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Sound Spatialisation, Free Improvisation and Ambiguity

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Abstract—**This paper documents emergent practice led research that brings together live sound spatialisation and free improvisation with digital tools in a performance context. An experimental performance is described in which two musicians – a turntablist and a laptop performer – improvised, with the results being spatialised via multiple loudspeakers by a third performer using the Resound spatialisation system. This paper focuses on the spatial element of the performance and its implications, its technical realisation and some aesthetic observations centring on the notion of 'ambiguity' in free improvisation. An analysis raises numerous research questions, which feed into a discussion of subsequent, current and future work.**

I. INTRODUCTION

The aim of this research is to explore the use of the multi-loudspeaker sound spatialisation system as an instrument in free improvisation. As a starting point, the authors staged an experimental performance, a video of which is available online [1]. The performance raised issues relating to ambiguity in musical performance, as well as technical and aesthetic issues pertaining to the practice of sound spatialisation itself. The purpose of this paper is to document the performance, summarise observations and pose research questions, preparing the ground for further research.

II. BACKGROUND

A. Sound Spatialisation

In electroacoustic music, sound spatialisation - often referred to as 'sound diffusion' in this context - describes the act of presenting music from CD, audio file, or other fixed medium, to an audience via multiple loudspeakers. The performer controls the distribution of sound among the loudspeakers by way of a diffusion system, often based around an audio mixing desk. As a simple example stereo sound from CD might be spatialised via four pairs of loudspeakers, with one mixing desk fader controlling the level of each loudspeaker. Bespoke systems have been developed by many institutions specialising in electroacoustic music (see refs. [2] through [11]).

In general, sound diffusion practice is applied in the performance of predetermined music, either from fixed medium and/or from a score; in either case the sequence of sonic events is essentially known in advance. It is more rare for this kind of practice to be applied in the context of free improvisation.

B. Free Improvisation and Ambiguity

The outcome of a free improvisation is not known prior to any given performance. The expression 'ambiguity,' broadly, refers to the unknown, and to the experience of 'not knowing,' in a musical context. Similarly, when one hears a sound, one might know (be able to identify) its source, or one might not know, in which case there is an ambiguity. More broadly, in the context of a musical performance one might know what is going to happen next, or one might not know. Furthermore, what is ambiguous for an audience member may not be so for a performer, or *vice versa*. Clearly ambiguity is at work on many different levels within freely-improvised performance, and fostering it can become a creative strategy and catalyst for extended musical dialogues. For Gaver, Beaver and Benford ambiguity 'is a resource for design that can be used to encourage close personal relationships to systems' [12]. Unintentional sounds ('Where did that come from?') can also elicit unforeseen responses as performers evaluate, interpret, and feedback into the situation.

Through the utilisation of electronic technologies the legibility of gesture is often obscured: there may be no direct correlation between input gesture and output sound; the relationship between the two is ambiguous. However, connections may appear legible through exaggerated theatrics. This is particularly evident in DJ practice, where allowing pre-recorded sounds to play unmediated as opposed to physically intervening in them is inherent, and selection and performance are coterminous. A comparable scenario exists in sound diffusion, where 'fixed' compositions are played without any physical sound-generating process on the part of the performer. Used in free improvisation, the selective use of pre-recorded materials can be employed as a means to probe, provoke and generate creative response, at the same time problematising the conventional wisdom that 'music-making skill paradigmatically requires the immediate causal intervention of the player' [13]. Ambiguity is discussed further in [14]. As we shall see, use of the sound spatialisation system as an instrument in a free improvisation engages with these issues of ambiguity on various levels.

III. DEAD DIALOGUES: AN EXPERIMENTAL PERFORMANCE

An experimental performance entitled *Dead Dialogues* was staged at Culture Lab, Newcastle University on 10th March 2008 [15]. Two improvisers – a turntablist and
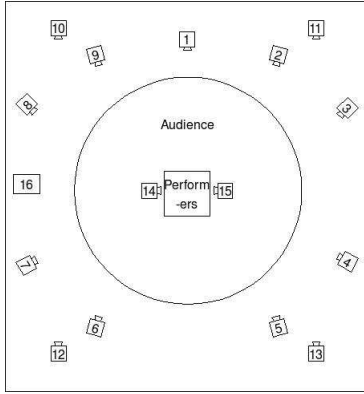
Fig. 1. Venue schematic of *Dead Dialogues* performance.

Fig. 2. Diagram of the MIDI controller interface used to control spatialisation.

