

Virtual Spaces: Spatial Characteristics as Compositional Tool and Performance Practice in the
Music of Jonty Harrison

Jon Fielder

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I. Introduction

The practice of sound localization in physical space is a topic that has been developed in compositional practices throughout history. It can be traced back to as early as Gabrieli's use of multiple spatialized choirs singing antiphonally, Heinrich Schutz's *Musikalische Exequien*, which used an elevated choir to represent rising to heavens, and into the 21st century with pieces such as John Luther Adams' *Inuksuit* in which an undefined number of percussionists are spread out in various locations in an outdoor listening space to fully surround the audience with sound. Since the early developments of *musique concrete* in 1948, composers of electronic music have been fascinated with space to the point that sound spatialization has become a compositional tool and performance practice **in** through live sound diffusion using multi-channel speaker arrays. The practice of live multi-channel sound diffusion and multi-channel electronic composition in fixed mediums has a long history spanning nearly 70 years with numerous theories of structure, aesthetics, craft, compositional practice and even the concept of space itself. Jonty Harrison, a composer who has written acousmatic music for live and fixed sound projection, has done a great deal of work in the field of acousmatic music research, theory and practice. This paper will focus on some of the work and theories of Jonty Harrison and analyze how his perception of space as a compositional construct has influenced his music. Other topics covered will include a brief history of the development of multi-channel diffusion systems, some discussion on the performative act of sound diffusion and its role in the construction and perception of acousmatic music (specifically as it relates to Harrison and his work), ending with a comparative analysis of three works by Jonty Harrison - *Klang* (1982), *Aria* (1988) and *Unsound Objects* (1995) - with specific attention paid to the role of space within the fixed medium and how that role impacts the perception of space and eventual diffusion.

II. Acousmatic Music and Space

Before any fruitful discussion of Jonty Harrison and his theories can take place, it is essential to have an understanding of the development of acousmatic music, the role of space in acousmatic music, and the manipulation of space that takes place during the presentation of the music in the listening space. The term acousmatic, or the French *acousmatique*, refers to music that is played through loudspeakers in a listening space. The term has its roots in the lectures of Pythagoras, in which he would lecture to his students from behind a curtain, forcing them to pay closer attention to his words and the meaning of his teaching free from any visual stimulation or distraction. The probationary students who listened to these lectures were referred to as the *akousmatikoi*, or “hearers.”¹ The term acousmatic in a musical sense is an adjective that describes music in which the source of the sound is not heard. This concept is a central tenant of acousmatic music, which itself is an outgrowth of the French *musique concrete* developed by Pierre Schaeffer and Pierre Henry in the late 1940s. The practice of *musique concrete* involves working directly with recorded sonic materials as opposed creating notation to be interpreted by musicians and experienced in real time. Schaeffer referred to the sonic materials created through manipulating recordings (often of “real-world” sounds, or traditionally non-musical sounds) as sound objects - the compositional elements and virtual instruments of *musique concrete*. In 1955, Jérôme Peignot and Pierre Schaeffer referred to the term *acousmatique* to describe the experience of listening to works of *musique concrete* on loudspeakers, which masked the source of the sound objects, and thus forcing the audience to pay close attention to the inherent qualities of the sounds themselves and their relationships to one another.

¹ Charles Kahn, *Pythagoras and the Doctrine of Transmigration: Wandering Souls* (London: A&C Black, 2011), Ch. 2, taken from electronic edition of the book without page numbers included.

In the late 1960s and into the 1970s, Francois Bayle became interested in the idea of localizing sound objects in space through carefully constructed arrays of multiple loudspeakers. Bayle, in an interview with Sandra Desantos, once said “I saw that one could decouple the sound, to make it appear to emerge from a deep space behind the loudspeaker, or to make sounds fly between loudspeakers at different rates of speed. I sensed in this new possibility a great opening for our aesthetic perception.”² This culminated with the invention of the Acousmonium in 1974, an orchestra of loudspeakers, today totalling nearly 80 speakers placed in front of and around the audience in various configurations depending on the performance situation. Bayle’s Acousmonium began a long-running interest in the manipulation of space using acousmatic music as the artistic medium in which composers worked.

