

From Stethoscopes to Headphones: An Acoustic Spatialization of Subjectivity

Charles Stankieveh

*Get out of my mind. Get out of the room. Get out of my mind.
Get out of the room. . .*

—Bruce Nauman [1]

Continuing the trajectory of listening first established by the medical stethoscope, this essay discusses the role of headphones in shaping our acoustic perception of the world and the resulting spatial organization of our subjectivity. Instead of considering (a) the social relations of sound reproduction, as is the norm in the humanities and cultural studies [2], or (b) the “high fidelity” of headphone technology in scientific R&D and consumerist desire [3], this essay considers the psychoacoustics of headphone space from a phenomenological and topological position. In particular, I explore the strange effect of “in-head” acoustic imaging, which is usually deemed a “noisy” (or unwanted) artifact of technology.

A survey of literature on the topic reveals that little is written on the history and development of headphones compared to the length of their use (exceeding that of motion pictures, for example) and their present ubiquity in several fields, ranging from the military to the arts and from broadcasting to medicine [4]. The first part of this essay traces the history of modern listening as developed by the stethoscope and the technical system maintained with headphones. The second part presents three sound artists who work creatively with headphones to produce peculiar spatial results. In the 21st century, Bruce Nauman may be crying for us to get out of *his* mind, but he and other sound artists are wanting more and more to get into *our* heads. What matters is not only what they are saying, but how they are saying it.

INTERIORITY OR IN-HEAD?

From the 20th century on, the concept of “interiority” has been treated with suspicion in many areas of science and philosophy. Ironically, as current neuroscience theories advance a bottom-up conception of consciousness, the ubiquity of headphones creates an effect reminiscent of Descartes’ error: the location of “the seat of soul” in the pineal gland. However, we need not look at current theories for a debunking of the “seat of the soul” concept. Thinking concurrent with the development of the stethoscope and the invention of headphones already expressed these contemporary objections. One of the strongest critiques came from Merleau-Ponty’s elegant re-

working of Husserl’s notion of phenomenology, where the starting point lies in the subject embodied in the external world of the everyday. In this context, the term “interior” itself becomes a pejorative. As Merleau-Ponty pointed out, the idea of interiority arises partly out of a historical and religious tradition expressed in Christian mystical language, such as in Saint Augustine’s *interiore homine*. However, Merleau-Ponty famously disagrees with Augustine’s conception: “Truth does not ‘inhabit’ only the ‘inner man,’ or more accurately, there is no inner man, man is in the world, and only in the world does he know himself” [5]. “Interiority,” however, is not solely the product of religion nor a derelict relic of it. What would it mean if, instead of conceptualizing interiority as a mystical utopia (or non-place), we were to think of interiority in either a Cartesian or even perhaps non-Euclidian sense? Our first step lies in considering what it means to conceive of a space that is not necessarily out in the world but in one’s head. I am not referring here to what the “mind’s eye” sees, but rather the spatial possibility of what acoustic engineers call “in-head” acoustic imaging. To experience such a phenomenon, a certain tool is needed: headphones.

A modern technological prosthetic, headphones are quite literally a bracketing of the world for a precise analysis of sound, allowing for a focused investigation into a “phenomenology of interiority” [6]. For with headphones, a unique

ABSTRACT

Working from a phenomenological position, the author investigates “in-head” acoustic localization in the context of the historical development of modern listening. Starting from the development of the stethoscope in the early 19th century, he traces novel techniques for generating space within the body and extrapolates from them into contemporary uses of headphones in sound art. The first half of the essay explores the history, techniques and technology of “in-head” acoustics; the second half presents three sound artists who creatively generate headphone spatializations. The essay ends with reflections on how these sound “imaging” techniques topologically shape our subjectivities.

Fig. 1. With binaural stethoscopes the experience of “in-head” acoustic imaging first became possible. (Courtesy the Osler Library of the History of Medicine, McGill University)



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Fig. 2. Koss SP-3 Stereophone, 1958. (© Koss Corporation) The first commercially available stereo headphones, which allowed for spatial manipulations of sound within the head.

acoustic experience can be created, unlike anything else in the history of listening—except, that is, for its immediate precursor: the stereo stethoscope [7]. It follows that the stethoscope deserves attention for its creation of a *technique* of listening that continues in the *technology* of headphones.

