disonancia: An Electroacoustic Music Composition for a Hybrid Audio Diffusion System

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ABSTRACT

This paper explores the application of a Hybrid Audio Diffusion System (HADS) in electroacoustic music composition. Focusing on "disonancia," (dissonance) a piece from the four-part series collectively titled "Inward Voices, Outward Struggles," the study demonstrates how the HADS enhances the listener's auditory experience. This is achieved by integrating egocentric (head-fixed) audio cues delivered through open-back headphones with allocentric (room-fixed) references projected via a speaker array, thereby creating a fully immersive 3D sound environment. By detailing the creative implementation of the HADS and the artistic principles informing its use, this paper illustrates the capacity of 3D audio techniques and hybrid systems offer new avenues for immersive, narrative-driven electroacoustic compositions and soundscapes.

1. INTRODUCTION

Advances in digital technologies have enabled the creation and perception of immersive audio experiences that replicate 3D sound fields through systems such as headphones and speaker arrays. 3D audio techniques can mimic real-world listening, providing listeners with an experience that feels more natural and engaging [1]. Spatial audio capitalizes on auditory cues to anchor the listener within a space, integrating directional and non-directional sound sources with environmental elements such as reverberation to construct a compelling auditory environment [1]. The spatial capabilities of Ambisonics, combined with the personal immediacy of binaural audio, open new compositional pathways, enabling artists to experiment with sound localization, movement, and depth.

This paper explores compositional possibilities by integrating headphones and speaker arrays to create an augmented immersive experience. In this setup, binaural audio is delivered through open-back headphones—allowing speaker sound to bleed through—and represents the egocentric frame, offering a personal and intimate sound experience. Meanwhile, a speaker array utilizing Ambisonic playback creates an expansive, room-centered environment that envelops the listener. Through compositional practice, this paper explains how the HADS framework can expand the sonic palette. By layering sound fields and exploring the interplay of clear and ambiguous localization effects, the project aims to highlight the unique auditory experiences achievable with this hybrid system.

1.1 Artistic Motivation

In Mexico, an average of 10 women are murdered every day due to gender-based violence [2]. These femicides, often reduced to fleeting headlines, represent only one aspect of a broader systemic issue [3]. Beyond the murders lies a web of structural, systemic, and social violence that targets women in multifaceted ways. This violence is rooted in deep misogyny and neglect, where women not only suffer gender-based harm but also face the compounded effects of marginalization within society [4].

In this composition, spatial audio provided a means to engage with gender violence by leveraging the inherently spatial nature of human hearing. Auditory events are always perceived in relation to space, as spatial hearing is fundamental to how we cognitively map environments and emotionally respond to them [5]. Beyond reinforcing a sense of physical presence, spatial audio expands the ways in which we interact with sound, offering new dimensions for communication, collaboration, and creative expression [1]. By treating space as a musical parameter [6], spatial techniques facilitate the construction of immersive sonic environments that shape perception, evoke emotional resonance, and deepen engagement with listening [1]. This interplay between space and sound positions spatial audio as a powerful medium for the artistic exploration of complex social themes.

1.2 The Hybrid Audio Diffusion System (HADS)

The HADS, a system developed by Enrique Mendoza to explore new possibilities in spatial sound diffusion, enhances immersion by integrating open-back headphones and speaker arrays into a unified monitoring system. Grounded in Roberta Klatzky's frames of reference [7], the HADS manipulates sound localization within both egocentric and allocentric sound spheres. This dual spatialization is particularly apparent when the same sound exists in both frames simultaneously, allowing listeners to perceive it in distinct spatial contexts. This approach can be effective for creating hyper-realistic or deliberately disorienting soundscapes, actively engaging the listener's perceptual processing of spatial hearing and playing with their sense of sound localization. A key perceptual factor

in this system is Inside-the-Head Locatedness (IHL), a phenomenon unique to headphone listening, where sounds appear to originate inside or near the listener's head—often considered a failure of externalization in binaural playback [1]. The HADS deliberately embraces IHL, using it as a compositional tool to explore internalized sonic perception while simultaneously achieving externalization through the speaker array.

2. RELATED WORK

Research in spatial audio, immersive systems, and socially engaged art has informed the use of the HADS in *disonancia*, providing conceptual and technical frameworks for employing spatial sound as an instrument of artistic and social critique. Enrique Mendoza employs the HADS in his electroacoustic composition *Inner Outer Self-Variance and My Deranged Disembodied Voices*, which explores the tension between inner and outer perception through the interplay of three sound fields: headphones, a speaker array, and a live acoustic ensemble [8]. The piece immerses the audience in a disorienting blend of verbal and non-verbal auditory hallucinations.

