

Abstract: There is interest in our era in the topic of sound spatialization, as evidenced by the writings, compositions, and facilities dedicated to the practice. One frequently expressed goal is to elevate space in importance as a compositional parameter. There are many approaches that make this possible, one of which is to create multichannel compositions for listeners who move physically through the presentation space. This article is an examination of such works. This article will discuss several elements in relation to navigable sonic creations using a variety of case studies, including my 96-channel piece for mobile audiences, *First Vision*.

Sound spatialization, defined as the placement and, if applicable, movement of sound in space (Roads 2015, p. 240), has a long pedigree in compositional practice. Examples of its use can be found in every epoch of Western music history: antiphonal and responsorial psalmody in ancient and medieval music, *cori spezzati* in the Renaissance and Baroque periods, spatially separated ensembles in the Classical period, offstage instruments in the Romantic era, and works for numerous configurations of spatially distributed performers or loudspeakers in the 20th and 21st centuries (Grout and Palisca 2001, pp. 24, 38–44; Moeller 2011 p. 1; Boren 2018). The possible approaches to sound spatialization have certainly not been exhausted, and the range is already broad and varied (Zvonar 2005). Much discussion has taken place about space as a significant compositional parameter. There are many approaches to elevating space to such a status (Brant 1967, p. 223; Ball 1997; Varèse 2004, pp. 17–18; Smalley 2007, pp. 35, 54–55). Of course, the necessity of space, in conjunction with a medium, is recognized in the transmission of sound. The discussions cited speak of treating space as more than that, however—namely, as a significant parameter to be directly considered in the assembly and presentation of sonic material. In this article, I will analyze a compositional method that, by its nature, raises space to an important compositional parameter: multichannel spatial composition for nonstationary audiences. I will explore point-source sound spatialization, sculpture as a metaphor, mapping the space, and the performance venue in relation to such works. As concrete examples, I will

reference my recent composition *First Vision* (2016) and a variety of additional works.

Overview of *First Vision*

In 2016, I completed and premiered a 96-channel acousmatic work for nonstationary audiences entitled *First Vision* (Moeller 2016a). The composition is a sonic depiction of the theophany of Joseph Smith, Jr. (1805–1844) described in *The Pearl of Great Price* (Smith 2013 JS-H 1:5–20; cf. Smith 2018). The piece is one hour in duration, consisting of three movements in 26 sections. It is intended to be presented outdoors.

The work is listened to using 96 mini loudspeakers spread out in a field. Each loudspeaker rests on the ground and points upwards. Each loudspeaker is connected to a time-synchronized tablet, the two sitting together on a tray (see Figure 1).

The loudspeakers are laid out in a grid formation: eight columns by twelve rows. The size of the grid area is approximately 21 × 34 m. The audience members are able to move freely among the loudspeakers during a performance of the piece (see Figure 2). They are also given a listening guide that provides information about each temporal section of the piece.

Algorithmic processes were used for many compositional parameters, including attack time, amplitude, duration, spatial position, frequency selection, timbre selection, and time-varying effects such as amplitude modulation and delay (for a variable comb filter). Pitch was organized throughout the piece using a just-intonation system based on the harmonic series. Sounds were spatialized by routing them to discrete loudspeakers. Signal processing

Figure 1. Close-up of a single unit, consisting of a small loudspeaker and a tablet computer.



was used to embed additional spatial effects, such as Doppler shift, reverberation, and variable comb filtering, into various individual sounds.

