

CinematicAmbiX: Cinematic Sound in Virtual Reality

Adam Schwartz

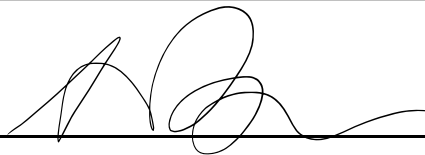
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A handwritten signature in black ink, appearing to read 'Andrew Bernstein', written over a horizontal line.

Andrew Bernstein  
Capstone Advisor

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## ABSTRACT

CinematicAmbiX is a three-movement piece of virtual reality art that is focused on sound for film. I sought to separate trailer sounds, foley, and ambience from their standard visual accompaniment. I chose virtual reality (VR) as a mode of exhibition for its ability to allow me to replace the two-dimensional plane of the cinema screen with the three-dimensional virtual gallery. VR granted me the use of the ambisonic audio format to create an interactive and immersive sonic environment. I was able to spotlight cinematic sound in a format that encouraged audience interaction while maintaining sound as the focus. This is contrary to what Christoph Cox calls, the “hegemony of the visual” through which sound is often overshadowed in visual media. In this writing, I explain how human hearing connects to a film’s soundtrack by investigating the evolution of cinema audio formats and the technologies that drive them.

## INTRODUCTION

The growth and availability of virtual reality (VR) devices, including the essential head-mounted display, has led to a surge in content creation.<sup>1</sup> As a result, the arsenal of tools content creators have at their disposal is making VR development increasingly viable for artists and creators who are not full-time game developers or programmers. While writing this paper I am simultaneously completing an interactive, sonically focused piece of VR art, *CinematicAmbiX*. *CinematicAmbiX* explores sound that an audience is accustomed to hearing synchronized to film. The piece is in three movements that explore sounds for trailers, foley sound effects, and ambient backgrounds. Unity, the game engine in which much of this project was developed, is most thoroughly used by creating custom scripts in the C# programming language. After some research, I found a path that would lead me to my goal of creating sound focused VR work while writing only a minimal amount of code.

In Unity, I created objects that act as audio sources moving in virtual three-dimensional space to separate sounds typically associated with film productions, dissociated from their visual source. The concept of dissociating sounds from their usual source stems from the work of Pierre Schaeffer. Through Schaeffer's concept of acousmatic listening, "we will discover that much of what we thought was heard was in reality only seen, and explicated, through the context".<sup>2</sup> As a practitioner of sound for film, I created *CinematicAmbiX* to give the participant an interactive, immersive experience, aiming to gain them an understanding of some of the sonic

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<sup>1</sup> Smith, Jennifer. "VR Content Creation Market will be growing at a CAGR of 67.0% during the forecast 2019 To 2027" Medium, January 20, 2020. Accessed November 16, 2020. <https://medium.com/@jennifersmithbriskinsights/vr-content-creation-market-will-be-growing-at-a-cagr-of-67-0-during-the-forecast-2019-to-2027-9925b621f056>.

<sup>2</sup> Pierre Schaeffer, in *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner (New York, NY: Continuum, 2006), 78.

tropes of cinema, while using the audiovisual immersion of VR to experience these sounds in a unique and focused manner. In this paper I will describe the parts of a film's soundtrack, examine how we (humans) experience hearing, investigate how film sound has evolved to increase audience immersion, and discuss the creation of and thought behind *CinematicAmbiX*.

## COMPONENTS OF A FILM SOUNDTRACK

Before investigating the tropes of a film's soundtrack it is essential to explain the major components of the soundtrack itself. These include dialogue, sound effects, and music. It is the sound editorial team's job to complete the sound editing and creation of each of these categories and bring them to the re-recording mixer to be combined into the finished soundtrack of the film. The process of, "re-recording, otherwise referred to as *mixing* or *dubbing*, is where you bring carefully prepared tracks from sound editorial and music and weave them together into a lush, seamless soundtrack."<sup>3</sup> For feature film productions this process typically takes place on a mixing stage. The mixing stage is almost identical to a movie theater, similar to the space in which an audience would experience the film. The large, sound-treated room features a large format mixing console approximately two-thirds of the way back in the room so that the rerecording mixer(s) can hear and manipulate the sound delivered by the editorial team as the audience would experience it in a theater environment.<sup>4</sup>

While a film's dialogue mix consists of just that - the dialogue - and the music mix consists of the film's score and licensed music cues, the sound effects mix is the most varied.

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<sup>3</sup> David Lewis Yewdall MPSE, *The Practical Art of Motion Picture Sound* (Burlington, MA: Focal Press, 2013), 482.

<sup>4</sup> Yewdall, *The Practical Art of Motion Picture Sound*, 482.

The sound effects mix is comprised of ambiences, practical foley effects, and sound effects that are recorded and/or created by a sound designer. The ambiences in a soundtrack ground the scene and create and enhance the mood. They can tell a significant portion of a story without the need for the image to do so. The audience, presented with a closeup of a character's face with no background elements in the frame will be able to establish the character is indoors, outdoors, in a busy area, in a remote area, the season, if the building they are in is well maintained, if they are in a moving vehicle, an airport or any other location. The genre of science fiction is also fertile ground for emotional tone-setting using ambience. A frequently used example is the feature film *Blade Runner*. A scene between Harrison Ford's character Deckard and Sean Young's Rachael in Deckard's futuristic apartment has a synthetically created ambience, designed to sound futuristic as well as unsettling. The unease between the characters is solely created by the ambience.<sup>5</sup>

Foley is also used to enhance a film's storytelling. A foley track is made up of sounds that are recorded during postproduction synchronously to the moving image. "One of the most surprising audiovisual phenomenon allows the audience to believe that whatever sound is synchronized to the image is the sound being emitted by that image."<sup>6</sup> This experience is what Michel Chion refers to as "synchresis", "The forging of an immediate and necessary relationship between something one sees and something one hears at the same time." Chion created the term by combining synchronism and synthesis.<sup>7</sup> All postproduction sound stems from the concept of synchronism, but foley recording is often the most deceptive. A foley team for a feature film will often include at least two foley artists and a foley mixer who work together to create live-to-

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<sup>5</sup> Ridley Scott, *Blade Runner* (June, 25 1982; Los Angeles, CA: Warner Bros.), Feature Film.

<sup>6</sup> David Sonnenschein. *Sound Design: The Expressive Power of Music, Voice and Sound Effects in Cinema*. (Studio City, CA: Michael Wiese Productions, 2001), 35.

<sup>7</sup> Chion, Michel. *Audio-Vision* (New York: Columbia University Press, 1994)

tape recordings of character movements and interactions with each other and the environment they inhabit. Footsteps are among the most recorded foley sounds. A foley team is concerned not only with coverage, making sure there is a sound for each footstep in a scene, but also with supporting each character's intent in the scene. A footstep can be heavy and menacing or light and balletic. Aldo Ciorba, foley artist for all of director Sergio Leone's films, intently watched actors' performances to fully grasp how each actor moved and their body weight was distributed.<sup>8</sup> This intense focus on, not just the materials being recorded, but the intent with which the materials interact with each other is where the performance aspect of foley is felt by the audience.