FROM THE STETHOSCOPE TO HEADPHONES: CONSTRUCTING INTERIOR SPACES

A brief history of the stethoscope allows us to determine two important attributes of the development of modern listening materialized in headphones. First, we can determine the difference between *listening* to an interior space of the body and *creating* an interior space in the body. Second, we can locate the technique of listening with headphones within the longer historical evolution of modern audition. Collecting the research of several philosophers and medical historians, Jonathan Sterne's historical narrative of sound reproduction includes the history of the stethoscope as a pivotal artifact in the development of modern listening. From this perspective, the 1816 invention of the stethoscope becomes the site where cultural techniques of listening were both developed and reified. Working mainly from R.T.H. Laennec's *Treatise on the Disease of the Chest and on Mediate Auscultation* (1819), Sterne constructs a history of doctor-patient relations, medical epistemology and listening practice. Crucial to his research is the observation that the medical paradigm shifted from listening to the *meaning* of the voice as a bearer of truth to studying the *sound* of

the voice as truth in itself. In other words, instead of doctors listening to patients describing their maladies with speech from their mouths, the stethoscope fostered a different engagement with the patient by allowing attention to the voice's sonic quality as it resonated in the body: "The pure voice becomes a kind of sound effect—a container of timbre and an index of the states that shaped it." Focusing, intensifying and isolating the sound of the internal body with the stethoscope created an increased valuation of sound in medicine. The interior of the body was listened to with great care, because the "whole thorax becomes a kind of resonating chamber; the lungs especially become like the interior of an instrument" [8].

While the stethoscope provides a shift in patient-doctor relations, it also creates a new sonic frame that was previously unheard—literally. The binaural stethoscope provided the first means of "in-head" acoustic imaging. I refer not to listening to the interior of the patient's body (which is actually the old practice of auscultation, dating back to Hippocrates) but rather to the reconstruction of the doctor's psychological image of his own body and his resulting consciousness. With the use of the binaural stethoscope (and subsequently with headphones) a sound field can be virtually located within the head. More accurately, *space is created within the mass of the body where sound masses float in an impossible space*. This image makes us think of a similar situation described only a few years previous to the invention of the stethoscope. I am referring to G.W.F. Hegel's description of the "night of the world"—the poetic description of the birth of the subject based upon the transcendental imagination:

The human being is this night, this empty nothing, that contains everything in its simplicity—an unending wealth of many representations, images, of which none belongs to him—or which are not present. This night, the interior of nature, that exists here—pure self—in phantasmagorical representations, is night all around it, in which here shoots a bloody head—there another white ghastly apparition, suddenly here before it, and just so disappears. One catches sight of this night when one looks human beings in the eye—into a night that becomes awful [9].

Perhaps not so much awful as awfully melodramatic, Hegel's account of the birth of subjectivity articulates an uncanny parallelism between the birth of modern philosophical phenomenology and the birth of modern medical prac-

tice. For both Hegel and Laennec, describing the modern subject entails recognizing that behind the subject's eyes is an "emptied" space where phantasms and phantom signals suddenly appear and disappear. The modern subject must face the creative necessity of generating his or her own intersubjectivity—a task that is fundamentally a spatial activity. However, this spatial organization is not a neat box but rather the complex topography of the urban environment and the topology of knots and Möbius loops.

The twisting tubes of the stethoscope begin to map out this newfound subject. For with the stethoscope there occurs a remapping of one body onto another. The interior space of the patient's body coincides with the interior of the doctor's body: the heart chamber is remapped to the cranial cavity. In this newly created space organs float in the abyss dissected by auditory exploration. It is here also that the two senses of "interior" overlap. The imaginative powers of the mind's ability to imagine space coincide with a literal location of an interior space "in the head." We can read Linda Montano's *Heart Murmur* as a performative example of this transposition of interior space. In 1975, the American performance artist taped a stethoscope to her heart for 3 days [10]. As much self-reflection as remapping, *Heart Murmur* is perhaps a play on the phrase "hole in the head." For Montano, the head is emptied, or rather the space between the ears is pounded out to create a space for another interior space: the heart. One organ is remapped onto another organ, one instrument onto another, one space into another space. Lasting 3 days and not 4'33", the "always sound" [11] of John Cage's silences is rewired inside Montano as a sonic feedback loop between central nervous system and circulatory system. Practicing the audition of isolation as originally fostered by the stethoscope, Montano creates her own mobile anechoic chamber.