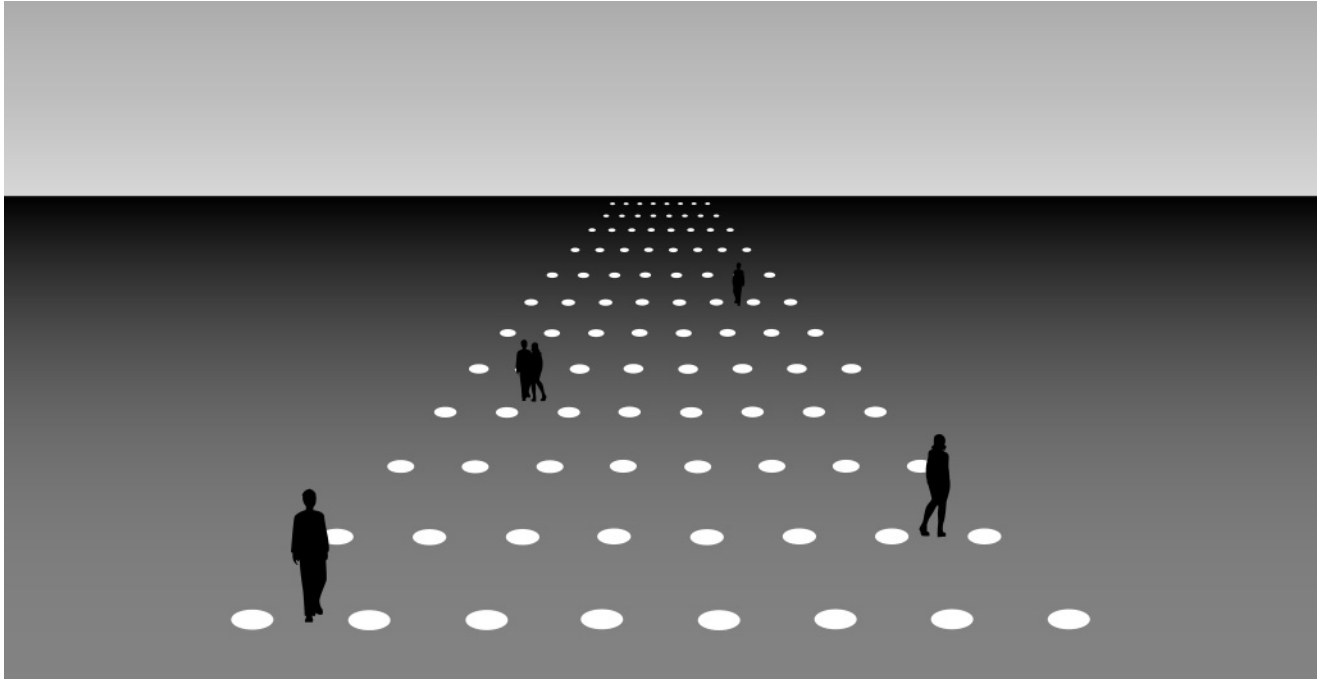
The sounds of the composition originate from several sources: a cello, multiple types of flutes, a human voice, synthesized noise, and several kinds of percussion instruments. Several hundred sound samples were obtained from recordings of the sound sources, which were then used in the creation of the piece.

The composition was rendered and mixed using the audio programming language Csound. Each of the 26 sections was rendered independently to one or more multichannel, interleaved sound files of varying channel counts. Then the whole piece was mixed and rendered to a full-length, 96-channel, interleaved sound file. Csound proved useful because

the `diskin2` opcode, in array-output mode, does not have a limit to the number of channels (Varga 2005). When rendering multichannel content to a file in Csound, however, only a single, interleaved file can be created, rather than multiple monophonic files (McCurdy and Heintz 2015), hence the aforementioned use of the interleaved sound files. The fully mixed 96-channel sound file was split into its 96 unique constituent sound files, and each sound file was loaded onto its respective tablet.

At concert time, each tablet begins playing its individual sound file simultaneously, thus commencing a performance of the piece. In another publication I have given further details about the compositional methodology of the work, the rendering and mixing of the piece, and the multichannel playback system (Moeller 2017).

Figure 2. Illustration of all 96 units laid out on a field (not to scale).



Point-Source Spatialization

Point-source sound spatialization refers to a one-to-one correspondence between sound and sound source (i.e., the spatial position from which the sound travels during a performance; cf. Burns 2006; Hagan 2017, p. 36). It is achieved by using monophonic sound reproduction methods to route each sound signal to a single loudspeaker at a time (Roginska 2018, p. 91), and thus each audio output channel is unique. The sound is perceived as emanating from the location of the loudspeaker from which it is emitted (Geluso 2018, pp. 63–64). Point-source spatialization has also been referred to as multichannel monophony or polyphony (Baalman 2010, p. 211). It contrasts with the variety of virtual sound-source positioning methods in existence, such as binaural, stereo, multichannel, and sound-field reproduction methods (Boren 2018).

A concern that potentially arises when using point-source spatialization is the number of available spatial positions in terms of angle and distance

between listener and sound source, since there are only as many spatial positions as there are loudspeakers, as noted by Chowning (1971, p. 2). If a creator deems spatial resolution to be an issue, the solution in this case is to increase the number of sound sources. For example, the 96 loudspeaker positions of *First Vision* provide significant spatial options in terms of angle and distance.