Sounds that are necessary to complete a film's soundtrack but are not dialogue, music, or foley are either recorded in the field asynchronously, synthesized by sound designers, or are found in sound effects libraries. The major Hollywood studios amassed their own sound effects libraries for the first several decades of film with soundtracks. The studios began to license their libraries, for a significant cost, in the 1980s. My first experience with sound effects libraries involved looking up the name of a sound effect in a *Yellow Pages* sized reference book and then hunting down the referenced compact disk from the hundreds in the library before recording the sound into an early digital editing system and then synchronizing the sound to picture. This was a laborious process, though far quicker than the reel-to-reel or Moviola film editing that previous generations of sound editors endured. In the early 2000s, there were only a few major sound effects libraries available to those outside of the major media companies. The result of this limited access to large varieties of effects was a lack of variety. Films created by a particular studio would reuse the same gunshot or horse hoof or explosion sounds in every film that was

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<sup>8</sup> Ament, Vanessa Theme, *The Foley Grail: The Art of Performing Sound for Film, Games, and Animation* (Burlington, MA: Focal Press, 2009) 25.



edited at the studio. One of the most famous examples of this is the Wilhelm Scream. First used in the 1951 movie, “Distant Drums”, the sound has been used in over 100 feature films.<sup>910</sup> In 2013 Asbjørn Anderson’s *A Sound Effect* website, quickly followed by others, created open markets in which sound designers could create their own unique, specialty libraries and license them to other sound designers and filmmakers.<sup>11</sup> The result has been a fantastic diversity of sound and sonic points of view. The abundance of available sounds and the increased flexibility of digital audio workstations to manipulate and combine sounds has meant that even recognizable sounds, “can now be converted into thousands of variations, from the vaguely familiar to one completely obliterated from the original meaning”.<sup>12</sup> There is no longer an excuse for a film to sound recognizable unless that is the intended result.

## THE MIX: SOUND PLACEMENT AND SPATIALIZATION IN FILM

In his keynote address at the 2020 *Mix: Sound for Film & TV* conference, sound designer and film editor Walter Murch spoke about sound location when mixing for film. He stressed that the parts that make up a film’s soundtrack are perceived differently than in other media. The existence of image that accompanies sound changes the way audiences perceive the sound. Murch references a scene from the 2003 film *Cold Mountain* in which a character, playing a

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<sup>9</sup> Viers, Ric. *The Sound Effects Bible* (Studio City, CA: Michael Wiese Productions, 2008), 3.

<sup>10</sup> Business Insider, “Over 100 Hollywood films use the same scream,” Accessed October 20, 2020. <https://www.businessinsider.com/why-wilhelm-scream-same-sound-effect-hollywood-movies-2018-11>.

<sup>11</sup> Anderson, Asbjørn. “Welcome to A Sound Effect” *A Sound Effect* (Blog) August 19, 2013. Accessed October 20, 2020. <https://www.asoundeffect.com/welcome-to-a-sound-effect/>.

<sup>12</sup> Sonnenschein, *Sound Design*, 36-37.

violin moves from one side of the screen to the other. Murch explains that panning the dialogue across the screen to make the character's voice come from a more realistic, accurate perspective makes the scene feel disjointed as the dialogue jumps around the screen, breaking the suspension of disbelief the filmmakers have worked to create. However, Murch contends that the same is not true of the sound of the violin the actor in question is playing. The violin was necessarily panned across the screen to the accurate location of the player. Murch describes a fundamental difference in the way humans perceive sound when compared to visual information. He refers to, "the primacy of vision that we have which is forward, and the ancillary sense of sound which is 360 degree spherical. The theater really starts to play mind games on you when you bend that reality."<sup>13</sup>

Alternatively, there are examples of critically acclaimed feature films that go against this mixing concept. Alfonso Cuarón's 2013 film, *Gravity* abandons the necessity of maintaining dialogue panned to the center of the screen and pans the dialogue into the surround speakers when characters speak off-screen. This provides a feeling of detachment the filmmaker, Cuarón, and re-recording mixer Skip Lievsay were attempting to achieve.<sup>14</sup> The result makes the audience feel as if they are immersed in the 360 degree action that surrounds them during the space adventure. Writer, sound editor and mixer, Cormac Donnelly, when writing about dialogue panning for *Designing Sound*, writes that "this seemingly haphazard approach to panning was not only integrated into, but also driven by the film's narrative."<sup>15</sup> The narrative must always lead mixing decisions.

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<sup>13</sup> Murch, Walter. "The Role of Art and Technology." Lecture, Mix: Sound for Film and Television, via Zoom, September 25, 2020.

<sup>14</sup> The Sound of Gravity. Produced by Michael Coleman, Los Angeles: Soundworks Collection, 2013.

<sup>15</sup> Donnelly, Cormac, "Dialogue on the move – panning in Gravity, Cars and Strange Days," DesigningSound.org, January 30, 2014, <https://designingsound.org/2014/01/30/dialogue-on-the-move-panning-in-gravity-cars-and-strange-days/>

Crucial to filmmaking decisions including and beyond panning is the way that each sound interacts with the images on screen. A sound, such as a typical film ambience is most often implemented to blend seamlessly with the visual image. The ambience should not distract from the story or focus of the film, but instead, ground the photography in a location. Often these ambiences are crucial to bringing realism to filmmaking which, in the narrative genre, can be wholly artificial. For instance, to capture dialogue that is free from unwanted background sounds, a film production will often stop traffic on a street or have background actors pretend to speak but make no sound. The dialogue can then be captured cleanly, but the dialogue alone played back in sync with the image, will feel artificial without the sound of the space or the background actors in the scene. The choice of ambience to introduce to a scene serves as an example of a common but essential decision that demonstrates an artist's intent.

Michel Chion refers to the way in which sound and picture meet as an “Audiovisual Contract”.<sup>16</sup> Sound and visuals do not naturally come together in film. Each image frame and each inch of tape or sample of audio are purposefully placed together by the filmmakers. A film is a series of decisions regarding the recording, editing, color correcting, mixing, etc. A change to any one of these decisions changes the outcome and potentially the emotional effect of the film on its audience. Chion defines the “Audiovisual Contract” as “a sort of symbolic pact to which the audio-spectator agrees when she or he considers the elements of sound and image to be participating in one and the same entity or world.”<sup>17</sup> So much of creating a film's soundtrack involves synchronizing sounds that the audience expects to hear in a given scene to visible on-screen actions. This creates realism and grounds the storytelling in time and place. When the

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<sup>16</sup> Chion, *Audio-Vision*, 1994. 222.

