation in space). The two structural elements here, gesture and texture, are initially spatially separated and display contrary spatial behaviour, spatial displacement and immobility respectively. This motif, and its variations, appear throughout the work, displaying similar spatial behaviour, to signify key structural points and articulate and frame the space.

The next example comes from approximately half way through the piece. A rich resonant texture is framing impalpable gestural behaviour, a paradigm of Smalley's 'environmental' texture distributed in space (Figure 2). Here



Fig. 2. Atropos, 6min01sec to 6min06sec, spectrogram

the intention was to create an enveloping ambience. Notice that distinct areas of the spectrum are assigned to different loudspeakers. Timbre is constructed in space. This is a very different listening experience to the projection of the sum of these formants from all five speakers in the system.

Figure 3 demonstrates the case of different lines of spectrally similar or identical material in a contrapuntal arrangement. Only two stereo pairs are used in this example. The central speaker has been omitted to retain a clear frontal stereophonic image mirroring the speaker arrangements on the rear of the listening space. The second stereo pair in this case allows voice separation, meaningful space articulation and with a combination of reverberation and filtering techniques, makes available additional layers of counterpoint. This section displays a strong notion of placement and makes use of the intrinsic musical space. Again, percussive sounds with

high frequency content are employed, as localisation of the material is integral to the musical argument. This is a case

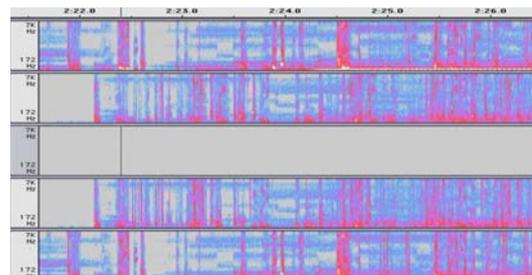


Fig. 3. Atropos, 2min22sec to 2min27sec, spectrogram

where a multi-channel format allows subtle relationships to be exploited. To achieve such structural associations in stereo format one would have to use highly contrasting material to avoid two or more lines being perceptually merged and perceived as a single auditory stream [2].

V. SUMMARY

Articulation of acoustic space can and has been used as one more expressive dimension of the musical language. As a result of new techniques and technologies, the temporal shaping of spatial parameters can be of equal structural substance to the shaping of timbre, pitch, amplitude and duration, contributing towards a musical technique that embraces the totality of musical means [1].

REFERENCES

- [1] Adorno, T., "Musik und Technique", *Gravesaner Blatter*, 4, pp. 11-12, 1958
- [2] Bregman A., "Auditory Scene Analysis: The Perceptual Organisation of Sound", MIT Press, Cambridge, 1990
- [3] Harrison, J., "Imaginary Space - Spaces in the imagination Australasian Computer Music Conference Keynote Adress", *EContact!*, 3(2), 1999
- [4] Harrison, J., "Diffusion - Theories and Practices, with Particular Reference to the BEAST System", *EContact*, 2(4), 1999
- [5] Henriksen, "Space in Electroacoustic Music: Composition Performance and Perception of Musical Space", Doctoral thesis, City University, 2002
- [6] Manning, P., "Electronic & Computer Music", Oxford University Press, Oxford, 1993
- [7] Manning, P., "The significance of techne in understanding the art and practice of electroacoustic composition", *Organised Sound*, 11(1), pp. 81-90, 2006
- [8] Mooney, J., "Sound Diffusion Systems for the Live Performance of Electroacoustic Music", Doctoral thesis, The University of Sheffield, 2005
- [9] Smalley, D., "L'Espace du Son II", Special Edition of *Lien: revue d'esthétique musicale*, Ohain: Editions Musique et Recherches, 1991
- [10] Smalley, D., "Spectro-Morphology and Structuring Processes", In Emmerson, S. [Ed.] *The Language of Electroacoustic Music*, Macmillan Press, London, pp. 61-93, 1986
- [11] Wishart, T., "On Sonic Art", Harwood Academic, Amsterdam, 1996
- [12] Zvonar, R., "A History of spatial music", *EContact!*, 7(4) (CEC), 1999