A characteristic of point-source spatialization is consistent spatial perception regardless of listener location. In other words, a sound source will remain firmly fixed in its perceived location (or trajectory, if moving) regardless of the listener's position. This is in contrast to the collection of virtual sound-source positioning methods that are dependent on the listener's position and result in an optimal listening zone commonly referred to as a "sweet spot" (or "sweet area" in the case of wave-field synthesis), where the fidelity of the intended spatial image is the greatest. There is no need for listeners to remain in an optimal listening area when using point-source spatialization techniques (Baalman 2010, pp. 211–214). For instance, audience members can listen to

First Vision from any position and the sound-source locations remain perceptually anchored in place.

By knowing that the sound-source locations will be consistently perceived, it is possible to confidently use space to convey the meaning of a piece. As mentioned, the work *First Vision* is a sonic depiction of the theophany of Smith, and thus I placed aural representations of the elements of Smith's account in spatially significant areas, where they can interact musically and spatially in service of the portrayal of his narrative.

Another feature of point-source spatialization is the elimination of the perception of constructive and destructive interference found in loudspeaker-based spatialization systems that reproduce correlated signals from multiple loudspeaker positions. The interference patterns in such cases are particularly audible to listeners moving in relation to the loudspeakers. Additionally, point-source spatialization eliminates the possibility that a correlated signal reproduced from multiple points in space could result in differences in the time of sound arrival due to listener location. Such differences can create deviations from the intended spatial image through image shift or the precedence effect (Kendall 1995).

Sonic Sculpture

I find myself thinking of sculpture in the round when I consider music and sonic art that consists of point sound sources through which a listener can physically navigate. I observe how such works can be listened to from any angle, because all listening positions are valid (note how this contrasts with compositions that have a sweet spot, as described earlier, but also with any music in which the listener cannot move freely among the sound sources). I contemplate how listeners experience something different, depending on their position in space. I sense how the sounds themselves are organized into a navigable acoustic sculpture that has structure and form. Janet Cardiff, who used point-source spatialization for her rendering of Thomas Tallis's *Spem in Alium* (ca. 1570) in her

40-channel installation *The Forty-Part Motet* (2001), wrote:

While listening to a concert you are normally seated in front of the choir, in traditional audience position. With this piece I want the audience to be able to experience a piece of music from the viewpoint of the singers. Every performer hears a unique mix of the piece of music. Enabling the audience to move throughout the space allows them to be intimately connected with the voices. It also reveals the piece of music as a changing construct. As well, I am interested in how sound may physically construct a space in a sculptural way and how a viewer may choose a path through this physical yet virtual space (Cardiff 2017).

Size of the Performance Area

In *First Vision*, a listener cannot hear the entire piece from a single location. In other words, a listener in one area cannot hear what a listener on the other side of the field can hear and vice versa, because of distance. When reflecting on the previous sculptural analogy of traversable sonic works, this may be compared to a sculpture that cannot be seen all at once owing to its size. This manifestly provides an additional dimension of artistic expression that is unavailable in works that can be listened to from a single position, namely, sounds can occur at the same time in different places that are only heard by those listeners near the respective sound sources. This also underscores and amplifies the idea, articulated by Cardiff and myself, that audience members can have a different experience from each other, depending on their chosen path through space.

Stasis and Dynamism

Cardiff's phrase "changing construct" is worth exploring in greater depth. The sound sources of her

Table 1. Combinations of Dynamism and Stasis

	Content	Sound Position
1	Static sound content	Static sound position
2	Static sound content	Dynamic sound position
3	Dynamic sound content	Static sound position
4	Dynamic sound content	Dynamic sound position

work remain fixed in position, but their content is dynamic throughout the work, thereby creating a sonic sculpture that changes over time. The phrase “changing construct” may not necessarily apply in the case of Peter Ablinger’s installation *Weiss/Weisslich 15* (1995), described later, as the sounds are static both in content and in position. Nevertheless, listeners can have a distinct experience because of the particular path they each choose through the installation. On the other hand, the term can certainly be applied to *First Vision*, as the sound sources in *First Vision* are dynamic in content and in position.

To be clear, in this article I am referring to sound content that is perceived as static due to uniform randomness or persistent periodicity (i.e., perceptually stationary processes), or to sound content that is perceived as dynamic due to a perceptible temporal trajectory in its nonspatial aspects such as timbre (Roads 2015, p. 311). Additionally, I am referring to sound-source position that is fixed in space or, conversely, not fixed in space (whether by changing channels or by physical movement of the sound source).

Contemplating these opposites of stasis and dynamism in both sound content and sound position, we can conceive of four total combinations of these pairs of opposites (see Table 1).