<sup>17</sup> Chion, *Audio-Vision*, 1994. 222.

sound editor is able to add or mix in sounds that an audience would not expect to hear in a given scene, the element of hyperrealism is created.

In *Midsommar*<sup>18</sup>, director Ari Aster and supervising sound editor and re-recording mixer Gene Park used ambience and the lack thereof to increase the anxiety of the film's audience. In several outdoor scenes the camera clearly shows wind, insects, and birds, and yet very little ambience is played. As the audience, we expect to hear what is shown on camera and, when it is taken away, the film with sound and visuals combined feels uneasy. As the character, Siv, begins to speak, Gene Park, referring to the ambience, begins, "pulling out the sounds because we wanted to make the focus on her".<sup>19</sup>

## HUMAN HEARING AND SONIC PERCEPTION

It is essential for audiovisual creators to technically grasp the many and various audio formats as well as the ways humans, the audience, perceive those formats. Humans respond to sound in some predictable and controllable ways. Scientifically, the most basic descriptions of a sound are expressed as amplitude, which humans perceive as volume, and frequency, which we perceive as pitch. Sound travels in this scenario through the air as variations in air pressure. The air pressure waves are then converted into an electrical signal by our ears. The ear acts as a transducer, converting the acoustic energy into electrical energy. This frequency and amplitude

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<sup>18</sup> Ari Aster, *Midsommar* (July 3, 2019; New York City: A24 Films, Publication date), Feature Film.

<sup>19</sup> Gene Park, "Designing the Deeply Disturbing Sound of *Midsommar*," interview by Abjoern Anderson, A Sound Effect, July 17, 2019, <https://www.asoundeffect.com/midsommar-sound/>.

information is sent to our brains where a myriad of connections are made, linking our memory and knowledge to the electrical information the ears provide.<sup>20</sup>

Though our ears are the most important and specific way that we experience sound, hearing is a full-body experience. Consider a loud, powerful event that one experiences in a movie theater: an explosion; a car crash; a spacecraft landing or taking off from the earth. These events, among many other possibilities, are largely felt as much as they are heard. Low frequencies, commonly referred to as sub-bass, vibrate the subwoofer or speaker cone with such low frequency that we feel the effect as much as we pick it up with our ears. We perceive these sounds as being physically low down on our bodies. We feel them in our guts, in our lower torso. This phenomenon is also experienced at music venues, another location where powerfully amplified speakers reproduce low frequencies. “As the frequencies increase (pitch), effects are felt more in the upper chest and, neck, and head”.<sup>21</sup> Introduce tempo and timbre into the sounds and one can affect the listener’s heart rate, breathing, and muscle tension along with other physical human responses. Experienced filmmakers use sound to manipulate their audience, to immerse them into the narrative experience. This is possible due to the vast associations, that our brains learn in the cultural environment we inhabit. It is essential to consider that the delivery of sounds that inform the modern cinematic soundtrack are based in learned signs. A sonic language that the media we are exposed to teaches us. These signs can differ from culture to culture. This means, “people can only infer and interpret a sound’s meaning, in a given text, a given context”.<sup>22</sup>

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<sup>20</sup> Alten, Stanley R., *Audio Basics* (Boston, MA: Wadsworth Cengage Learning, 2012), 11-20.

<sup>21</sup> Sonnenschein, Sound Design, 70.

<sup>22</sup> Noad, Betty, and Barton, Georgina. 2020. “Emotion Resonance and Divergence: A Semiotic Analysis of Music and Sound in ‘The Lost Thing’ an Animated Short Film and ‘Elizabeth’ a Film Trailer.” *Social Semiotics* 30 (2): 206–24. doi:10.1080/10350330.2018.1543115.

Michel Chion refers to the way in which sound influences time when related to moving image as “temporal animation”.<sup>23</sup> Think of the ticking clock, slowing down a scene, or the slowly increasing sound of a heartbeat. In the opening scene of Netflix’ streaming series, *Stranger Things*, the temporal control that sound has over the viewer can be felt. In the first scene of the series, a scientist (he is wearing a white lab coat and glasses) runs as if his life depends on it from an unseen enemy. He reaches an elevator, his escape. As he waits for the elevator door to close and protect him from danger, we hear a low frequency, repeating pulse, similar to an exaggerated heartbeat. The same sound is repeated with each repeat edited to be slightly closer together on the sound editor’s digital audio workstation timeline. This increasing tempo results in an involuntary physical response from the audience that increases the tension and often, heart rate of the viewer. The viewer’s tension is released when the scientist meets his inevitably sticky fate.<sup>24</sup>

Sound affects us physically but provides other information as well. Location is an essential part of how we perceive sound. Sound is omnidirectional. When an object vibrates and creates a sound, that sound disperses in all directions away from the source in a spherical, omnidirection. We are able to perceive from which direction a sound arrives at our ears and the distance and acoustical environment in which the sound was made. Our brains gain this information by comparing the information received by each ear. Interaural time difference (ITD) and interaural intensity differences (IID) are what the brain uses to compare the timing and intensity of when a sound reaches each ear. For example, if a sound occurs to the right of the listener, it will arrive at the listener’s right ear before the left and will reach the right ear with

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<sup>23</sup> Chion, Audio-Vision, 1994. 13.

<sup>24</sup> *Stranger Things*, "Chapter One: The Vanishing of Will Byers", Netflix video, 47:19, July 15, 2016, <https://www.netflix.com/watch/80077368>.

greater intensity or level.<sup>25</sup> This method of sound localization works well on the horizontal plane, but what if a sound is horizontally in front of the listener, but above or below? How do we localize along the vertical axis? The answer lies in our pinna. The pinna is the external part of our ears. Each human pinna is unique and this auditory funnel colors the sound we hear in a very specific way. The shape of our pinnae changes the frequency spectrum of each sound that we hear. This sound shaping that occurs varies in the vertical direction and gives our brain clues as to the vertical position of a sound's source. However, human vertical sound localization is not nearly as precise as our horizontal localization.<sup>26</sup> To complete the picture of human hearing in 360 degrees, one must take into account the head-related transfer function (HRTF). "HRTF describes how what we hear is filtered and shaped in establishing its location in three-dimensional space".<sup>27</sup> Using the combination of ITD, IID, and HRTF is known as binaural, two ear, hearing.

We also refer to a certain recording technique as binaural. Binaural audio is a format that replicates the way in which humans hear. The result is a two-channel recording in which each channel is recorded by a separate microphone in a setup that replicates the position of human ears in relationship to each other. This can be set up with any pair of identical microphones and some type of sound baffling to replicate the density of a head between the ears. Alternatively, there are commercially available products that deliver exceptional results such as the Neumann KU 100 and the 3Dio FS binaural microphones. Both consist of omnidirectional microphones inside of pinna-shaped funnels, a head's distance from each other with sound-absorbing materials between the two microphones. By capturing audio in this manner, a realistic 360-

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<sup>25</sup> Agnieszka Roginska and Paul Geluso, eds., *Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio*. (New York, NY: Routledge, 2018), 11.