Control Label	Stereo Source Channels		
	Left	Right	
A	Mexican wave amplitude		Mapping to loudspeakers
q	Mexican wave frequency		
C	6,7,8,9	2,3,4,5	
a	1	1	
b	14	15	
c	9	2	
i	8	7	
j	3	4	
k	6	5	
r	16	16	
s	10,12	11,13	

Fig. 3. Partial scheme for the mapping of interface controls and source-to-loudspeaker routings. 'Mexican Wave' refers to a semi-automated spatialisation behaviour; see [**?**].

a laptop performer – play with a third performer – the *spatialist* – operating the spatialisation system. The sounds generated by the turntablist and laptop performer are spatialised independently in real time by the sound spatialist; however, the spatialist cannot directly generate sound. Conversely, the turntablist and laptop performer are able to select their own sonic materials but have no direct control over the spatialisation. The three performers were located at the centre of the performance space with audience members, facing inwards, surrounding them on all sides, as illustrated in Figure 1.

A. Loudspeaker Array

An array of sixteen loudspeakers was deployed. This comprised nine Genelec 8050A loudspeakers (numbered 1 to 9 in Figure 1), two smaller Genelec 8040A loudspeakers (numbered 14 and 15) positioned on either side of the central performance area pointing inwards, four EAW NT26 PA cabinets (10 to 13) suspended from rigging around 3 metres above floor level, and a single subwoofer (16). The suspended PA cabinets were angled to point straight forwards rather than downwards towards the audience, providing a greater sense of height. Photographs of the setup are available online [16].

B. Spatialisation System

Sound was spatialised using Resound, a real-time, multi-channel, multi-loudspeaker spatialisation system based on freeware open-source software. Briefly, Resound allows the user to control an audio mix matrix using a MIDI or OSC control interface. Matrix nodes can be controlled individually or in groups, with multiple assignments being summed additively or subtractively by the Resound software. In this way, any input channel can be mixed to any loudspeaker in real time, the mapping of matrix nodes to controls having been defined in advance by the user. The system itself is described more fully elsewhere [3][17][18].

The spatialisation was controlled using a Waveidea Bitstream 3x MIDI controller. Eight faders plus twenty-four of the rotary controls were used during the improvised performance. Figure 2 shows the MIDI controller interface schematically, while Figure 3 exemplifies how
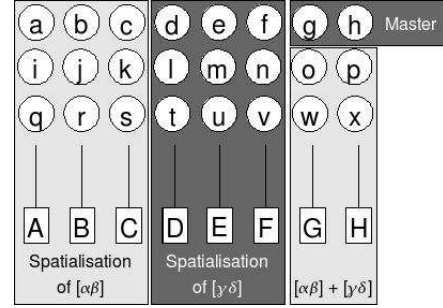
the interface was configured to spatialise the two stereo sound sources independently among various loudspeaker sets within the array. For example, rotary control *c* (referring to Figure 2) controls the level of a stereo source spatialised to loudspeakers 9 and 2 (referring to Figure 1). Control *s* would spatialise the left channel to loudspeakers 10 and 12 and the right channel to 11 and 13. Referring to Figure 2 it can be seen that the first bank of three faders and rotary controls was used to control the spatialisation of the live electronics as explained in detail in Figure 3. The next bank of three provided exactly the same functionality for the stereo feed generated by the turntablist. The final bank of controls treated the total four source channels as a single source.

IV. RESEARCH QUESTIONS

Following the performance, and against the background described previously, two emergent research strands are apparent, one focusing on musical issues from an aesthetic, experiential, interpretative or philosophical perspective, the other concerning technique, human-computer interaction and design. Two broad research questions are as follows.

●What can be learned from the use of sound spatialisation as an active instrument in free improvisation? How does the delegation of spatialisation to a third performer impact on the way the performance is experienced by players and audience? What role does ambiguity have to play?

●What HCI demands does the free improvisation scenario place upon the spatialisation system? How can

these issues be addressed through software and hardware design?

V. SOME PRELIMINARY OBSERVATIONS

A. From the Spatialist's Perspective

As both the laptop performer and the turntablist use prerecorded materials, with the laptop performer often sampling and processing the turntablist, the true origin of each sonic event becomes unclear. From the spatialist's perspective, it was sometimes difficult to differentiate between sounds originating from the turntables, and those resulting from the live electronics processing (once again, 'Where did that come from?'). The spatialist and the audience can only rely on the gestures of the other musicians to establish (and perhaps misconstrue) sound sources in the piece. Legibility of gesture, and its relationship to human-computer interaction, will be discussed again later.

Furthermore, the dexterity and concentration required to simultaneously spatialise two independent sources was found to be challenging, indicating considerable scope for virtuosity with practice. This raises important issues of interface ergonomics and HCI. In practice, pauses in the sonic texture gave time for shifts in spatial imaging to be prepared.