All but one of these combinations—namely, static sound content with static position—provide a changing construct in sound. All of these combinations nevertheless provide listeners with the opportunity for a unique sonic experience due to each listener’s position and trajectory, assuming listeners are able to navigate freely throughout the work.

Cardiff’s *The Forty-Part Motet*, Ablinger’s *Weiss/Weisslich 15*, and my work *First Vision* represent three different combinations of stasis and dynamism. Using the numbering in Table 1, these are combinations 3, 1, and 4, respectively. The remaining combination includes works that are composed of static sound content where the sound sources dynamically change position. Such works, specifically for mobile audiences, are relatively rare in the literature. It represents an area of potential future research.

Alvin Lucier does not allow audience members to move freely within the performing space during a performance of his work *Vespers* (1969), because that would conflict with the players moving throughout the space (e-mail correspondence with the author, October–November 2017). Still, the work is a useful model for exploration. Upon initial inspection, the composition appears to be a representative of combination 2—moving sound sources that consist of static content (albeit without the mobile audience members). During a performance of the composition, blindfolded performers navigate through a space with hand-held echolocation devices that emit directional clicks. The devices are called Sondols (a portmanteau of the words “sonar” and “dolphin”). The primary intent of the work is to articulate the space and the objects therein through the changing echoes that are perceived (Lucier and Simon 2012).

There are two sources of sound-content dynamism in Lucier’s work, however—the latter of which demonstrates an important aspect about moving sound sources. The first is potential dynamism in the sound content itself—specifically, the performers are instructed to change the click speed and perhaps even silence their Sondols if necessary to aid in echolocating, although they are expressly instructed not to change their Sondols for aesthetic purposes (Lucier and Simon 2012). The second is dynamism in the way the sound content is perceived, namely, if the position of a sound source changes, the acoustic response of the space changes accordingly. In other words, even if the sound-source content is static, a listener will perceive a change in the sound content because of the response of the space (barring a space free of sound reflections). It

should also be noted that acoustical effects such as Doppler shift can occur with moving sound sources, which is another potential source of dynamism in otherwise static sounds.

Continuing the Sculptural Metaphor

Recalling the sculpture analogy from the previous section, there are various types of physical sculpture that correspond to the four combinations listed in Table 1. We can easily recollect a whole range of physical sculptures that are fixed in substance and form, coinciding with static sound content and position (combination 1). On the other hand, we can also picture a spectrum of physical sculptures that correspond to the remaining three combinations of static and dynamic content and position. For example, we can call to mind a kinetic sculpture such as Calder's mobile, *Big Red* (1959), correlating with static material and dynamic position (combination 2). We can think of an earthwork sculpture such as Robert Smithson's *Spiral Jetty* (1970) connected to dynamic content and static position (combination 3). In Smithson's work, the form of the sculpture remains relatively constant (although it is subject to erosion), but the material changes comparatively rapidly through environmental forces, such as salt encrusting the rocks. Finally, we can envision a whole host of ephemeral sculptures whose material both moves and changes, corresponding to the category of dynamic content and dynamic position (combination 4). This would include various types of sculpture made from fog, pyrotechnics, and so forth, such as Fujiko Nakaya's *Fog Sculpture* #94925 "Foggy Wake in a Desert: An Ecosphere" (1982).

Comparing navigable sonic works to a variety of types of physical sculpture-in-the-round is an analogy intended to illustrate the three-dimensional nature of such musical works. It illustrates sonic works through which the listener can navigate, as opposed to works that depict a spatial scene that can only be observed. It also provides a potential source of inspiration for future compositions. For example, enumerating the possible combinations of stasis and dynamism in sound content and position provides

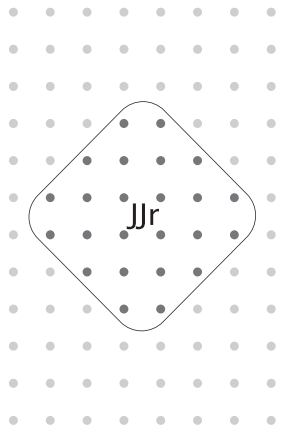
a creative springboard for additional works; specifically, it reveals possibilities in three-dimensional sound art for mobile audiences that a prospective creator may not have previously considered.