The invention of the Acousmonium, and other multi-channel arrays like it that would later be constructed, brought about a new live performance element to the presentation of fixed media acousmatic music, that being live sound diffusion. It is important to make the distinction between fixed sound projection, in which the composer assigns streams of audio to specific speakers in a multi-channel setup, and live diffusion in which the composer moves a limited number of audio channels (typically 2-channel stereo) around a 3-dimensional array of loudspeakers. In sound projection the composer makes decisions about the spatialization of sound during the composition process and in a studio equipped with a multi-channel speaker setup can compose and listen to their music with spatialization as they want it at the same time the piece is being composed. Sound diffusion relies on the composer to make decisions about where to place certain sounds in real time with the idea that the listening space might not be

² Sandra Desantos, translated by Curtis Roads, “*Interview with Francois Bayle*,” *Computer Music Journal*, 21, no. 3 (1997): 14.

identical from one performance to the next. Certain considerations can be **make** about diffusion during the compositional process, but ultimately it is up to the composer (or diffusion artist) to move, place and localize sound in real-time during the presentation of the work. The topic of sound diffusion will be revisited with additional discussion of Jonty Harrison's own theories and practices of diffusion and projection.

The philosophies, aesthetics and practices of acousmatic music and multi-channel spatialization of sound originally formulated by Schaeffer and expanded by Bayle and Francis Dhomont are a central feature of the electroacoustic music of Jonty Harrison, as well as many other composers of electronic and computer music since the early 1970s. Harrison, however, for nearly 35 years has been a prominent practitioner of acousmatic music and a leading researcher in sound diffusion systems and the performance practice of sound diffusion itself.

III. Sound Diffusion Systems - The Construction of the BEAST

Francois Bayle's Acousmonium was an early example of a multi-channel diffusion system that gave composers the opportunity to create a 3-dimensional listening space and physically move their sound around an audience. The Acousmonium was centered on the concept of using pairs of speakers with variations in size, power and frequency response, resulting in an altered coloration of the aural perception of a sound when an identical signal is sent through different pairs of speakers with different characteristics. Jonty Harrison expanded on this idea after obtaining a teaching position at the University of Birmingham in 1980.³ In 1982 Harrison constructed the Birmingham ElectroAcoustic Sound Theater, or BEAST. The BEAST is a multi-channel sound diffusion/projection system containing nearly 100 loudspeakers that can

³ Jonty Harrison, "Jonty Harrison - Biography," *Musique and Recherches*, accessed 4/15/2016. <http://electrodoc.musiques-recherches.be/fr/c/190/harrison-jonty>

be controlled as discrete independent channels of audio. The BEAST is configured around eight primary speakers, referred to as the BEAST “main eight.”⁴ The main eight setup consists of four stereo pairs of speakers. The first are the near-field speakers, angled at $\pm 15^\circ$, the second are a pair of speakers are a wide-spaced stereo pair in front of the audience at $\pm \sim 30^\circ$, the third pair a set of distant speakers placed directly between pair one and pair two, but placed some distance behind them and angled $\pm 60^\circ$ (the idea being that they will reinforce the stereo image of the near-field pair while also providing a sense of distance) and the final pair being a rear stereo pair placed behind the audience angled at 45° . Additional speakers in the BEAST setup include speakers at the sides of the audience facing both inward and outward, speakers suspended overhead specifically for high-frequency content, a pair of “very distant” speakers at the back of the stage facing directly toward the wall, a pair of speakers in the front center of the stage facing 110° away from one another (called the “punch” speakers) and many others. It is important to keep in mind that while the speakers in the BEAST setup can be controlled as independently discrete channels, their setup (specifically the main eight configuration) is seemingly designed with the idea of left and right quadrants separated by a distant single front speaker and distant single rear speaker. The left and right setup on either side of the front left and right is completely symmetrical and lends itself well for the diffusion of stereophonic works which were composed in a smaller studio, possibly with only a left and right stereo pair. Harrison’s configuration of the BEAST setup allows for the diffusion of a stereo work on a larger space capable of more depth, but in which the perception of left and right is not lost, but is actually enhanced by the added dimensions of depth and vertical height.

⁴ Jonty Harrison “Sound, Space, Sculpture: some thoughts on the ‘what,’ ‘how,’ and ‘why’ of sound diffusion,” *Organized Sound*, 3, no. 2 (2000): 122.