<sup>26</sup> Roginska and Geluso, *Immersive Sound*, 17.

<sup>27</sup> Alten, *Audio Basics*, 26.

degree auralization can be achieved via high-quality headphones. It should be noted that binaural audio does not achieve a sense of three-dimensional sound via loudspeakers as the placement of the sound source cannot be colored by room reflections and outside noise. Importantly, stereo sound, sound that has been mixed or recorded with a left and right channel format that does not take into account the above criteria, will not be able to replicate the 360-degree sphere of near realistic sound that binaural can. Stereo sets the stage for sound reproduction only between the two stereo (left and right) speakers. “When the HRTFs for a listener and for each point in space are used to filter the signal before it is presented over headphones, listeners often perceive the sound source similarly to the way it is perceived when it was presented in the real world. Otherwise, headphone-delivered stimuli are lateralized inside the head”.<sup>28</sup>

## THE EVOLUTION OF CINEMA AUDIO FORMATS

1927’s *The Jazz Singer* was the first feature film to move beyond just musical accompaniment to include the addition of speech and singing. At the time, sound was recorded and played back in mono, meaning a single signal from a single speaker. The speaker, in the case of the movies, was centered behind the screen. This tradition with regards to dialogue has not fundamentally changed as most dialogue for film and television still resides in the front center channel. In 1940, Walt Disney, after a decade of research, and in conjunction with

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<sup>28</sup> William A. Yost and Raymond Dye, “Fundamentals of Directional Hearing,” *Seminars in Hearing*, Volume 18, Number 4. (1997), 333, [https://www.researchgate.net/publication/247476067\\_Fundamentals\\_of\\_Directional\\_Hearing](https://www.researchgate.net/publication/247476067_Fundamentals_of_Directional_Hearing) (accessed October 26, 2020).



engineers at RCA, released *Fantasia* as the first film to be released with *Fantasound* by RCA.

*Fantasound* was a true stereo speaker array able to play sounds from either side of the screen.<sup>29</sup>

Stereo sound creates a stage between the two speakers, left and right. A sound played at the same volume level from both speakers simultaneously sounds to our ears as if the sound is coming from between the two speakers. This phenomenon is known as the *phantom center*. To move the phantom image of a sound from the center, toward the left speaker, the volume of the sound would be increased in the left speaker as the sound level is decreased in the right. This is known as panning. The result is, “such that the resulting reproduced sound provides a convincing and sharp phantom illusory image.”<sup>30</sup> This area between the left and right speaker gives the re-recording mixer the ability to move sounds to any point along the horizontal axis between the two speakers.

In 1979, the first feature film release with a larger than stereo or left, center, right (LCR) speaker configuration was Francis Ford Coppola’s *Apocalypse Now*. For the film’s mix, Walter Murch planned to use the Dolby Laboratory’s new technology called Dolby Stereo. Dolby Stereo, or “split stereo” as Murch referred to it, was, in fact, the first theatrical surround sound format to include discrete left, center, right, and center surround channels.<sup>31</sup> Director Coppola’s demand for earth-shaking low frequencies and his love of quadraphonic sound lead to Murch designing the first 5.1 surround sound system. The speaker configuration for 5.1 includes channels for left (L), center (C), right (R), left surround (Ls), right surround (Rs), and a low frequency effect (LFE) channel on a dedicated subwoofer. This system would go on to become

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<sup>29</sup> Bob Furmanek, "The First Year of Stereophonic Motion Pictures," 3-D Film Archive, 10/26/20, <http://www.3dfilmarchive.com/the-first-year-of-stereophonic-sound>.

<sup>30</sup> Gerzon, Michael. 1992. "Panpot Laws for Multispeaker Stereo." Presented at the 92<sup>nd</sup> Audio Engineering Society Convention, Vienna, March 24-27, 1992, 2. New York, NY: Journal of the Audio Engineering Society.

<sup>31</sup> Murch. "The Role of Art and Technology", 2020.

the industry standard for theatrical and DVD releases for decades to come.<sup>32</sup> The 5.1 format enables the re-recording mixer to move a sound completely around the audience by panning through the speaker array. Cinema sound systems continued to expand to accommodate large theaters with the introduction of the 7.1 surround sound format.<sup>33</sup> The addition of left-center (Lc) and right-center (Rc) to the L, C, R, Ls, Rs and LFE was introduced with the release of Pixar's 2010 feature, *Toy Story*. (fig 1)

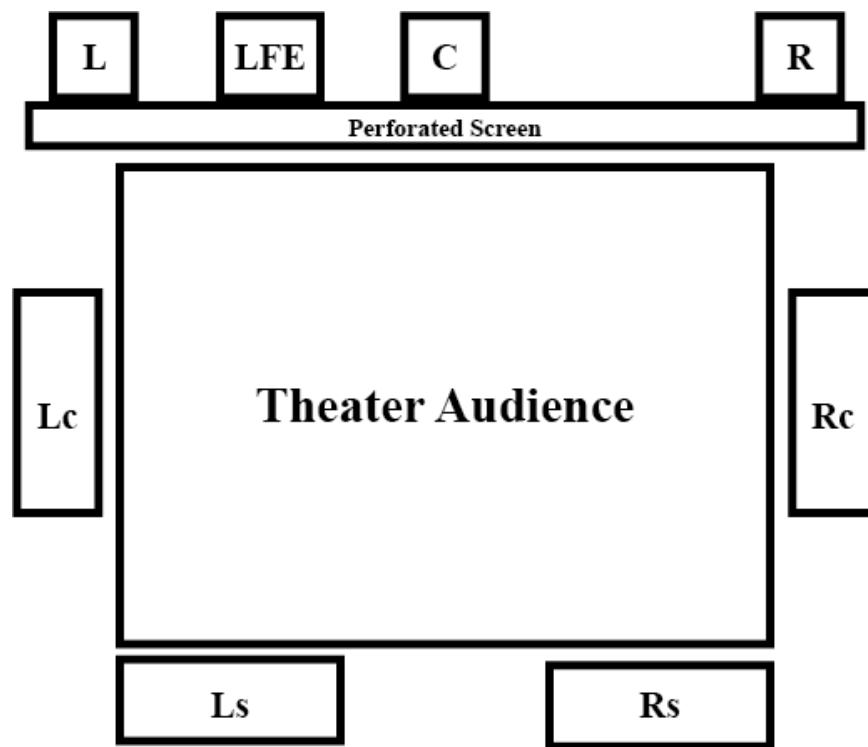


Figure 1 Diagram of a 7.1 Surround Theatrical Speaker Layout

<sup>32</sup> Web of Stories – Life Stories of Remarkable People, "Walter Murch – The Beginning of 5.1 Sound," YouTube video, 4:00, September 13, 2017, <https://youtu.be/EoHLddyhPBE>.