Mapping the Space

In a work such as my composition *Life* (2008), which is also for a nonstationary audience, the position of nearly every sound type remains fixed throughout the entire composition. *Life* has been presented in two versions: as a 30-channel version for a mobile audience, and as a binaural walkabout recording; all references in this article refer to the 30-channel version. The sounds are dynamic in content, but they remain in the same physical location (Moeller 2011, pp. 38, 40). In such an instance, it is expected that members of the audience can each create their own mental map of the sonic scene. In other words, as they travel throughout the performance space, they potentially become aware that if they listen in one area they will experience a certain sound type, whereas if they go to another area they will experience another sound type, and so forth. It is certainly not essential, however, for audience members to actually do this when experiencing *Life* to understand the piece.

Conversely, knowing the spatial positions of the sounds in *First Vision* contributes to the audience members' understanding of Smith's narrative. As mentioned previously, I put sonic depictions of elements of Smith's account in spatially significant areas, where the elements could interact spatially and musically in the re-creation of his narrative. The positions of the different sound types do not remain static throughout the entire work, however. As the narrative unfolds and the scenes change, sound elements are introduced, disappear, and change position. Thus, the creation of the aforementioned mental map is essentially impossible without listening to and experiencing the piece multiple times. Therefore, a listening guide is provided for each audience member (Moeller 2016b). The guide has information about the spatial layout, along with illustrative maps. The guide also contains information about each section: the section number and section

Figure 3. A selection from the listening guide to First Vision.

<p>Section 14 (29:00)</p> <p>Whispered text</p> <p>At length I came to the conclusion that I must either remain in darkness and confusion, or else I must do as James directs, that is, ask of God. I at length came to the determination to "ask of God," concluding that if he gave wisdom to them that lacked wisdom, and would give liberally, and not upbraid, I might venture.</p> <p>Snippets from 0.7 to 1.0 seconds in length of whispering appear in each loudspeaker. A Doppler shift and rapid rise and fall in amplitude are applied to each snippet. The base pitch of each selection varies within -200 to +1100 cents from the original pitch. The temporal position of each of the sounds in each channel is according to a uniform distribution. At the end of this section, all the sections that are related to whispering come to a close.</p> <hr/> <p>Section 15 (32:00)</p> <p>Bass flute, alto flute, concert flute, quena, and recorder</p> <p>So, in accordance with this, my determination to ask of God, I retired to the woods to make the attempt. It was on the morning of a beautiful, clear day, early in the spring of eighteen hundred and twenty. It was the first time in my life that I had made such an attempt, for amidst all my anxieties I had never as yet made the attempt to pray vocally.</p> <p>After I had retired to the place where I had previously designed to go, having looked around me, and finding myself alone, ...</p>	<p>Joseph's sound begins once again. It fades in over a period of forty-five seconds. It emerges in twenty-four speakers in the center of the field. The sounds were generated as described previously, using the same fundamental pitch (i.e., B_2). However, the lower and upper bounds of the random-walk process, described in Mvt. I, begin at 2 and 6 and increase over time according to the shape of an exponential curve until they reach 28 and 32 by the end of Mvt. II.</p>  <hr/> <p>Section 16 (35:00)</p> <p>Glockenspiel</p> <p>... I kneeled down and began to offer up the desires of my heart to God. ...</p>
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start time (in minutes), the constituent sound types, the accompanying text from Smith's account, and the compositional method (see Figure 3).

A composer may choose to provide a map of the space even when the position of the sounds is fixed and even when the content of the sounds is essentially static. For example, Ablinger provides a map for visitors of his installation *Weiss/Weisslich 15*. Similarly to *Life*, the sound-source types remain fixed in place, and they are even delineated by separate rooms. But unlike *Life*, the content of the sound sources is perceived as static. Thus, we see that the desire of a composer to provide a map to

the audience members is not based solely on stasis or dynamism of the content or the position of the sounds, but on the composer's desire to transmit information about spatial position (see Figure 4). Ablinger's work is described as follows:

Five successive gallery rooms, each leading on to the next by a single door, have been fitted with loudspeakers, which are fed by one CD player each. The five vowels, a, e, i, o, u, were employed in the studio to colorize the noise resulting in five CDs of noise, each colored by one vowel. A noise colored by one vowel can

Figure 4. Ablinger's
Weiss/Weisslich 15 in 2008
at the Haus am Waldsee in
Berlin. (Photograph by
Maria Tržan.)



be heard in each gallery room. The volume is reduced in such a way as to make the noise barely discernible, unless one goes in search of the noise, perhaps on account of one of the information sheets on a music stand in the center of the room. (Scheib 2003)

Choosing a Performance Space

A sculpture created of sound waves is not visible to the eye, although elements of it may be, such as the sound sources and the physical effects caused

by the sounds. Additionally, the emotional effects of the sounds on the listeners may also be visible (Roads 2015, pp. 35–36). On the other hand, the physical space surrounding the sonic sculpture is visible and tangible—and the nature of that space impacts the perception of the sonic sculpture. There is a reciprocal relationship between a sonic artwork and the space in which it resides: The acoustics of a physical space are not evident unless there is sound energy present, and the perception of the sounds is subsequently impacted by the nature of the physical space. Aspects such as reverberation, resonance (including room modes and resonating

objects), ambient sound, aesthetics, and symbolism must be taken into consideration.