While the stereo stethoscope (whether binaural or differential) allows for a *transposition* of a real space onto an imaginary space, headphones allow for the creative manipulation of sound to create imaginary spaces within another imaginary space. Continuing the technique of *isolation* and *amplification* inherent in the stethoscope, headphones provide the ability to play any type of sound, from natural to technical to musical. We become keenly aware of the "space between the ears" if four technical attributes are maintained: First, an identical sound source is presented to both ears at the same vol-

ume levels (inter-aural amplitude difference); second, there is no temporal delay in perceiving the sound event between the ears (inter-aural time difference); third, the cross-talk and phasing present with loudspeakers is absent; and finally, because sound enters directly into the ear canal when using headphones, the listener's shoulders, pinnae and torso do not filter the incoming sound, which allows equalization cues to source location (technically referred to as Head Related Transform Functions [HRTF]). Combined, these four specifications allow for a sound event that places a "sound mass" (Varèse) inside the head. It should be noted that this type of listening was the typical experience available until the invention of the stereo headphone, which is usually attributed to John C. Koss and Martin Lange, Jr., who demonstrated the "SP-3 Stereophone" in 1958 [12] (Fig. 2). Nearly 50 years later, when binaural recordings, M-S (Middle-Side) stereo recordings, or ambisonic recordings are mixed for headphones, each can create a convincing perception of an exterior world. Audiophiles might disagree, as might audio research engineers, but this mentality positions itself within the conception of "high fidelity" and spatial resolution embedded in the desire for mimesis. While this intention is important for technical purposes (with spin-off benefits in fields such as aviation, military, medicine, etc.), from a different perspective, several artists are attempting not to reproduce the world but rather to create their own worlds . . . worlds that exist not only in their imagination but in the heads of their audience as well. As a result, these artists are attempting not to overcome in-head acoustics but to utilize this unique phenomenon.

ARTISTIC MANIPULATIONS OF IN-HEAD ACOUSTIC IMAGING

Headphones are the norm. The new addiction replacing smoking, headphones frame the head and the perception of most urbanites today in some form or other. Whether one is commuting with an iPod, exercising to the radio, talking on a hands-free cell phone . . . or attentively listening to music, headphones create a mobile and continually changing architecture that follows the listener, wrapping him or her in a private bubble. Headphones appear publicly at science museum exhibits and art galleries, as well as in handset audio guides for tourists. In these cases, however, the sounds played through these headphones are not de-

signed for headphones; rather, headphones are selected for the practical reasons of noise control and privacy—not for conceptual or aesthetic reasons. On the other hand, while it is quite the norm for sound artists and musicians who deal with the subtlety of sound spatialization to recommend listening to their works with headphones, few of these sound artists make work specifically for headphone listening. Instead, headphones are a cheap compromise in the face of expensive multichannel sound systems. Rarely does a sound work require headphones to express its core intention. Furthermore, there are other reasons to use headphones to play sound that have nothing to do with their unique *spatial* characteristics [13]. In a few cases, however, some works do require headphones as a necessary element for the production of the piece. The final sections of this paper discuss three sound artists who utilize headphones' unique capacity to create dynamic aural architectures: Ryoji Ikeda creates a psychoacoustic space out of a precise matrix; Bernhard Leitner creates a phantom interior space based on moving sound objects; and Janet Cardiff and George Miller create mobile, hybrid spaces that complicate notions of interiority and exteriority.

RYOJI IKEDA

Ryoji Ikeda describes his work as having

a particular sonority whose quality is determined by one's listening point in relation to the loudspeakers. Furthermore, the listener can experience a particular difference between speaker playback and headphone listening. The sound signals can be thought of in the same way as spotlights [14].

Echoing the precise techniques used by audiologists and sound engineers to test for psychoacoustics, Ikeda's work explores the minutiae of sound, both

in frequency and in space. While his work spans theatrical performance with *Dumb Type*, expanded cinema performance and sound installations in collaboration with architects [15], he also makes solo audio work highlighting the specific qualities of headphone listening. Almost all Ikeda's work could be described as metric, with beats and blips piercing space-time at consistent intervals. However, the psychoacoustic effect is anything but the metric or striated space that Deleuze and Guattari problematize [16]. Like that of the American Minimalists who preceded Ikeda, his work generates a topological space that is constantly in flux—even if the sequencing of the music is more precise than a quartz pulse. In fact the sound's exceedingly meticulous interval forces the mind to react with a paradoxically increased intensity. The point of course is to modulate one type of space with the other. An odd piece in Ikeda's oeuvre, *C7:: Continuum*, from the album *0°C*, does exactly this [17]. Underlying the piece is an organic heartbeat—a rare choice for Ikeda—but the heart's natural sound is contrasted with his typical high-frequency oscillating pulse, and the normal repetitive metric matrix is created. Laying down a meditative framework, an unusual sample opens a wormhole between the history and the future of listening.

