The Extended Stereo Speaker Configuration as an Individual Spatial Experience

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ABSTRACT

Creating engaging spatial experiences for listeners of electroacoustic music can come in a variety of forms. While much of the work carried out in the field builds upon utilization of a greater number of loudspeakers and diffusion networks, this paper presents an 'extended stereo speaker configuration' comprised of simultaneous use of headphones and speakers. Through discrete development, treatment, and control of proximate (headphones) and distal (speakers) sonic material, this configuration allows for, and encourages the manipulation of the listener's perception of space. In this way, the work presented in this paper transforms a utilitarian aspect of electroacoustic music production into an aesthetic and compositional one.

1. BACKGROUND

The advent of multichannel configurations has provided sound artists and researchers with new abilities to develop various spatial aesthetics and to replicate real world spatial dynamics. The introduction of stereophonic sound by Alan Blumlein allowed for the coupling of the movement on the screen to movement of sound in film production [1]. As the stereo format became popular, other multichannel configurations were also devised, with quadraphonic and octophonic arrangements appearing in the 1950s, used primarily in compositional contexts, in works such as Stockhausen's *Kontakte* (1958-60), or Cage's *Williams Mix* (1953).

In addition to the new multichannel systems that were developed for audio in film (e.g. 5.1, 7.1, and Dolby Atmos), many other approaches to multichannel spatialized sound exist within the culture of acousmatic and electroacoustic music. In the case of conventional octophonic or quadraphonic arrays, multiple speakers are placed equidistant from the optimum listening position, or 'the sweet spot'. The focus on the sweet spot also exists within circular/spherical 3-dimensional arrays such as John Coulter's Sound Dome [2]. In fact, being positioned at the sweet spot within multichannel configurations is key to the reception of many works. Certain composers such as John Cousins would allow their works to be experienced only at the sweet spot, or within the confines of their personal setup [3].

Configurations such as University of Birmingham's BEAST [4] or the Sonic Laboratory at Queen's University Belfast allow for multichannel diffusion across a very large number of loudspeakers, intended for use in live performance situations. Other approaches include multichannel output systems such as wavefield synthesis, which, through a large array of speakers, create a virtual acoustic environment. More contemporary novel approaches to sound spatialization include Bridget Johnson's *speaker.motion* [5], which bypasses the need for a sweet spot through the use of rotating speakers, or Bernhard Leitner's work *Gallery of Mirrors* [6] which is comprised of a non-centralized multi-speaker array of parabolic dishes projecting sound towards mirrors.

Experiencing such multichannel works in an intimate and individualized setting would be unlikely for general audiences. Even in shared or group scenarios such as live performance, the likelihood of being situated at the sweet spot to fully receive the work as intended by the composer is low[1]. Additional to that issue, spatial audio systems are often expensive and inaccessible to those outside of academic institutions. While projects such as Klangdom [7] have made efforts to address these problems through developing new apparatuses, the 'extended stereo speaker configuration' presented in this paper is an effort to tackle the issue at a more accessible level, and from an experimental and creative angle.

The following sections discuss the specifications of the configuration, as well as the acousmatic compositions developed for this system, and the unique ways in which they explore the concept of spatial sound. This paper will also discuss how this simple but novel approach can lead to more widely accessible modes of spatial audio experience.

2. EXTENDED STEREO SPEAKER CONFIGURATION

Developed by the first author, the 'extended stereo speaker configuration' is a four channel system where the listener wears a pair of headphones, and is situated between a pair of speakers (one on each side of the listener, at ear level, 1-1.2 metres apart from the ear[2] - see Figure 1).

[1] It is important to acknowledge that, while it is common to do so, not all composers necessarily adhere to the notion of a sweet spot.

[2] At 1-1.2 metres, the delay between material coming out of the headphones and material coming out of the speakers is 2.9-3.5 ms. At this

The input signals for the headphones and speakers are sourced with a stereo signal, and can be manipulated individually in terms of amplitude. The speakers are set at 180 degrees apart in order to prevent phantom imaging[3] [9]. In this way, the speaker outputs are perceived as individual mono signals that act as extensions of the corresponding headphone signal, creating an augmented spatial experience. The setup was initially realized using a pair of Genelec 8040B speakers, and a pair of Audio Technica M50x headphones[4].

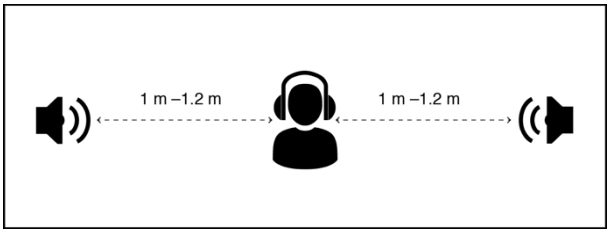

Figure 1. Diagram of the extended stereo speaker configuration. © 2018 Jesse Austin-Stewart

The proximity of the headphones' signal allows the composer (or listener) to explore space within the binaural field. The outer, more distant speakers then extend this sound field. As the listener puts the headphones on, the contextual setting suggests a focus on the headphones' signal and the attenuation of the sonic activity occurring in the room [10]. However, through careful configuration of the relationship between the headphones and speaker signals in terms of compositional and sonic material, it is possible to create a variety of interesting perceptual effects. Therefore, while the extended stereo speaker configuration creates an isolated experience of multichannel sonic material, the augmented auditory field allows for the manipulation of the listener's understanding of space and spatial sound. In this way, the work is, to some respect, a sonic equivalent for experiencing VR imagery.

The next section introduces some of the compositional strategies employed by the first author in the development of a series of acousmatic works that utilize this configuration.

