GEOSONICS: BODIES, INSTRUMENTS, INTERFACES

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ABSTRACT

This dissertation examines, from a media-cultural and sound studies perspective, how we make the earth audible; and how we conceive of listening as an embodied experience and a technocultural act in relation to an audible (or at least audifiable) planet. In the introduction I approach sound, mediation, and materiality through the concept of transduction, which refers to the material and metaphorical conversion of sound in and across cultural, technical and geological environments. I develop an alternative set of phenomenological and media-critical terms (e.g., enearthment, enlistenment and infrastruction) to describe the co-constitution of human embodiment and geology in media infrastructures. The first and second chapters focus on techniques of audio seismology and audio stretching (respectively) to understand how scientists, technicians and artists convert earth-scale vibrations into human-scale aesthetic artifacts. The third chapter (on cyborg art) and fourth chapter (on the aesthetics of sleep) emphasize how human embodiments are complexly embedded in technological and planetary infrastructures. Each chapter probes the aesthetic, political and ecological assumptions that frame the transductive processes I analyze. The dissertation develops original concepts and analyses relevant to current, theoretically informed work in critical media studies, sound studies, and environmental media studies. The overall aim of the dissertation is to use sound and listening to unsettle how we think of materiality at human and geological scales; and to argue for the centrality of transduction as a critical tool for rethinking the complex relationships between earth, media, and experience in the 21st century.

This dissertation is dedicated to:

Daniel
&
Martin

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Introduction: Geosonics

Part I: Audible Earths

The aim of this dissertation is to examine, from a media-cultural and sound studies perspective, how we make the earth audible; and how we conceive of listening as an embodied experience and a technocultural act in relation to an audible (or at least audifiable) planet. Despite the promise of the title, the earth is *not* the protagonist of this inquiry and in fact barely makes an appearance in the following pages. Before our discussion inevitably shifts to questions of sound, materiality, media, and historically bound configurations of aesthetic experience, technical infrastructures and human imagination, let us consider two artworks where the earth might be said, rightly or not, to have its say.

Doug Aitken's *Sonic Pavilion* (2009) is an architectural and sound installation at Inhotim, a large cultural foundation and nature preserve (founded by a mining magnate), situated in the Brazilian rainforest. The installation consists of a hole, one foot in diameter and 700 feet deep, drilled into the earth and lined with concrete. Microphones and accelerometers are suspended at various depths inside the hole, and the sounds they pick up are mixed and piped into speakers arranged throughout a spacious glass pavilion at the surface, with the hole at its centre. Visitors can look through the pavilion's curiously frosted glass windows (which are designed to blur the periphery and render clearly visible only what is directly in front of the viewer's gaze), and listen to what

Aitken's website describes as "the sound of the earth turning and the tectonic plates shifting."[1] The pavilion is also an open-air structure, and the reverberations of the deep-earth sound merge with the lush sounds of the surrounding environment (bird calls, wind in the trees, rainfall, etc.) and the aestheticizing panoramic views to "create a living artwork." Through the sounds of the *Pavilion* we can experience the inorganicity of soil and rock alongside the teeming vitality of the flora and fauna it sustains. It is a kind of ultimate ambient music, not just of the background, but the underground, too: a terrestrial and telluric soundscape.

But are we really hearing the sound of the earth's rotation? It is true that accelerometers measure minute changes in gravity and can thus detect planetary rotation. But there are accelerometers in your smartphone, tablet or wearable device that can be programmed to do the same thing without the hassle of subterranean installation. And the sound of plate tectonics? A 700-foot concrete tube is surely a wondrous conductor of sounds and vibrations of all kinds. But seismic activity, strictly speaking, describes the internal movement of energy through rock. The air inside the column where the microphones are mounted is *exterior* to seismic movement. Seismic vibrations also propagate at frequencies well below the lower threshold of human hearing. So the question of how exactly the microphones use air to transmit the inaudible, elastic vibrations of rock is silenced (albeit pleasantly) in the musical ambience of the "living artwork."

Despite its conceptual naiveté and the technical wrinkles that accompany it, I like to think of *Sonic Pavilion* as an ironic comment on the mining industry, a kind of reverse extraction in which deep-earth boring techniques are used to re-deposit the valuable

metals contained in microphones and electronics into the earth (in much the same way that a mining magnate might redirect his capital to preserve nature, promote the arts, and so on). However, the seductive immediacy of a microphonic connection to nature and the earth has a surprisingly illustrious history in 20th century avant-garde music and the arts, most prominently in the work and writings of John Cage. Cage's "Future of Music: Credo" (1937) calls for "means for amplifying small sounds" as fundamental to new music.[2] By 1962, microphones had become the technical basis underlying Cage's famous *0'00"* composition (which I discuss in Chapter 2), in which sounds of everyday actions are amplified by contact microphones to demonstrate that "everything we do is music, or can become musical through the use of microphones."[3] Cage even theorized listening to the molecular vibrations of everyday objects, like an ashtray, which, if placed in an anechoic chamber and suitably miked, could reveal "the meaning of nature through the music of objects."[4] Cage's aesthetic aim was to direct attention away from human-centered actions (like composing music) to the aleatory happenings and indeterminate processes that fill everyday and non-human worlds with musical meaningfulness. Yet as Douglas Kahn has argued, the expansion of the object of attention does not necessarily entail a change in attention itself: "Cage explicitly sought to subvert tactics based in human-centeredness, yet all he did was shift the center from one of utterance to audition" (1999: 197). Cagean listeners may no longer listen to a determinate creative act, but they do listen (to any and all sounds) with the same expectations of music and meaning as if they were in a classical concert hall. The microphone facilitates a disavowal of the technical mediations of the installation and thereby preserves an uncritical and antiquated mode of listening. In the case of the *Sonic Pavilion*, then, we would have to admit that the

primary thing we listen to is not the earth, but the sound of microphones amplifying the air inside a giant, subterranean concrete tube. But rather than contemplate this truly remarkable set-up for what it is, we have to listen past it to hear "the sound of the earth." When it comes to listening, the more we ignore the technical infrastructure, the more we embrace a false, or at least rhetorically heightened, earthiness.