The central feature of the BEAST setup and aesthetic principle driving it is that it allows composers the ability to manipulate and create a unique listening space for the audience. Jonty Harrison claims that his goal with BEAST was to restore the “spectral/spatial detail and the dramatic intensity of works which the acoustic properties of public performances spaces tend to distort.”⁵ Harrison is referring to the manner in which performance spaces can for acousmatic music (specifically a performance space utilizing only two speakers in a stereo configuration) are not always capable of capturing the dramatic and spatial qualities of the sound objects that make up a piece of acousmatic music. This can be due in part to the structure of the room, the placement of the speakers, the size and power of the speakers in relation to the physical space and the capability of a stereo pair of speakers to fully capture the spatial possibilities of sound and music within a physical space. By diffusing or projecting an acousmatic piece on the BEAST setup, Harrison has the opportunity to create new spatial relationships, create the perception of distance and height in addition to lateral spatialization/localization, and can create a fully immersive listening environment for the presentation of his works. This immersive environment is a space in which the audience is not only able to pick up on localization of sound objects and perceive moving sound, but also be fully enveloped in an imagined soundscape or cacophony of sound that cannot be experienced in a studio or on a pair of stereo monitoring speakers.

IV. Space and the Role of Diffusion

A. Compositional Space vs. Listening Space

In his 1991 article “Spatial Experience in Electro-Acoustic Music” Denis Smalley refers to the concept of the composed space and the listening space. The differentiation between these

⁵ John Palmer, “In Conversation with Jonty Harrison,” *eContact!*, 10, no. 2, accessed 4/15/2016, econtact.ca/10_2/HarrisonJo_Palmer.html

two spaces is that the compositional space is the environment in which a composer assembles and creates a piece of acousmatic music. This space is typically a studio capable of stereo playback, but possibly with a larger speaker configuration. In this space the composer makes decisions as to where sounds will be placed within a stereo or possibly limited surround-sound field. The listening space is the area in which the music will be presented in “performance.” However, as mentioned in the previous section, certain characteristics of acoustic performance spaces do not always lend themselves well for the presentation of an acousmatic work, especially one presented through a single pair of speakers.

Jonty Harrison has expanded on Smalley’s topic of composed space and listening and the issue they present for acousmatic composers. The distorted result that Smalley and Harrison refer to is what Smalley calls the “superimposed space.” To imagine what this distorted superimposed space would be like in an actual experience consider a sound that pans quickly from the right speaker to the left. As it moves quickly it also becomes lower in amplitude and takes on a brief reverb tail. The perception created is that the sound object is both moving laterally from right to left and simultaneously receding away from the listener (implied by the reverberation). Now imagine that this gesture was created in a composed space consisting of a stereo pair of speakers in a studio. The aural perception might be successful. However, in a large concert hall containing only a single pair of distantly spaced speakers, the effect of the sound moving laterally might be lost for those sitting too close to one speaker or the other. Additionally, anyone sitting closer to the rear of the space (farther away from both speakers) might hear the natural reverberation of the space fuse with the original signal and the reverb tail added artificially by the composer. In this situation the lateral movement of the sound object and the aural perception of distance is

completely lost. This is an example of “superimposed space” in which the originally intended gesture created in the composed space and intended for the listening space is superimposed in a natural space that does not allow for the dramatic shape of the gesture to fully take form, thus interrupting and distorting the musical discourse.⁶

B. Organic vs. Architectonic Musical Thinking

Jonty Harrison refers to two primary types of musical thinking - organic and architectonic - which represent the qualitative (organic) and quantitative (architectonic) elements that make up a composition.^{7,8} In many ways **out** thinking of instrumental music is primarily quantitative in nature. The concept of pitch, rhythm, duration, onset time, and dynamics (to a certain extent) are all qualitative components of a musical fabric. One could argue that the actual timbre of an instrument or the nuance of an articulation informs the qualitative nature of the sound. Harrison maintains that thinking in terms of the sound object in *musique concrete* and acousmatic music, composers are able to think in more qualitative ways, in terms of the quality and timbre of a sound object, the physical space in which it was recorded, any extra-musical characteristics it might have, the way the sound moves and other spectral and spatial characteristics of a sound object. These are all more organic ways of approaching musical thinking

Harrison maintains that many composers might be inclined to consider space an architectonic element of a composition, in that the performance space is a fixed venue over which the composer (and performers for that matter) have little to no control. In this regard,

⁶ Jonty Harrison, “Diffusion: theories and practices, with particular reference to the BEAST system,” transcript of a paper given at the 2000 SEAMUS Conference at the University of North Texas in Denton, TX. p. 3. No exact phrasing taken from the Harrison article, but the reference to moving sound distorted by a 2-speaker stereo setup in a large listening space is the central theme in the section subtitled “Diffusion - theory and practice”

⁷ Harrison “Imaginary Space,” *eContact!*, 3, no. 2 (2000)

⁸ Harrison, “Diffusion: Theories and Practices...”