At first "Continuum" simply repeats the spatial remapping established by the stethoscope: the internal heartbeat sample from someone else's chest mapped into one's own cranium. This subtle and classic bodily exchange is further supported when halfway through the track a spatial murmur punctures the soundfield, creating a floating hole in the head that opens into an ambiguous space that reveals our leaky souls. The Baroque monad may be windowless, but headphones are a neo-Baroque infrastructure, allowing spotlights from hidden realms to ripple an interior space [18].

Fig. 3. Bernhard Leitner, *Headscapes Oscillating Space*, 2002. (© Bernhard Leitner)



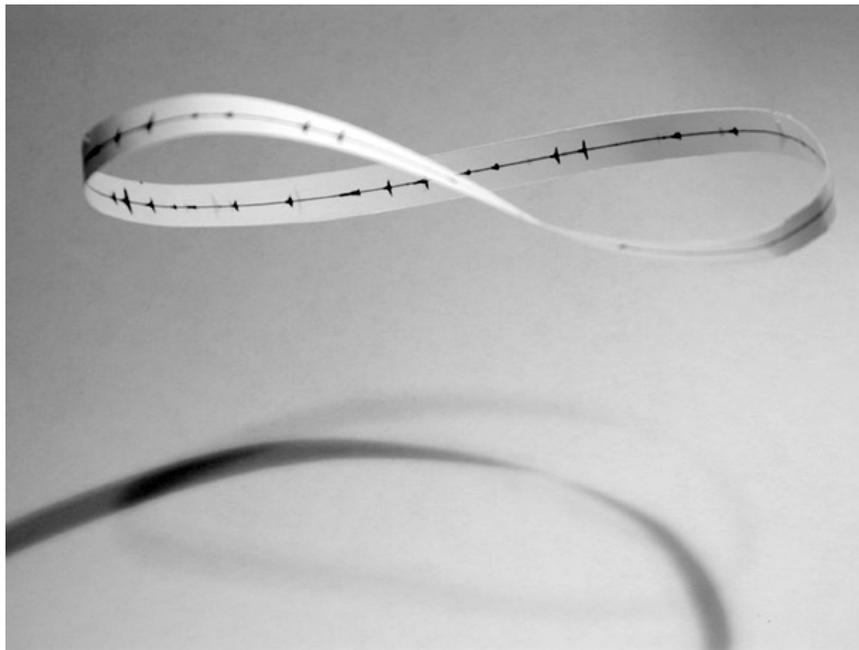


Fig. 4. *Möbius 19566591.71717²*, sound installation, 2006. (© Charles Stankieveh) Space-time becomes a Möbius loop in contemporary sound art.

BERNHARD LEITNER

Bernhard Leitner is another sound artist who has released an audio CD of music specifically exploring an imaginary rendering of the cranial cavity (Fig. 3). Having originally studied architecture, Leitner has been creating dynamic “sound-spaces” since the early 1970s [19]. Often his work is permanently installed and balances the concerns of traditional metal sculpture with the ephemeral nature of soundfields. Arguing that sound is a building material itself, he attempts to create a sensory experience of space out of sound. In 2003 he took a break from the minimal metal sculptures and created an audio CD specifically to explore headphone space. The work is called *Kopfräume* (Headscapes), and he introduces it with the following note:

Headscapes are the works specifically created for the interior of the head. They can only be experienced with earphones. The head is here conceived as hollow volume, as a globe-like receptacle for time-based acoustic-geometric spaces. Sensing, hearing space in motion within the resonant inner space of the head. Hearing, contemplating the interior, the inside however unfathomable it may be [20].

By materially thinking, Leitner empties the head of linguistic thought and sculpts an abstract sense of space through the motion of what Deleuze might call a sound *objectile*, creating a situation

where fluctuation of the norm replaces the permanence of a law; where the ob-

ject assumes a place in a continuum by variation; where . . . the new status of the object no longer refers its condition to a spatial mold—in other words, to a relation of form-matter—but to a temporal modulation [21].