<sup>33</sup> Roginska and Geluso, *Immersive Sound*, 190.

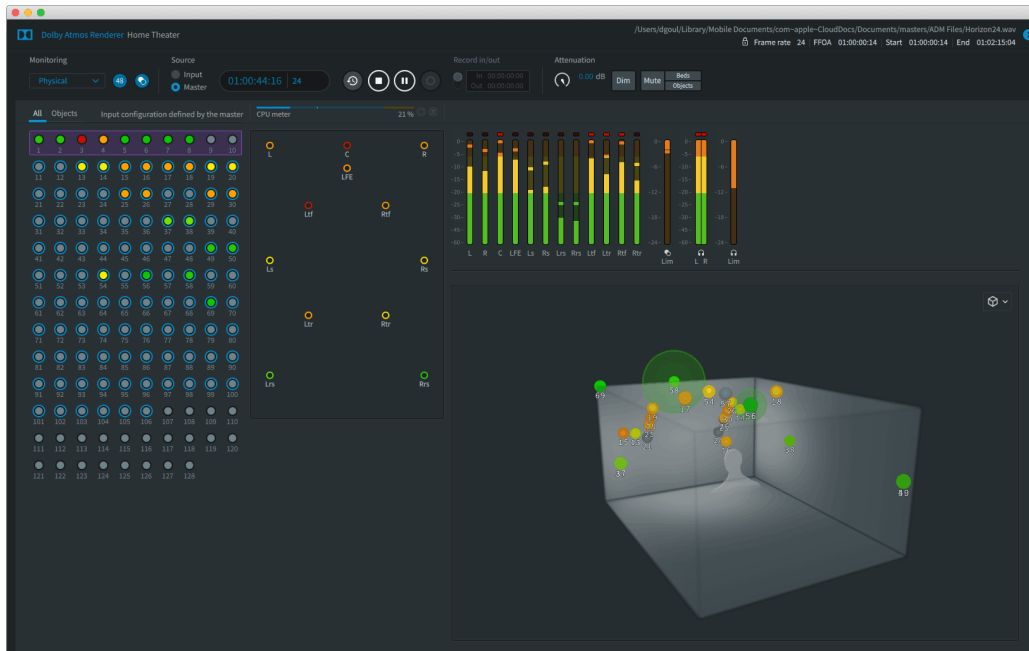


Figure 2 Image of the Dolby Atmos Renderer, “What Dolby Atmos® Software is Right for You?,” Avid Blogs, September 15, 2020, <http://www.avidblogs.com/what-dolby-atmos-software-is-right-for-you/>.

Though there are other formats such as DTS:X and Auro 3D, the pervasive modern mix format for feature films and television is Dolby Atmos. This immersive format varies radically from the previous generations of film mixes that were only able to playback sound on the 360-degree horizontal plane. Dolby Atmos and its competitors introduced height channels which the audience hears either through speakers placed above the audience or through a binaural rendering of the mix. This technology is known as object-based, meaning the sounds are turned into virtual objects which the re-recording mixer can place and move through three-dimensional space. (fig 2) The most straightforward of these concepts is the inclusion in these systems of height channels. A large format theater mix, until recently, would be output to 7.1 surround (8 channels). A re-recording mixer now delivers a single Dolby Atmos mix that can be decoded by the playback system on the consumer or theater end. The decoded mixes can range depending on the systems decoder. The mix can range from a binaural headphone mix (2 channels) to 7.2.4 (L, C, R, Ls, Rs, Lc, Rc, 2 LFEs, 4 height/ceiling speakers) to 64 individual speakers including

subwoofers and overheads.<sup>34</sup> The same mix information is delivered to the playback system, i.e. headphones, home a/v system, or cinema. The delivered mix is then decoded by the playback system on the consumer end. This means that the spatial intent of the mix is delivered across all formats.<sup>35</sup> (fig 3)



Figure 3 Image of a Dolby Atmos configured mixing stage at Formosa Sound in Hollywood, CA. Harvey, Steve. 2018. "DOLBY ATMOS: The Business and the Technology." *Mix* 42 (7): 32–34. <https://www.mixonline.com/technology/dolby-atmos-the-business-and-the-technology>.

While the modern audio formats mentioned above are proprietary, they are directly connected to another audio format that has been in use for almost 50 years, ambisonics. The ambisonics audio format was created by Michael Gerzon and his colleagues in the Oxford University Tape Recording Society (OUTRS) during the late 1960s and early 1970s. Gerzon was a mathematician and inventor who published 121 papers and was the recipient of the prestigious Gold Medal from the Audio Engineering Society. His life's work (Gerzon died in

<sup>34</sup> Dolby, "Dolby Atmos for cinema playback," October 27, 2020, <https://professional.dolby.com/cinema/dolby-atmos/4>.

<sup>35</sup> Toole, Floyd E., *Sound Reproduction: The Acoustics and Psychoacoustics of Loudspeakers and Rooms*. (New York, NY: Routledge, 2018), 430.

1996) is responsible for the way audiences and users experience, record, and create sound for film, television, streaming video, video games, virtual reality, and augmented reality.<sup>36</sup>



Figure 4 Image of an Ambeo VR Mic Tetrahedral Microphone, "Product Highlights," Sennheiser, date accessed November 15, 2020, <https://en-us.sennheiser.com/microphone-3d-audio-ambeo-vr-mic>.

Though fully viable and available since the early 1970s, ambisonic audio has shot to the forefront of modern entertainment technologies. The audio format enables the recording and playback of fully immersive 360 spherical sound through a multitude of devices. When recording with a traditional stereo format, all audible sounds are recorded. However, when they are played back, the only directional information (localization) the listener receives is along the horizontal plane between the left and right speaker or between the left and right headphone. In order to capture more than the single-axis dimension between two speakers, it is necessary to use more microphones and to capture directional information.<sup>37</sup> This is achieved in recording with a tetrahedral microphone array. (fig 4) Often combined into one microphone, a first order (tetrahedral) ambisonic microphone has four microphone capsules and must be oriented in a

<sup>36</sup> Hulme, Daniel, "Into The Soundfield" - Michael Gerzon & Ambisonics at Oxford," YouTube video, 8:30, June 29, 2018, <https://youtu.be/X23hZNoSkUs>.