Harrison is speaking primarily about the physical structure of the space and the space's inherent acoustical properties. Harrison also maintains that composers who consider space as a quantitative component run a great risk of becoming more engaged with the physical placement of sound. This can lead to an obsession with discrete spatialization in defined channels/speakers and the ultimate goal being that of obtaining the same perception of the piece in each performance. While this is possible in certain situations - specifically considering the double-diamond 8-channel configuration that is somewhat common in North America and Europe - in the situation of a stereo piece created in composed space, thinking of space as an architectonic component instead of organic, a space which can be manipulated and changed depending on the speaker configuration and size of the room, the composer runs a great risk of falling into the trap of superimposed space, resulting in a potential loss of drama and essential spatial and spectral relationships of the sound objects.

C. The Importance of Space

Composer Trevor Wishart refers to three interdependent components of "landscape" in his book *On Sonic Art*. These three characteristics are 1) the nature of the perceived acoustic space, 2) the disposition of sound objects within a space, and 3) the recognition of individual sound objects. Wishart's conclusion is that the idea of space and landscape is presenting acousmatic involves an understanding of the actual acoustic space in which the music is presented (the listening space), the disposition (or placement) of the sounds objects and the ability to recognize those sound objects within a landscape.

Harrison has presented his own version of Wishart's components of space in their relation to an acousmatic work. Harrison's components are 1) that musical space of sound

material has a bearing on spatial considerations in performance, 2) the placement of an object in both compositional and listening spaces, 3) the concept of “environment,” as it relates to original field recordings and the environment in which they were captured, and 4) the composer’s actual intentions involving the three aspects as realized in a public diffusion performance.⁹ For Harrison the fourth component is crucial and that a faulty diffusion performance could distort the intended perception of the space and the manner in which sound objects interact with the space and with each other, resulting in a weakening of musical discourse.

It is important to note the first element in Harrison’s list of components deals with the inherent space contained within a sound object. The fact that it is first on the list does not necessarily lend it more weight, but one could infer that inherent space is a crucial component in Harrison’s consideration of his materials and how they will be arranged into composed space and the final listening space. In addition to the spatial characteristics of sound objects, Harrison also refers to the “environment” in which the sound was recorded (in a dry studio, outside, in a stairwell, etc.) which creates the connotation of a pre-existing space that should not be ignored. One method Harrison employs to ensure that the inherent space of a sound is captured is that all of his source recordings are made in stereo.¹⁰ By always recording in stereo the composer is always guaranteed to capture any subtlety or nuance in the spatial characteristics of a sound, or how the spatial characteristics of the source in relation to microphone impact amplitude and/or frequency content of a source recording.

⁹ Harrison, “Imaginary Space”

¹⁰ Palmer, “In Conversation...” This method of recording entirely in stereo was also a topic of discussion in Jonty Harrison’s keynote address at the 2015 International Computer Music Conference at the University of North Texas in Denton, TX, at which this author was present.

Harrison also places a lot of weight on the live diffusion aspect of presenting acousmatic music. It was mentioned earlier that a more organic mode of musical thinking might lead a composer to live diffusion as a performance practice to gain better control and manipulation of a listening space. Careful attention must be paid to the placement of sounds, the immersiveness of the space, quantitative and qualitative characteristics of the sound object, and ultimately, how those sound objects are used to create an engaging sonic environment through manipulation of a listening space. The following section will look at how these spatial considerations are manifested in three works by Jonty Harrison.

V. Analyses - *Klang*, *Aria* and *Unsound Objects*

The following analysis will examine three acousmatic works by Jonty Harrison written between 1982 and 1995. The analyses will include a discussion of the sound sources and formal aspects of the piece and how space plays a central role in the presentation of the sound objects. Some possible speculations on how select could be diffused will also be provided.¹¹

Klang, the earliest of the three compositions, composed in 1982, is a piece that explores the sonic characteristics of earthenware casserole bowls. The piece consists of two primary sound sources - attacks with resonance from striking the bowls and a constant rolling sound from rotating the lid inside of various bowls. Other sounds sources are used, but all share a clangorous metallic timbre with rich overtones and resonances.¹² *Klang* was originally conceived in 1981 and was composed in 1982, the same year that BEAST was fully constructed. Given the time it

¹¹ My conjectures about the potential diffusion plan for *Klang* and *Aria* are not based on experience or research, but only from the context of Harrison's own writings on diffusion, and are offered only as a guide for imagining how composed space could become organic listening space. However, discussion of diffusion practices for *Unsound Objects* is based experiencing the composer diffuse the piece live on a 24-channel multi-channel array at the 2015 International Computer Music Conference at the University of North Texas.