With Leitner’s work, a temporal fluctuation of sound objects sketches out a sense of space.

JANET CARDIFF AND GEORGE MILLER

While Ikeda and Leitner create soundscapes within the head, visual artists Janet Cardiff and George Miller contrast the difference between “in-head” acoustic imaging and exterior binaural soundfields, articulating the radical difference from a psychological standpoint. Cardiff and Miller’s sound work ranges from model cinemas to 40-channel recordings, but they are best known for audiowalks that use binaural recordings, echoing the 1970s soundscape works of R. Murray Schafer, Barry Truax and Hildegard Westerkamp [22]. Listeners to Cardiff and Miller’s audiowalks wear pairs of headphones with a pre-recorded soundtrack overlaid upon an actual route that they are instructed to walk. Deceptively simple looking, Cardiff and Miller’s audiowalks recall William Gibson’s claim that Walkmans are the most effective virtual-reality device invented thus far [23]. Headphones provide a relative transparency to a supplemented reality, which accounts for their effectiveness (compared with the “blinder” effect

experienced with VR goggles, for example).

By using headphones, Cardiff and Miller’s work reveals the strange ambiguity of the subject’s exterior/interior. The outside is re-created in a postulated soundfield beyond the source of the small speakers pressed to the ears. Playing on the isolation of the subject’s acoustic perception of the exterior world and substituting the banality of the everyday with their own manipulated cinematic version, the works cause a strange disorientation. This disorientation is not due to a *loss* of reality but is a *supplement* to reality. Nor does one become lost in reality. Instead the listener enters a hybrid reality in which he or she is given a dramatic role to play, in contrast to everyday life, which is directly interpellated into their mind by the instructional voice of the character “Janet.”

The spatiality of Janet’s voice is also different from the rest of the binaural recording of the soundscape, and it is this difference that creates the strongest effect on the listener. First of all, the voice does not move; it is the one motionless component in the entire piece. Sound effects rush by the listener’s body, which in turn moves through a landscape, but Janet’s voice remains firmly implanted within the cranium: “It is an interiority of space, and not yet of motion; also, an internalization of the outside, an invagination of the outside that could not occur all alone if no true interiorities did not exist *elsewhere*,” Deleuze writes [24]. Furthermore, her voice is recorded in close proximity to the microphone and in mono. On a few pieces, such as *A Large Slow River* and *Villa Medici Walk* [25], her voice contrasts with that of her partner, George, whom we also hear on the recording. His voice is also not recorded binaurally; however, it is processed as a noisy tape recording. The result is a mediated voice that keeps its distance from the listener, further highlighting the unmediated and direct call of Janet’s voice, which is continually “out-of-field” or out of the frame. Janet’s voice thus seems to speak not only from within the soundscape but from within one’s own body. The out-of-frame is commonly associated with the process of perception itself—that which creates the frame and is thus excluded. This confusion between the exterior/interior creates a sense of what most critics usually refer to as the *unheimlich* (or uncanny), a reflection that is somewhat true. However, most people experience Cardiff and Miller’s work in an environment that is probably not familiar to them in the first place. Neither the

walking route nor the generated sense of interior space in the head is probably part of the listener's everyday life or childhood [26]. However, the two unfamiliar feelings combined impress upon the listener the sense that one *should* be familiar with this place.

Perhaps, however, a way to engage Cardiff and Miller's work—and headphone listening in general—is not with Freud's *unheimlich*, but with Lacan's topologically structured term *l'extimité*. Developed in the later phase of Lacan's writing, the idea of the *l'extimité* continues the importance of the voice in the psychoanalytic tradition since Freud first outlined the foundations for the "talking cure." *L'extimité* is a neologism coined by Lacan that combines *exterior* and *intimacy* in a slide away from phenomenology and structuralism into mathemes, topology and knot theory. The underlying concept starts to take shape in Seminar VII, where Lacan begins by describing it as "something strange to me, although it is at the heart of me" [27]. Echoing the movement of Lacan's tortuous career, *an investigation into a phenomenology of interiority twists into a topological complication*.