<sup>37</sup> Thresh, Lewis, Armstrong, Cal and Kearney, Gavin, "A Direct Comparison of Localization Performance When Using First, Third, and Fifth Ambisonics Order for Real Loudspeaker and Virtual Loudspeaker Rendering," Presented at the 143<sup>rd</sup> Audio Engineering Society Convention, New York, October 18-21, 2017, 2. New York, NY: Journal of the Audio Engineering Society.

specific direction with the capsules pointing diagonally front left up (FLU), front right down (FRD), back left down (BLD) and back right up (BRU). The resulting four track recording is known as ambisonics A-Format and is not particularly useful on its own. However, if the signals are combined and decoded in exactly the same manner as a mid-side recording, a common stereo recording technique that uses the phenomenon of phase cancellation to give the sound technician control over the horizontal width of the recorded source when mixing, the result is a B-format ambisonic file which can be further decoded into a variety of formats. The B-format file can be decoded into traditional stereo, binaural and horizontal surround formats in addition to higher order ambisonics. Various multichannel ambisonic formats of increasingly specific virtual sources begin with B-format four channel First Order Ambisonics (FOA). The mathematical process of phase manipulation and combination can then be further applied to create more and more specific virtual sound sources beyond the first order FLU, FRD, BLD, and BRU. Second Order Ambisonics (SOA) are nine channel files; Third Order Ambisonics (TOA) are 16 channel files. Studies have shown that continuing the decoding beyond the third order can lead to more specificity in sound localization.<sup>38</sup> Ambisonic audio creates a 360-degree sphere of sound that is unrestricted by the limitations of any specific playback system. Ambisonic audio's ability to be decoded into multiple formats makes it an ideal, flexible format for many applications. Beyond the previously discussed film applications, ambisonic audio is also prevalent in other media, such as video games, virtual, augmented, and mixed reality (VR, AR, and MR).

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<sup>38</sup> Bertet, Stéphanie; Daniel, Jérôme; Gros, Laëticia; Parizet, Etienne; Warusfel, Olivier, " Investigation of the Perceived Spatial Resolution of Higher Order Ambisonics Sound Fields: A Subjective Evaluation Involving Virtual and Real 3D Microphones," Presented at the 30<sup>th</sup> International Audio Engineering Society Conference, Saariselkä, Finland March 15-17, 2007, 8. New York, NY: Journal of the Audio Engineering Society.

## CINEMATIC AMBIX: THREE MOVEMENTS

For more than 15 years, I have worked in the medium of sound for television and film and I now teach the subject at Towson University. Capturing, synthesizing, designing, and mixing sound has been my focus, with a particular interest in the methods with which film and television sound professionals manipulate their audience. When conceiving *CinematicAmbiX* I was looking for methods of exploring immersive, cinematic sounds that would enable audience interaction without the need for a large space and potentially dozens of speakers. I recently completed a project, *ElectroAmbiX*, an interactive VR experience that enabled the user to pick up and interact with neon cubes that emitted a series of my own electromagnetic field recordings inside of a circuit board shaped room. The experience was my introduction to investigating sound in VR and led me to a more thorough understanding of how interactive, immersive sound in an ambisonic format can be uniquely experienced by each user when they are allowed to explore and interact with the virtual space and even the sound sources themselves.

I chose to focus on sounds that I would exhibit in a VR environment, rather than the sound being driven by user interaction as in my previous VR work. To explore cinematic sound, I chose to allow the user to freely move around the sound sources in *CinematicAmbiX* while still experiencing a linear, film-like narrative structure. The piece was conceived in three movements - each investigating a unique element of conventional sound for moving image. The first movement is based on the film trailer. Trailers are rarely unique and often are edited and created to conform to an easily marketable genre. They exist at the boundary of creativity and the business marketing side of the film business. A film's trailer is usually finished long before

the film's release, often before shooting has been completed.<sup>39</sup> It is made of parts of the film from its most raw, unedited, unmixed state, "an intrasemiotic translation or a model that is constructed out of the same material as its object".<sup>40</sup> So few elements of the completed visuals of a film are finalized at the time of the trailer's creation, the sound of the trailer, "is arguably more dynamic, formative and foregrounded in trailers than in feature film, which is understandable considering the time constraints in which it has to accomplish its tasks."<sup>41</sup>

The sound for a trailer is even more separated from the film it seeks to preview. Trailer sound has become a sound effects genre unto itself, with many library creators releasing libraries solely focused on trailers. *Boom Library* is a renowned sound effects creator and distributor. They have to date created over 90 sound effects libraries and sound design tools dedicated to the trailer genre.<sup>42</sup> *Soundly Pro*, another popular purveyor of sound effects has a *Soundly Collection*, a sort of playlist, with a rotating selection of the most popular sounds in the *Movie Trailer* genre. The *Soundly Pro* Movie Trailer sound effects list is where I sourced my sound effects for the first movement of *CinematicAmbiX*. I used it as an excellent example of a source that sound designers and mixers of trailers would use as material for a modern trailer.

After watching many contemporary film trailers it quickly becomes clear that the trailers follow genre-dependent tropes. As Jessica Fox, Creator at Mark Woolen & Associates, a trailer producer in Los Angeles, explains, "Creators of trailers rely on tropes to help convey a lot of information to an audience quickly".<sup>43</sup> There are numerous tropes, but a sonic trope that Fox

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<sup>39</sup> Jackson, Blair. "Trailer Mixing and Music." *Mix* 30, no. 8 (August 2006): 58.

<http://search.ebscohost.com/login.aspx?direct=true&db=f5h&AN=22083887&site=eds-live&scope=site>.

<sup>40</sup> Oja, Martin. 2019. "On the Concept of the Deceptive Trailer: Trailer as Paratext and Multimodal Model of Film." *Sign Systems Studies* 47 (1/2): 177–204. doi:10.12697/SSS.2019.47.1-2.07.

<sup>41</sup> Deaville, James, and Malkinson, Alex. 2014. "A Laugh a Second?" *Music, Sound & the Moving Image* 8 (2): 121–40. doi:10.3828/msmi.2014.8.

<sup>42</sup> <https://www.asoundeffect.com/>

<sup>43</sup> "Movie Trailer Expert Breaks Down 5 Trailer Styles," November 14, 2019, video, <https://www.vanityfair.com/video/watch/movie-trailer-expert-breaks-down-5-trailer-styles>.



references is what she calls the “trailer pulse”. I used this type of sound as my starting point and continued to build the first movement of *CinematicAmbiX* using other sonic tropes including Trailer Hits, Trailer Sub Falls, Trailer Impacts, Trailer Stingers, and Trailer Risers.

For the second movement, I was moved to work with foley sounds. Foley, sound effects recorded live to picture, is an art form unique to film and video production. Named for Jack Foley, pioneer of the form, foley artists work in tandem with a foley mixer to create sounds that were not captured cleanly on the day of filming. Dialogue is the focus of a production sound team and often clean dialogue recording comes at the expense of natural atmosphere including footsteps, character-prop interactions, and interactions between characters.<sup>44</sup> Often a production sound team will use tricks-of-the-trade such as placing carpets on the floor to soften footsteps on hard surfaces, have actors use rubber bags to prevent the sound of crinkling, or tape jewelry down to prevent and jangling sounds. These techniques work well for capturing clean dialogue, but the missing sounds do need to be added to make the scene feel “real” to the audience. In order to maintain the suspension of disbelief the director must create for the audience, the foley team will reproduce all of these sounds. Footsteps are an important part of foley recording. Foley artists often perform on a foley stage, a quiet studio with space for the foley artist to perform and be recorded while viewing the film, in order to maintain synchronization. Footsteps are often recorded in foley pits, shallow boxes filled with common surface materials, such as gravel, grass, mud, concrete, etc. The foley artist will select the ideal shoes and will perform the walking, running, or shuffling of a character in such a way that helps to convey the appropriate sonic and emotional notes of the character.<sup>45</sup>

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<sup>44</sup> Viers, *The Sound Effects Bible*, 115.