¹² Prefatory notes of *Evidence materielle*. IMED 0052. 2000.

was written it would be reasonable to believe that *Klang* might not have been composed with the eventual diffusion on the BEAST setup, but instead composed it as a stereo tape piece. However, one can still hear how the influence of space plays a central role. The opening attacks with resonance and rolling sounds immediately evoke images of bowls and/or plates being struck and lids rolled around, and that powerful image is enhanced by the inherent spatial qualities of the sound object itself. After an introduction of sharp attacks there is a single attack with a long resonance at 0:25, at wherein the entire stereo field is covered by a single layer of sound. Leading to this point there are short attacks, but all specifically localized. Moving forward all attacks with an audible resonance through the end of the introduction fill up the stereo field. One could imagine these being the first instance of diffusion out of multiple speakers, as if to immerse the audience in the resonance, essentially putting them inside of the bowl, an imagined but implied space. The rolling and scraping sounds also occupy a portion of the field just left and right of center and very clearly imply the sound of a rolling lid back and forth. The “Development 2” section of the work starting at 3:55 presents another set of sound objects with clear spatial characteristics. The two primary layers are the sound of the constant rolling back and forth in combination with high-frequency resonant synthesized drone. Both of these sounds move back and forth across the stereo field slowly with a Doppler shift each time the sounds reach the right speaker, falling in frequency slightly as they reach the left. Sharp attacks are presented over this layer in localized places within the stereo field. These sounds move into the Development III section as very resonant heavily processed attacks with the same spatial characteristics. Leading into Development IV the resonant processed attacks become granulated noise and saturate the frequency spectrum and stereo field. One could imagine this being the

climax of the piece in which all sound is projected from all speakers to create a fully immersive environment.

Aria, composed in 1988, six years after the creation of the BEAST, is an acousmatic work that explores “elaboration[s] on a gust of air.”¹³ The thought of a gust of air immediately implies a sense of motion as air needs to move from one location to another, and with a relatively high velocity, in order to be perceived. Harrison interrupts the gusts of air with what he refers to as “garden[s] of relative stasis,” which come in the form of processed sounds of an outside natural environment. The gusts of air have an inherent sense of motion, but Harrison enhances the sense of motion through the use of rapid panning and Doppler shift applied to the gusts as they move across the stereo field. The rapid energy of the gusts combined with interruptions of spectrally processed crescendo/decrescendo gestures creates a stark contrast when compared to the “gardens,” which are more placid. The difference between these sound worlds could be further demonstrated by the use of careful diffusion creating localized sound in the gust gestures and enveloping the audience as the “garden” texture takes over during the second half of the composition. This method of diffusion and focus on space helps craft a musical narrative in which the rapid, localized embellished gusts are swallowed by the more immersive garden environment. Whether or not this is what the composer intends to show with the spatial characteristics built into the piece in the composed space is not to be determined here, but should be left to the experience of the live diffusion performance of *Aria*.

Unsound Objects, composed in 1995, explores the idea of the “sound object” as defined by Pierre Schaeffer in the 1950s, the building block of *musique concrete*. *Unsound Objects* is

¹³ Prefatory notes of *Articles indefinis*. IMED 9627. 1996.

primarily an exploration of how as listeners we can divorce meaning from sound and begin to draw new connections, interconnections and meanings between sounds. This piece, like the previous examples, also explores the spatial characteristics of the sound objects which are enhanced through a live diffusion performance. From the onset of the piece every sound is localized to the right or left portion of the stereo field, or some slight deviation from the center. The individual sonic events move rapidly and change slightly in timbre, resonance and reverberation throughout. These gestures become more dense, eventually leading to a climax at 4:40. At this point in the piece a resonant granulated sound emerges to a piercing amplitude and is quickly cut off by the sound of a thunderstorm. The resonant granulation begins to be re-introduced during the thunderstorm. One interesting aspect of this transition is that the thunderstorm seems underwhelming following the resonant granulated gesture, which is fairly dry and present in the overall spatial image. When the thunderstorm begins it is perceived as being a natural environment, an extreme contrast of what came before. The start of the storm also presents a drop in amplitude, which also makes the moment somewhat anticlimactic. However, in a live diffusion situation, most of the sounds leading from the beginning to the thunderstorm entry are placed in specific localized speakers in the entire listening space.¹⁴ As the resonant granulation swells the entire space begins to fill and on the first thunderclap the entire space is filled with sound from all speakers wavering slightly in intensity, acting as an almost overwhelming climactic moment. In order for this gesture and arrival to have the perception of moving from one artificial space into a perceived “real” space that was louder than anything that came before the composer had to reduce the amplitude of the thunderstorm arrival to make up for