Other works, such as Dora Bartilotti's participatory performance and installation *Voz Pública* [9], focus on the intersection of sound, media, and social commentary. Bartilotti's project integrates electronic textiles, an online platform, and community workshops to create a repository of anonymous testimonies, later vocalized through textiles embedded with micro-speakers. The work bridges historical forms of resistance with contemporary technology in public spaces marked by violence. Teresa Margolles' *Sonidos de la Muerte* [10] is a sound installation that addresses femicides in Ciudad Juárez, Chihuahua, where over 600 women were killed between 1993 and 2011—most of these cases remain unsolved. Using recordings from sites where victims were found, the work confronts audiences with the brutal realities of gender-based violence and exposes impunity. It transforms these auditory traces into a powerful social commentary on the lasting impact of femicides and the erasure of victims' stories.

3. DISONANCIA

3.1 Conceptual Framework

The composition employs the HADS to explore gender-based violence in Mexico. By combining field recordings, digital audio processing, and spatial audio techniques, the piece aims to blur the boundaries between personal experiences of struggle and public narratives. The headphones represent the personal, often silenced and hidden experiences of women, while the speaker array reflects the public sphere, where systemic violence and misogynistic structures are perpetuated. By juxtaposing these mediums, the piece reveals the tension between private pain and public erasure, emphasizing the challenges faced by gendered bodies in a society that simultaneously inflicts and denies these violences. This duality is rooted in the feminist principle that "the personal is political," which connects women's private experiences of exploitation and violence to broader social and political contexts [11]. The composition explores the dissonance experienced by women in Mexico, where systemic violence and its denial coexist. By employing the spatial interplay and contrasting modes of listening enabled by the HADS, the piece immerses listeners in a soundscape that reflects the fracturing impact of misogyny on both individual and collective identities.

3.2 Layering

Mexico City, known as one of Latin America's cultural capitals and a vibrant megalopolis, is also among the most sonorous urban environments in the world [12]. The foundation of *disonancia* lies in a series of site-specific field recordings captured using a Zoom H3-VR microphone. These recordings were made across diverse locations in the city, including public plazas such as *Coyoacán* and *Centro Histórico*, Catholic churches, metro stations, outdoor markets, and natural reserves. This sonic material constitutes the core layer of the composition, grounding it in the city's vibrant auditory identity.

Throughout *disonancia*, layering is achieved by spatially and narratively differentiating materials between the Ambisonic speaker array and the binaural headphone playback. While the speaker array carries public, environmental, and communal soundscapes—such as urban field recordings, church interiors, and market scenes—the headphone layer delivers more private, internalized sonic experiences. These include processed vocalizations, inner monologues, and symbolic gestures, designed to evoke personal reflection or dissociation. This dual presentation enables simultaneous access to both shared and individual auditory spaces, enhancing narrative complexity and emotional depth.

3.3 Creative Implementation of HADS

The composition employs the HADS to spatially distinguish between internal and external auditory domains. In the headphones, a more abstract and fictional soundscape is presented, contrasting with the real-world-like sounds of the speaker array. At times, the same sound appears in both mediums, but with distinct processing in the headphones—such as distortion, pitch shifting, or granulation—creating perceptual tension and encouraging active listening to the spatial and textural divergences between sources. This layering contributes to the conceptual framework of the piece, reinforcing themes of internal conflict and perceptual dissonance.

The HADS also enables nuanced spatial manipulations with effects such as reverb and delay. For example, in one section, the dry signal of a sound is played exclusively through the headphones, while the wet signal is presented in the speaker array. This creates a detached auditory experience, playing with the listener's perception of space and positioning. Conversely, another section reverses this arrangement, with the wet signal in the headphones and the dry signal in the speaker array, producing slightly disorienting soundscapes. Notably, during these moments, audience members were observed removing their headphones, suggesting curiosity about the origin of the sounds and the interaction between the two mediums.