It is widely acknowledged that recorded sounds are affected acoustically by the space in which they were originally captured, as well as by the equipment with which they were recorded (Roads 2015, pp. 240, 242). Additionally, it is recognized that a whole range of spatial effects can be embedded directly into sounds through signal processing, as was done in *First Vision*.

When selecting a performance venue, a composer will take into consideration these factors and how they will affect the perception of the work. Performances of Cardiff's *The Forty-Part Motet* have taken place in a variety of reverberant spaces, and such spaces are congenial to the choral nature of the work (Cardiff 2017). In e-mail communication with the author (10–12 May 2017) Ablinger stated his preference to have *Weiss/Weisslich 15* installed in rooms that are matched in terms of size and reverberatory characteristics. Performances of my piece *Life* take place in a space where the reverberation time is sufficiently short, thereby increasing the probability that the sounds are readily localizable (Moeller 2011, p. 40). Lucier states the following about the performance area for his piece *Vespers*:

Play . . . indoors, outdoors, or underwater. . .
In empty spaces, objects such as stacked chairs, large plants, or human beings may be deployed (Lucier and Simon 2012, p. 16).

My work *First Vision* is intended to be performed outdoors, where the intent is to obtain an acoustically free-field condition. The aim is to avoid acoustic reflections that cause reverberation and resonances. This allows each sound source to be discerned with a minimum of exertion and ensures that certain areas of the frequency bandwidth are not unduly reinforced. The ambient sounds of nature found outdoors are also welcomed, as they highlight the meaning of the piece.

Thus far, performances of *First Vision* have taken place on the East Lawn of Texas A&M University. The performance area is flat, without obstructions, and sufficiently far from the sounds of modern machinery. In terms of acoustics, the area approximates a free-field condition. The area was

also selected for its aesthetic appeal and its absence of obvious physical structures or objects that the listeners might inaccurately think are somehow significant to the piece.

As an additional point of interest, the premiere and second performance of *First Vision* took place in the morning in the summertime. The music began at 6:00 AM on both 4 and 9 July 2016. On each occasion, the concert began before sunrise and the sun emerged during the unfolding of the piece. This allowed the listeners to avoid the heat of the day. It also enabled listeners to connect the rising of the sun to the events of Smith's account represented by the composition in a symbolic way, potentially heightening the emotional impact of the performance. I felt this was appropriate considering the theophany depicted in the work.

Conclusion

This article has discussed several elements that pertain to multichannel compositions for mobile audiences. It demonstrates that point-source spatialization has certain attributes that can be viewed as advantageous in relation to such works. It shows that comparing such pieces to physical sculpture can be valuable for conceptualization and as a creative stimulus for future creations (cf. Lyon 2016, particularly 28:38–29:17). It describes how artists can provide maps for their navigable, spatial sonic art when they deem it important for the listener to know the location of sound events. Finally, it examines the importance of the performance space of such compositions and outlines a variety of types of spaces composers have selected and the reasons why.

Future Work

There are several areas in which to carry out future research in multichannel works for nonstationary audiences. As mentioned earlier, compositions comprised of static content that is dynamic in spatial position are relatively rare, and it is a domain of potential future investigation. Additionally, sculpture

has proved to be a useful analogy for navigable sonic creations, and yet there are other metaphors that can also be analyzed to provide further insight and inspiration, such as gardening and landscaping. This is a metaphor that some composers, such as Denis Smalley and Curtis Roads, have already touched upon and found value in (Smalley 2007, pp. 46, 49; Roads 2015, pp. 367–368). Furthermore, performance venues that consist of regions with contrasting acoustics are worth consideration—for instance, a navigable composition that is spread over a site that consists of both reflective indoor spaces and free-field outdoor areas. Finally, a logical extension of immersive sonic works is to simultaneously engage other senses. Such combinations are also a fertile domain for future exploration.

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