Due to the improvised nature of the performance, the spatialist has no instructions regarding compositional intent of how a sound should be spatialised. As Denis Smalley notes [19], many sounds imply space and movement anyway. The spatialist has to choose whether to embrace or challenge this, as well as ascertaining whether the different sound sources may be in conflict or unity, and how this should influence the spatialisation.

B. From the Improvisers' Perspective

The spatialist was able to determine the final presentation of the sounds to both the improvisers and the audience. Levels of ambiguity became apparent through surround spatialisation as the improvisers could not anticipate the spatial origin of the sounds. The immediacy of the spatialisation meant the improvisers were instantly enveloped by their own gestures, heightening and extending aural and spacial awareness.

Ultimately, sound spatialisation addresses issues relating to the way an improviser constructs musical meaning. If we accept listening as not merely a passive exposure to sensory phenomena, but an active process of constructing meaning, then it becomes clear that the spatial profile of a sound will affect how that meaning is constructed. Much of our listening and capacity for signification of sounds is mediated by bodily and spatial metaphors, as improviser and theorist David Borgo notes, asserting that 'Our musical vocabularies are in fact filled with embodied metaphors: pitches are high or low; sounds are close or distant; textures are dense or sparse' [20]. The spatialisation system was able to exploit this, continuously altering the timbral characteristics of the sounds, shaping the course of the improvisation as it affected the way in which the turntablist and the laptop performer listened

to the sounds they produced, and the way in which the audience listened to the improvisation. Unity or conflict between the improvisers was made explicit through discrete placement and inter-manipulation of their separate stereo feeds.

VI. RECENT PERFORMANCES

A. Vreemdeling: A Performance with Joystick Control

Composer Robert van Heumen has recently completed a two week residency with the Resound system, using a SuperCollider patch to spatialise his stereophonic electroacoustic work *Vreemdeling* in a performance that took place at Culture Lab on 13th June 2008. Three simultaneous stereophonic layers were spatialised using a joystick controller, with SuperCollider performing the intermediate logic between the joystick and the Resound client application [21].

B. A Second Turntables and Electronics Trio

A second improvisation with turntables, electronics and spatialist was presented as part of the same performance. The same physical interface – the MIDI controller described previously – was used for spatialisation, but the configuration was rather different. More semi-automated behaviours were used following recent developments to the Resound system. This, along with the use of different materials by the sounding musicians, resulted in an altogether different dynamic during the improvisation.

VII. FUTURE WORK

Clearly there is scope for further exploration of the broad research questions posed earlier, particularly in light of the subsequent performances just described. This final section describes, in no specific order, some future considerations.

Very brief feedback has been given from the perspective of the performers. This could certainly be elaborated. Further empirical research into how multiple sources can be independently spatialised would be useful, as would a deeper analysis of the interaction between sounding musicians and the spatialist. It would be useful also to gather feedback from audience members.

From the HCI perspective, a fuller discussion of, and further experimentation with the control mapping of source-channel-to-loudspeaker combinations would clearly be beneficial as this would have a significant impact on the logistics of performance from the spatialist's perspective.

In terms of sound spatialisation as an instrument, a review of how the use of the Resound system in particular differs from other approaches to live, improvised sound spatialisation will be helpful. Specifically, a study comparing the present approach to the perhaps more common scenario in which electronic performers control their own spatialisation directly, will be worthwhile. This point will be particularly useful in comparing the improvisation trio performances – where the spatialist is an independent musician – and the performance of *Vreemdeling*, where the composer is in full control. There is clearly also

a discussion surrounding the difference between fixed medium and strictly live performance.

Further exploration of the possibilities offered up by alternative control interfaces is also warranted. New interface technologies such as sensor based instruments open up the possibility of developing a control surface which offers a legibility of gesture, providing intuitive links between the movements of the spatialist and the way in which the sound is manipulated, and allowing for dexterous control of the sound sources. The use of multi-touch table-top interfaces in musical applications is already subject to investigation [22].

The audience and the other musicians may construct musical meaning through an understanding of the performative aspects of the improvisation, and perceiving a connection between the physical movements of the performer and the sounds produced, or the way in which sounds are manipulated. This semiotic dimension of movement during a performance is a common concern of musicians developing 'virtual' instruments. Suguru Goto, who developed the SuperPolm MIDI violin, refers to researcher Claude Cadoz who suggested semiotic gesture as a possible category of gesture, describing 'gestural behaviours that function to make others know: the gestures that produce an informative message destined for the environment' [23]. In developing an instrument for spatialisation, it may be desirable to dramatically relate gestures to the movement of sounds, enabling sweeping arms to craft sweeping pans, or it may be that such obvious relations would place the theatre of the movements over the manipulation of the sounds. It thus remains a significant point of interest to investigate the effectiveness of different types of control interface with the Resound system in the context of free improvisations.

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