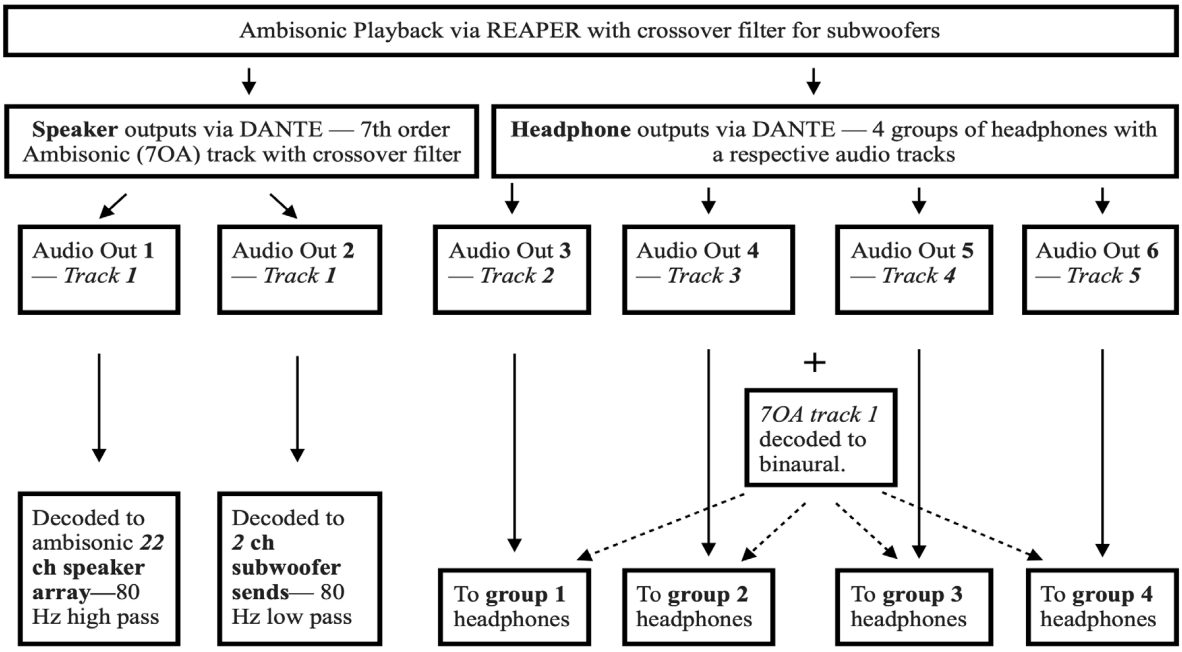

Figure 1. Overview of the HADS routing.

4. TECHNICAL SETUP

The composition was realized in REAPER, [1] chosen for its reliable support of higher-order Ambisonics. The IEM plugin suite [2] was used for managing Ambisonic channels and enabling binaural decoding, allowing flexible monitoring through headphones during the composition process—particularly useful when a full speaker array was not available. The Chip Davis Technology Studio at the University of Michigan SMTD provided the playback environment for the piece, equipped with a 22-speaker Ambisonics array. Audio routing was handled via Dante, [3] a digital audio-over-IP protocol. In this setup, 22 channels were sent to the main speaker array, with two additional channels dedicated to the subwoofers, which isolated low-frequency content from the primary system.

For the headphone component of the HADS, 4 stereo channels (8 total) were routed to Beyerdynamic DT 990 Pro 80-ohm open-back studio headphones, connected through the Aviom D800-DANTE A-Net Distributor. This expanded the system to a total of 32 output channels from a single computer: 22 for the speaker array, 2 for the subwoofers, and 8 for the headphones. Audio routing and channel assignments were configured within REAPER and managed using the Dante Controller software. A detailed overview of this configuration is shown in Figure 1.

5. DISCUSSION

Seated in a circular arrangement of chairs and wearing headphones, the audience experienced *disonancia* in a personal yet communal way, as can be seen in Figure 2. A key feature of the composition is the use of multiple versions, made possible by the individualized nature of headphone playback. Four distinct versions of the piece were created, utilizing the additional tracks (8 channels) outlined in Figure 1. Each version was designed to provide a unique auditory experience, shaped by distinct effects applied to the headphone playback, while maintaining a consistent soundscape in the speaker array. This approach encouraged listeners to reflect on their experience as one variation among many, adding an extra layer of engagement to the work.

Figure 2. Performance of *disonancia*.

The psychological aspect of the listening experience played a crucial role in the artistic discourse. While the intent was not for listeners to experience all four versions, simply knowing of their existence shaped their interaction with the piece. Notably, audience members were observed discussing their individual experiences, comparing the differences between versions, and expressing curiosity about how others perceived the piece. This interaction

[1] https://www.reaper.fm
[2] https://plugins.iem.at
[3] https://www.audinate.com

among audience members contributed a unique form of shared experience. While each listener encountered a distinct auditory version, their conversations revealed a collective engagement with the piece. Informal feedback and discussions among audience members indicated a sense of curiosity and ambiguity. As they attempted to discern which sounds were shared through the speakers and which were unique to the headphones, they expressed uncertainty about the spatial origin of the sounds. This interplay of perception and interpretation highlights how the HADS can serve as an effective medium for presenting immersive works in a nuanced manner.

6. CONCLUSION AND FUTURE WORK

The HADS has demonstrated its potential to expand the sonic palette for electroacoustic composition, highlighting the possibilities of spatial audio not only in applications like VR or AR but also as a creative element in musical composition. By integrating egocentric and allocentric auditory frames, the HADS facilitates novel spatial interactions, offering composers a versatile tool to enrich their sonic vocabulary. Beyond its creative applications in music composition, the HADS also served as a unique medium for the artistic discourse of this piece.

The system's ability to create multiple versions of the composition, coupled with the individuality and privacy of the two playback modes, enabled a deeper exploration of both personal and communal experiences. This approach enhanced the narrative depth of the composition, addressing complex social themes such as gender-based violence. The HADS highlights the importance of spatial considerations in music composition, demonstrating how this approach can enhance immersion and enrich both artistic expression and the listener experience. Binaural rendering of the composition can be found here: `https://myumi.ch/n1Z5g`.

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