3. WORKS FOR THE CONFIGURATION

The works realized using the extended stereo speaker configuration explore the listener's perception of space through manipulation of the relationship between proximate and distal sound sources (the headphones and speakers). Exploiting various spatio-compositonal strategies, a total of four acousmatic works were developed and presented as a sound installation at play_station gallery[5] (Wellington, New Zealand) in May/June 2018. These strategies are briefly outlined below in the descriptions of the four works.

speed, the delay between the two outputs (headphones and speakers), due to the minimal distance, is unnoticeable [8].

[3] Phantom imaging is where two or more loudspeakers suggest that a sound is physically in between the loudspeakers by varying the amplitude of a sound.

[4] The relative amplitude levels of the headphones and speakers are set by the composer upon setting the configuration up, in an empirical manner.

[5] Video documentation available at <https://vimeo.com/300611352>

Figure 2. Photo taken at play_station gallery, Wellington, New Zealand. © 2018 Jesse Austin-Stewart

5.1 *Modulating Space*

According to Natasha Barrett, "a primitive reverberation effect can provide the illusion of a spatial enclosure, particularly if other spatial factors such as filtering and amplitude relationships between source and reverberant field confirm our perceptual decision" [11]. She argues that even though "we know the illusion does not *exactly* resemble a real-world image, [we] nevertheless accept the information as a good enough approximation" [11].

With this in mind, *Modulating Space* uses the spatial separation of the headphones and speakers as a way to vary the perceived size of the room in which the listener is located. The work uses identical material in the headphones and speakers, with the headphones' signal being dry (non-reverberated) and the speakers' signal fully wet (reverberated). The perceived size of the space then depends on the length of the reverb which varies over the course of the composition.

5.2 *Perception of Ambience*

This piece aims to use the contextual experience of headphone listening to subvert the listener's expectations. It operates on the premise that a headphone listening context suggests to the listener to attenuate the sonic activity taking place outside of the headphones [10]. However, the sonic material running through the loudspeakers is comprised of ambient environmental noise. This environmental noise emanates from the speakers, while more conventionally composed 'musical' material is fed to the headphones. The amplitude relationship of the two signals varies over time, changing from subliminal to liminal, altering the listener's sense of space and surroundings.

5.3 *Localising Sound: Sustain/Transients*

The third work in the series explores inherent localization characteristics of different sonic material. In a study Rakerd and Hartmann note that "impulsive tones were localized quite accurately… while the slow-onset tones were localized poorly as to reach the upper limit of our ability to measure the localization error" [12]. They claim that "a steady-state sound field of a sine tone does not provide useful localization in a room… [unless] it has an onset transient." [12]. This extends some of Hartmann's previous research where he claimed that "it is impossible to

localize a steady low frequency sine tone in a room… [and] the localization of steady noise can be significantly degraded by increasing reverberation" [13].

Building upon these findings, this work uses the extended stereo speaker configuration to examine the relationship between sustained and transient material and the abilities of sound localization of the audience. This is accomplished through using a combination of short bursts and sustained samples of sine tones and filtered noise.

5.4 *Localising Sound: Low/High*

Similarly, *Localising Sound: Low/High*, focuses on a specific type of sonic material. Here, instead of using sounds with differing amplitude envelopes and onsets, variations in the frequency domain is the employed technique.

As Barrett points out, "our aural perception can locate higher frequencies and texturally varying material more easily than lower frequencies and static material, the intrinsic nature of sound will play an important part in the composer's choice of material" [11]. Accordingly, this piece revolves around spatial relationship between low and high frequency material.

4. ALBUM

Eric Lyon argues that, due to lack of access to satisfactory spaces and equipment, spatial audio experiences are often inaccessible [14]. Listeners are often required to travel to spaces such as galleries, concert halls, or studios to experience works.

Figure 3. *beyond nearsightedness [album]* cover

In tandem with the creation of the extended stereo speaker configuration, an album (*beyond nearsightedness [album]*) has been created that addresses the issue of inaccessibility of spatial audio[6], primarily with regards to the logistics of multi-channel audio playback. While a collection of new works, the album explores the same spatial ideas and compositional strategies employed in the pieces described above.

Every piece within the album is developed in pairs, for simultaneous playback on a pair of headphones and a pair of loudspeakers. To listen to the work, the listener must play two tracks at the same time: one through their headphones using one device, and one using another device through a speaker pair. This process provides the listener with a degree of compositional agency, as the listener would be in charge of determining the relative gain between the two signals, as well as their temporal relationship and synchronicity.

While the distribution and reception of this series requires two playback devices, a pair of headphones, and a pair of loudspeakers, these requirements – although still more complicated than regular stereo playback – are more easily attainable than a multichannel setup, and more widely accessible to the broader audience and non-practitioners. Therefore, through an alternative approach to spatial composition, this project is an effort to bypass the logistical barriers associated with multi-channel audio.

5. CONCLUSION

The extended stereo speaker configuration is a new and alternative approach for creating an individualized sonic experience with a focus on the spatial qualities of sound. The use of proximate and distal sound sources enables the composer/artist with new creative opportunities.

The collection of works discussed in this paper demonstrate vast creative potentials provided by the extended stereo speaker configuration. While these compositions explore spatio-compositional strategies in a very direct way, there is much room for further development in the application of these strategies.

There is also room for integration of this spatial speaker system, or other similarly designed systems, with other technologies. Use of a system that combines headphones and speakers within VR would allow for more audiovisual spatial opportunities to be explored. Such an approach comes with its own set of complications – particularly when using multiple speakers – and warrants further research.

Lastly, there is much work to be done towards enhancing the accessibility of individualized spatial composition reception and distribution. While taking a step in this direction, the work presented in this article is an early experiment; a working proof of concept which can certainly be built upon.

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