¹⁴ This discussion of *Unsound Objects* is in reference to the live diffusion performance at the International Computer Music Conference in which Jonty Harrison diffused on a 24-speaker system that modeled a subset of the BEAST setup.

the dramatic increase in amplitude that accompanies diffusion out of 24 speakers as opposed to 2 in the composed space. There are numerous examples of this kind of manipulation of space throughout *Unsound Objects*, wherein specifically located and moving period gestures seem to meander around the listening space even in the stereo version. One can only imagine the number of possibilities that this effect could be enhanced with the aid of successful live diffusion.

VI. Conclusions

The information provided in the previous sections demonstrates the important role that space plays in the presentation of acousmatic music, but by exploring some of the theories and philosophies of Francois Bayle, Denis Smalley, and most importantly for this paper Jonty Harrison, one can understand how space also plays into the compositional method of *musique concrete* and acousmatic compositional. Jonty Harrison's fascination with space does not begin with the concert presentation of an acousmatic work, but is a basic **tenant** of his working method from the recording of his sound objects to the live diffusion performance that is used to depict his musical narratives. The spatial characteristics of the sound objects influence how the composer grapples with composed space, which ultimately influences how he thinks of the eventual listening and performative space.

References

- Anderson, Elizabeth. "Interview with Annette Vande Gorne." *Computer Music Journal* 36, no. 1 (Spring 2012): 10-22.
- Bayle, Francois. *Musique acousmatique, propositions... ..positions*, François Bayle, Paris, 1993, Bibliothèque de recherches musicales, Ina-GRM-Buchet/Chastel.
- Desantos, Sandra. Translated by Curtis Roads. "Acousmatic Morphology: An Interview with Francois Bayle." *Computer Music Journal* 21, no. 3 (1997) 11-19.
- Emmerson, Simon. *Living Electronic Music*. Farnham, UK: Ashgate, 2007.
- Harrison, Jonty. *Articles indefinis*. empreintes DIGITALes. IMED 9627, 1996. CD
- _____. "Diffusion: theories and practices with particular reference to the BEAST system." *eContact!* 2, no. 4 (1999), accessed April 4, 2016, http://econtact.ca/2_4/Beast.htm
- _____. *Evidence materielle*. empreintes DIGITALes. IMED 0056, 2000. CD
- _____. "The Final Frontier?" *eContact!* 14, no. 4 (2014), accessed April 4, 2016, http://econtact.ca/14_4/harrison_spatialstrategies.html
- _____. "Imaginary Space," *eContact!* 3, no. 2 (2000), accessed April 15, 2016.
- _____. "In Conversation with Jonty Harrison," *eContact!*, 10, no. 2 (2008), accessed April 15, 2016.
- _____. "Sound, space, sculpture: some thoughts on the "what," "how," and "why of sound diffusion." *Organized Sound* 3, no. 2 (1998) 117-127.
- Kahn, Charles, *Pythagoras and the Doctrine of Transmigration*
- Smalley, Denis. "Spatial Experience in Electro-acoustic Music," in *L'Espace du Son II. Special Edition of Lien: revue d'esthetique musicale*, 1991, pp 121-124
- _____. "Spectromorphology: Explaining sound-shapes." *Organised Sound*: 2, no. 2. (1997) 107-126.
- Tutschku, Hans. Translated by George Goodman. "On The Interpretation of Multi-Channel Electroacoustic Works on Loudspeaker Orchestras: Some Thoughts on the GRM Acousmonium and BEAST." Updated 2016, accessed April 4, 2016. <http://www.tutschku.com/content/interpretation.en.php>
- Vande Gorne, Annette. Translated by Julien Guillamat. "Space, Sound and Acousmatic Music: The Heart of the Research." Unpublished research paper, accessed April 4, 2016. https://www.academia.edu/9065377/Space_sound_and_acousmatic_music