<sup>45</sup> Viers, *The Sound Effects Bible*, 115.

The third movement of CinematicAmbiX focuses on ambience. The ambience in filmmaking refers to the sound of the space in which a given scene is taking place. Though there are notable exceptions, such as French New Wave director, Jean-Luc Godard, who often pushed ambience to the forefront of a mix, ambience in most film and television is placed in the background, unnoticed but necessary.<sup>46</sup> Ambience serves two essential functions. First, it is used as “fill”, “helping create the illusion that all the cuts of the scene are taking place in a continuum”.<sup>47</sup> It also serves as a scene setter, describing the location in detail without the need for the camera to pan away from its target. The audience is instantly aware that the setting is rural, urban, indoors, outdoors or many other details.<sup>48</sup> In a film scene, “the ambience ‘grounds’ the other audio events and maintains interest”.<sup>49</sup> An audience expects ambience. Its removal or manipulation can unsettle the audience as in the previously mentioned example from Ari Rastor’s *Midsommar*.<sup>50</sup>

## CINEMATICAMBIX: FROM STEREO SOUND TO VIRTUAL REALITY

For *CinematicAmbiX* my goal was to bring sound to the fore and allow the audience to hear cinematic sound separate and apart from typical film visuals, allowing the participant to be immersed in the audio. This links directly to Pierre Schaeffer’s “acousmatic situation”. Michel

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<sup>46</sup> Elisabeth Weis and John Belton, eds., *Film Sound: Theory and Practice*. (New York: Columbia University Press, 1985), 336.

<sup>47</sup> Sonnenschein, *Sound Design*, 36.

<sup>48</sup> Viers, *The Sound Effects Bible*, 210.

<sup>49</sup> Taylor, Michael, “Room Tone = Emotional Tone: The Importance of Hearing Ambience,” *DesigningSound.org*, November 15, 2012, <https://designingsound.org/2012/11/15/room-tone-emotional-tone-the-importance-of-hearing-ambience/>

<sup>50</sup> *Midsommar*, directed by Ari Astor (2019; New York, NY: A24 Films) Feature Film.

Chion writes regarding Schaeffer's idea that "isolating the sound from the 'audiovisual complex' to which it initially belonged...creates favourable conditions for reduced listening which concentrates on the sound for its own sake, as sound object".<sup>51</sup> The visual cues that we use to identify an object are removed in *CinematicAmbiX*.

Initially, a binaural rendering of a sound-only ambisonic piece was appealing, but the allure of interactivity drew me to VR. Unlike a film, with or without an immersive audio soundtrack, VR allows the audience to move through the simulated space with some level of control. The listener can move around and through the audio objects. The terminology of immersive audio formats, such as Dolby Atmos, refers to sounds or groups of sounds as objects that can then be manipulated, placed, and panned through the theater. Unity, the game engine that I used to create *CinematicAmbiX*, also refers to objects that can be created and manipulated in the game and to which an Audio Source can be attached.

The path to creating each of the three movements of *CinematicAmbiX* began by focusing solely on composing the sound. Using the aforementioned Soundly Pro sound effects library, I created each piece using the Reaper digital audio workstation as an editor resulting in a standard stereo mix. To graduate the mix to an immersive format, I employed Dear Reality's DearVR Pro which connects to Reaper via the commonly used VST plugin format. Using DearVR Pro in conjunction with the standalone software Spatial Connect, allows the creator to mix in immersive, third order ambisonics from within a virtual reality environment. The software enabled me to virtually grab sound objects with my hands (controllers) and move them around me in virtual space. I then recorded those movements and was able to translate them into X, Y, Z coordinates that would be used to animate each audio object in Unity using the DearVR Unity

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<sup>51</sup> Chion, Michel. "Guide To Sound Objects: Pierre Schaeffer and Musical Research," trans. John Dack and Christine North (London: Buchet/Chastel, 2009), 18.

Spatializer plugin. Dear VR Unity's default is to place each sound (Audio Source) on a generic object. The generic object is a sphere wrapped in a black and blue grid material. The objects, now playing the Audio Sources as they moved throughout virtual space, mimicked my instructions and movements from the DearVR Spatial Connect software. Though Unity objects need to exist in order for the sounds to have a source, the audience did not need to see them. I initially simply turned off each source's mesh renderer which displays the object to the "player", as it is referred to in Unity. However, through trial and error, I found it was easy for the player to wander away from the area of most sonic interest. My solution was to remove the mesh from the object but add a light source to it. The player could then see light emanating from an otherwise invisible source. To emphasize the placement of the sound sources, I used several levels of textured glass material, creating reflections that cue the player to their location. The light sources appear and move through the space as the player is able to move through the soundscape, creating their personal binaural mix of the sounds moving around them in virtual reality.

I continued to use light to trigger visual awareness of sonic location in the second movement which focused on foley sounds. Using Tovu Sound's Edward Ultimate foley instrument, I created two sonic characters, emulating foley created by a foley artist in live performance. The first was made up of boots walking on dirt, boots walking on grass, the sound of a rifle being carried, and the sound of an army vest's movement. The sounds move synchronously around the user's starting position, giving the impression of an invisible person walking around the player. The character then divides into its component parts, splitting its white light into its component colors. This is repeated with the second character, composed sonically of high heeled shoes on concrete, high heels on asphalt, purse movement, and the

movement of a silk blouse. The sounds separating is a unique way to hear foley and serves to demystify the creation of the characters.

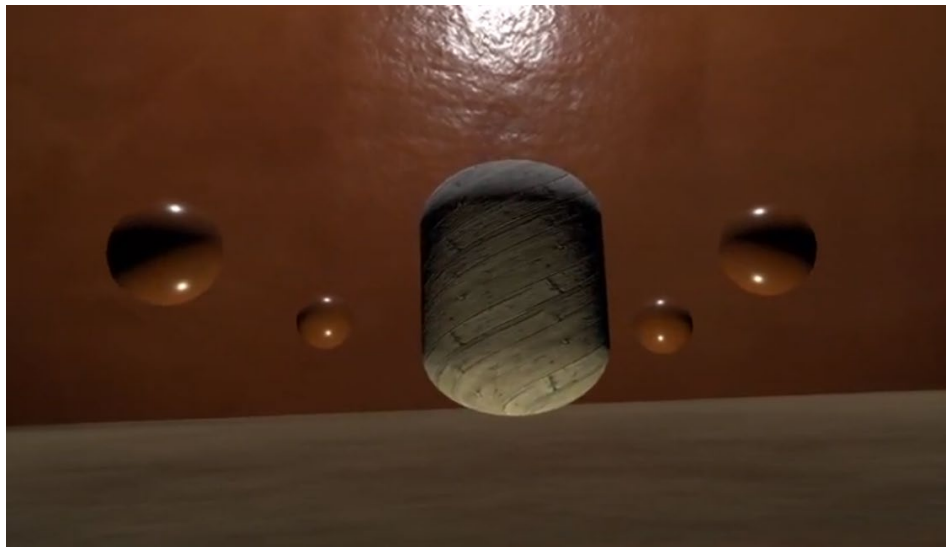


Figure 5 *CinematicAmbix*' third movement in which ambiances are attached to spherical objects that move throughout the virtual space.