In effect, *l'extimité* could be used to describe the general experience of listening with headphones, but listening to a phantom voice with headphones would be the event par excellence (*phone* being Greek for "voice"). Moving through a dynamic space that blurs the exterior with the interior via the topology of a Möbius loop or better yet, a Klein bottle, the subject listens; or shall I say the outside is on the inside of the listener? (Fig. 4) The difference between *contained* and *container* dissolves, as does the difference between you and me [28]. We easily identify with our fantasies once we have become the Hollow Men making room for an Other. Janet's words command me to listen, and touched by a phantom power, I do. I confess with the words of Roland Barthes, "The Other collects [her] whole body in [her] voice and announces that I am collecting all of myself in my ear" [29].

References and Notes

1. B. Nauman, *Get out of my mind, get out of this room*, sound installation, collection Jack Wendler, 1968. Recently remade for the exhibition *Raw Materials*, Tate Modern, London, England, 12 October 2004–2 May 2005. Sound installation with accompanying publication and audio CD.
2. The majority of writing in the arts and humanities looks at sound reproduction technologies from a cultural studies viewpoint, focusing on social relations. See, for example, Siegfried Kracauer, *The Mass Ornament: Weimar Essays* (Cambridge, MA: Harvard Univ. Press, 1995); Allen S. Weiss, *Experimental Sound and Radio* (Cambridge, MA: MIT Press, 2000); Douglas Kahn and Gregory Whitehead, eds., *Wireless Imagination* (Cambridge, MA: MIT Press, 1994); Michael Bull, *Sounding Out the City: Personal Stereos and the Management of Everyday Life* (Oxford, U.K.: Berg, 2000); Jonathan Sterne, *The Audible Past: Cultural Origins of Sound Reproduction* (Durham, NC: Duke Univ. Press, 2003).
3. For a sampling of technical papers, see F.E. Toole, "In-Head Localization of Acoustic Images," *Journal of the Acoustic Society of America* **41** (1967) p. 1592; F.L. Wightman and D.J. Kistler, "Headphone Simulation of Free Field Listening: II. Psychophysical Validation," *Journal of the Acoustic Society of America* **85** (1989) pp. 868–878; S. Kim and C. Wonjae, "On the Externalization of Virtual Sound Images in Headphone Reproduction: A Wiener Filter Approach," *Journal of the Acoustic Society of America* **117** (2005) p. 3657.
4. M. Bull, "The World According to Sound: Investigating the World of Walkman Users," *New Media & Society* **13**, No. 2 (2001) p. 180. "Since Walkmans were introduced by the Sony Corporation in 1979 they have sold consistently in their millions. Walkmans have become a truly international tool used in New York, Tokyo, Berlin, Paris or any metropolitan environment. Given this immense success Walkmans have been strangely invisible within sociological literature." I would add that there is hardly any literature on headphones in general outside of acoustic journals, which concentrate on scientific explorations as opposed to historical or philosophic questions.
5. M. Merleau-Ponty, *Phenomenology of Perception*, Colin Smith, trans. (London: Routledge, 1962) p. xi. Merleau-Ponty's text footnotes Augustine: "In te rei; in interiore homine habitat veritas."
6. Roland Barthes, "Listening," in Roland Barthes, *Critical Essays*, Richard Howard, trans. (Evanston, IL: Northwestern Univ. Press, 1972) p. 248: "A history and a phenomenology of interiority (which we perhaps lack) should here join a history of a phenomenology of listening."
7. It should be noted there are rare occurrences in which in-head localization can occur without the use of binaural techniques—particularly if there is abnormal impedance loading in the middle ear. This effect, however, is rare and limited to laboratory research and extreme noise art. For audio examples see Maryanne Amacher's sound installations or her one audio CD: Maryanne Amacher, *Sound Characters: Making the Third Ear*, Tzadik #7043 (1999); see also audiovisual artists Granular Synthesis, particularly with the controlled air pressure of their sound installation "Noise Gate: M6": Granular Synthesis and Peter Noever, *Granular Synthesis: Noise Gate M6* (publication with audio CD) (London: Hull Time Based Arts, 1998). Abnormal impedance loading effects were described as far back as Toole's 1967 research findings [3], but they are rare and not accurately reproducible due to the combination of body placement in a soundfield and the particular shape of the listener's ear.