The final movement of *CinematicAmbiX* spotlights ambience. (fig 5) Ambience is most often experienced in films as stereo, surround, or immersive audio, filling in the background of a scene, “creating a seamless sonic landscape”.<sup>52</sup> To demonstrate ambience used apart from its typical role in visual media, I applied it to solid objects. In this case, the objects are smooth, reflective wooden spheres. The sound emanating spheres, which begin inside of a capsule, quickly emerge and move away from their starting point. The user begins the piece within earshot of all five ambiances: a beach; an insect-filled summer night; an empty office room tone; underwater; a busy restaurant. As the sounds move up or toward the corners of the space the player is able to move between them, mixing the ambiances together based on their position. After changing positions while maintaining position several times in order to create changes in the user’s sonic environment, the objects then begin to swirl quickly around the central starting

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<sup>52</sup> Sonnenschein, Sound Design, 36.

position of the spheres. As they increase velocity and move past the player, the Doppler effect is heard: the phenomenon by which an audio source's pitch is perceived as rising as the object moves toward the listener and falling as the object moves away.<sup>53</sup>

The audio spatialization is processed in real-time as the player moves through each movement of *CinematicAmbiX*. This gives the player a unique sonic experience each time they enter the work. The piece concludes and the player moves toward an “outdoor” space, emerging as if from a theater into daylight.

## CINEMATICAMBIX: RELATIONSHIP TO OTHER WORKS

A foundational concept to *CinematicAmbiX* comes from the creator of *Musique Contréte*, Pierre Schaeffer. Schaeffer believed that sounds, *sonorous objects* (*objets sonores*) could be heard apart from their source. His idea of *Pure Listening*, listening to sounds, “without the support of vision”<sup>54</sup> is foundational to my approach to creating *CinematicAmbix*. He discovers, “that much of what we thought was heard was in reality only seen, and explicated, through the context”. Schaeffer’s theory came from his early experimentation with tape editing while working in radio at Radiodiffusion Française in Paris. His work sought to have the listener focus on the sounds he used separated from their source. Schaeffer’s earliest work of *musique contréte*, *Cinq études de bruits* serves as a perfect example. In the piece, Schaeffer uses such diverse sounds as trains, saucepans, and canal boats edited and looped to separate the sounds

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<sup>53</sup> Rossing, Thomas D., *The Science of Sound*. (New York: Addison-Wesley Publishing Company, 1990), 42-43.

<sup>54</sup> Pierre Schaeffer, in *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner (New York, NY: Continuum, 2006), 78.

from their sources and create a new piece that stands on its own. Schaeffer's work makes, "the sound object as a perception worthy of being listened to for itself".<sup>55</sup>

A contemporary artist who calls himself an Audio/Visual Creator, Isaac Cohen (aka Cabbibo) works in VR among other audiovisual digital media. His piece, *Immateria*, currently displayed in the VR based *Museum of Other Realities*, was one of the first pieces of VR art that emotionally connected with me.<sup>56</sup> As I thought about the reasons for my connection to the work, I realized that it was the visual and sonic interactivity that brought me into the world of Cohen's piece. *Immateria*, built around the architecture of the virtual museum is full of motion and life. It is a world of moving, seemingly breathing objects that flow around the participant, moving slightly to avoid collision.<sup>57</sup> *Immateria* also uses sound interactively. It uses the amplitude coming from the user's microphone to alter the brightness of the object in the various parts of the exhibit. This work was also my introduction to sound in VR creating texture in a space in much the same way that ambience and time-based effects such as reverberation and delay would in a film. Multicolored moving objects that hang above the audience's head in *Immateria* exude an array of calming dulled bell sounds, similar to a wind chime. The chimes are bathed in a lush reverb that creates a chapel-like resonance. It is calming and I found myself wanting to close my eyes to fully dissociate the sound from the visual.

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<sup>55</sup> Chion, Guide To Sound Objects, 12.

<sup>56</sup> Museum of Other Realities, "Spotlight: Isaac Cohen and the Telescope for the Mind," May 27, 2020, <https://www.museumor.com/blog/spotlight-isaac-cohen-and-the-telescope-for-the-mind>.

<sup>57</sup> Damiani, Jesse, "The Museum Of Other Realities Officially Opens Its Virtual Doors To The Public," Forbes.com, February 26, 2020, <https://www.forbes.com/sites/jessedamiani/2020/02/26/the-museum-of-other-realities-officially-opens-its-virtual-doors-to-the-public/?sh=3172a2d74d9d>

## CONCLUSION

Though the visual and interactive portions of *CinematicAmbiX* might remove it from the strict definitions of *sound art*, its goal is the same. My fascination with film sound was used as a lens with which to investigate, in the vein of *musique concrète*, the sounds that film sound designers and mixers use to affect their audience. I did this by separating film sound tropes from their traditional visual partners. Bringing VR into the piece was my method of combating the second-tier status in which sound creators often find themselves in the medium of audiovisual creating. This attitude perpetuates throughout academia as well. Author and academic Christoph Cox, when discussing synesthesia, refers to this mindset as, “the hegemony of the visual”. He stated that “cinematic sound is almost invariably subservient to the image”.<sup>58</sup> With *CinematicAmbiX* I strove to create one of those variances. “Genuine sound art today is fostered not by this consensus but by a dis-sensus that gives sound and hearing their due”. “The best sound works neither reject the visual nor succumb to it, but instead amplify differences among media and sensory modalities, drawing attention to sound as a semiautonomous power.”<sup>59</sup> VR’s role in the future of entertainment and its use of ambisonic sound to enhance audience immersion will continue to grow. My wish is that *CinematicAmbiX* can be not only a worthy piece of art in its own right, but also a bridge between the VR and sound for film communities with whom I hope to share this work.

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<sup>58</sup> Cox, Christoph. "Lost in Translation." *Artforum International*, 10, 2005, 236-241, <https://goucher.idm.oclc.org/login?url=https://www-proquest-com.goucher.idm.oclc.org/docview/214353052?accountid=11164>.

<sup>59</sup> Cox, “Lost in Translation”, 236-241.



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