8. Sterne [2] p. 124.
9. G.W.F. Hegel, "Jenaer Realphilosophie," in *Frühe politische Systeme* (Frankfurt, West Germany: Ullstein, 1974) p. 204. First published in 1803–1804; quoted in Slavoj Žižek, *The Ticklish Subject: The Absent Centre of Political Ontology* (London: Verso, 1999) pp. 29–30.
10. L. Montano, *Heart Murrur*, performance at Cawcraw Gallery, San Francisco, CA, 1975.
11. D. Kahn, *Noise Water Meat: A History of Sound in the Arts* (Cambridge, MA: MIT Press, 1999) p. 191.
12. This accreditation remains in the consumer, mass-produced category. Scientific experiments with stereophonic headsets date further back—actually to the birth of sound reproduction—when "Alexander Graham Bell, for instance, took up a series of experiments with "stereophonic" telephony in the late 1870s, on the grounds that "there seemed to be a one-sidedness about sounds received through a single ear, as there is about objects perceived by one eye." quoted in Sterne [2] p. 156.
13. C. Kubisch, *On Air—Six Themes on Open Spaces* (mixed-media CD) (Die Schachtel, 2004). Kubisch creates sound installations with specially modified headphones that receive transmissions from strategically strung wires that flow through a space.
14. R. Ikeda, +/-, TO: 30 (Touch, 1996). Audio CD with liner notes.
15. The most notable examples are Toyo Ito's *Bringing Architecture* installation (1999–2001) and Zahad Hadid, *The Mind Zone*, The Millenium Dome, London (2000).
16. G. Deleuze and F. Guattari, *A Thousand Plateaus*, Brian Massumi, trans. (Minneapolis, MN: University of Minnesota Press, 1987) pp. 361–362: "It is the difference between a *smooth* (vortical, projective, or topological) space and a *striated* (metric) space: in the first case 'space is occupied without being counted,' and in the second case 'space is counted in order to be occupied.'" (interior quotes are from Boulez).
17. R. Ikeda, 0°C, TO: 38 (Touch, 1998).
18. G.W. Leibniz, *The Monadology and Other Philosophical Writings*, Robert Latta, trans. (Oxford, U.K.: Oxford Univ. Press, 1925).
19. B. Leitner, *Sound : Space* (Ostfildern, Germany: Cantz Verlag, 1998).
20. B. Leitner, *Kopfräume—Headscapes* (Ostfildern, Germany: Cantz Verlag, 2003), audio CD with liner notes.
21. G. Deleuze, *The Fold: Leibniz and the Baroque*, Tom Conley, trans. (Minneapolis, MN: Minnesota Univ. Press, 1993) p. 19.
22. R.M. Schafer, *The Tuning of the World* (New York: Knopf, 1977).
23. W. Gibson, *Time Out*, 6 October 1993, p. 49: "[T]he Sony Walkman has done more to change human perception than any virtual reality gadget. I can't remember any technological experience since that was quite so wonderful as being able to take music and move it through landscapes and architecture."
24. Deleuze [20] p. 8.
25. J. Cardiff, *A Large Slow River* (Oakville, Ontario: Oakville Gallery, 2000), audio CD with booklet; "Villa Medici Walk," *Janet Cardiff: A Survey of Works Including Collaborations with George Bures Miller*, exh. cat. with Audio CD (Long Island City, NY: PSI, 2001).
26. For a sense of the *unheimlich* to occur, first a sense of *heimlich* needs to be established from either the familiarity of one's home (the everyday) or one's personal past (childhood). The possibility of the *unheimlich* stems from "a time when the ego was not yet sharply differentiated from the external world and from other persons." S. Freud, "The Uncanny," reprinted in Julie Rivkin and Michael Ryan, eds., *Literary Theory: An Anthology* (London: Blackwell, 2001) p. 163.
27. J. Lacan, *The Ethics of Psychoanalysis. Book VII*, Dennis Porter, trans. (London: Routledge, 1992) p. 71.
28. Compare to the Möbius inversions that riddle the last pages of *The Fold*: Cardiff's audiowalks invert cinema as Deleuze's writings invert the monad. We slide from sitting in the black box of the monad to the nomad who walks the streets as a character.
29. Barthes [6] p. 252.

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Charles Stankieveh works in the constellation of art, architecture and music. Recently, his work has been presented at the artLAB residency, Venice, Italy; Banff Centre for the Arts, Canada; Eyebeam, NYC; the Planetary Collegium, England; Subtle Technologies' Responsive Architectures, Toronto; and La Société des Arts Technologique (SAT), Montréal. He divides his time between Dawson City, Yukon, and Montréal, Quebec. An example of his work made specifically for headphones can be found on the LMJ16 CD.

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