What does *Sonic Pavilion* actually sound like? Seth Kim-Cohen, who visited the site, writes:

> The sound itself is nothing special: Only the suggestion of its source elicits our attention and grants it meaning. Of course, this is always the case. Meaning does not simply inhere within the in-itself, regardless of whether it is the thing-in-itself or sound-in-itself. Meaning is only ever produced by the friction between things. Like every medium sound derives its meaning from context, from intertextuality, from the play of difference in its conceptual and material strata. It is the worldly, rather than the earthly, that presents the possibility of meaning. (Kim-Cohen 2009a: 100)

The core of this comment resonates with Kim-Cohen's larger thesis in *In the Blink of an Ear: Towards a Non-Cochlear Sonic Art* (2009b), where he argues that the Cagean rhetoric of "sounds themselves" is a conceptual dead-end that prevents sound art from dealing critically with conceptual and material questions. I would fully agree with Kim-Cohen's critique of the *Sonic Pavilion*, which argues that there is no essential or immanent earthiness out there, and that there is no clever or "correct" way to place a microphone that could be said to amplify the sound of the earth as such. It would seem that mediation of any kind would land us firmly in the *world* of meaning, but never on the literal, geological *earth*.

The seeming opposition, if not outright exclusion, of world and earth is a reminder of another work of art that claims a kind of direct access to the sound of the

earth. It is the painting of peasant shoes by Vincent Van Gogh as described by Martin Heidegger in the essay "The Origin of the Art Work" (1977 [1936]). For Heidegger works of art are unique in their ontological ability to connect the *world* where (human) beings live out their lives to the otherwise insensible *earth*, which Heidegger conceives of as the world's ontological substrate or periphery. The way that Van Gogh depicts the peasant shoes affords an ontological revelation of the earth in precisely that humble interface of human uprightness and the earthly horizontal: the shoe. Even though we are talking about shoes and a painting, it is sound that carries the revelatory force of the earth. Heidegger writes:

> From the dark opening of the worn insides of the shoes the toilsome tread of the worker stares forth. In the stiffly rugged heaviness of the shoes there is the accumulated tenacity of her slow trudge through the far-spreading and ever-uniform furrows of the field swept by a raw wind. On the leather lie the dampness and richness of the soil. Under the soles stretches the loneliness of the field-path as evening falls. *In the shoes vibrates the silent call of the earth*, its quiet gift of the ripening grain and its unexplained self-refusal in the fallow desolation of the wintry field. [. . .] (159 emphasis added)

Instead of a microphone, it is a painting of shoes that transmits the vibrations, the call of the earth. Heidegger, like Aitken, downplays multiple levels of mediation to make an essentialist sonic connection to the earth. He writes about leather, wind and soil, but strictly speaking, the object of his contemplation is oil on canvas. He personifies a peasant woman behind the shoes and only understands the weathering of the (pictorial) leather through the fiction of her imagined life. Finally, the alleged ontological depth of the (painting of) shoes only emerges in Heidegger's uncharacteristically vivid and descriptive language, including the mixed metaphor of shoes vibrating, calling out silently.[5] The more the shoes are conceptually and rhetorically framed and mediated, the

more immediately the aesthetic connection to the earth seems to take effect. If it is not a technical instrument like a microphone, it can be the aesthetic imagination, working in relative silence, which manages to conjoin sound and the earth in some essential way.

The key conclusion to draw from the juxtaposition of these two artworks is that the earth, like anything else, may only be grasped through technical sensing, embodied sensation and the reach of the imagination, all of which necessarily take shape within diverse cultural and discursive frameworks that change over time. As a technocultural construction, then, "earth" should always be read within scare quotes. The immense bulk of rock, water and air that surrounds us (or that we surround) only becomes intelligible through the means by which we (make) sense (of) it through our bodies, instruments and imagination. Any introductory course in cross-cultural anthropology, religion or the history of science will yield up a number of different earths depending on language, culture, technology, geography, politics, etc. Even though I have a particular earth in mind at the time of this writing (predominantly the Anthropocene earth of early 21st century "global" capitalism), I recognize that the earth I am describing is produced in and through culturally contingent ways of knowing, (not) the least of which is my own writing. Unlike Heidegger or Aitken, I avoid essentialist claims about the earth, preferring instead to dwell on the technical and aesthetic set-ups that sustain such claims, not for what they reveal about the earth, but what they indicate about geo-technocultural relations at a given place and time.

Part II. Geosonics: Sound as Earth Media Interface

Sound has a material basis as vibrations, as waves of mechanical energy propagating through a medium. This is the sound Aitken is after in the *Sonic Pavilion*. Sound is also a metaphor, literally: a carrying-across that joins two things by differentiating them. This is the kind of sound that, I suggest, Heidegger hears in Van Gogh's painting. Rather than try to separate the material from the metaphorical, I join many scholars working on/in sound in trying to conflate those two dimensions as fully as possible, to listen to the material and the metaphorical as one and the same sound.[6] One consequence of this duality within sound is a doubling of the temporality of listening. When we listen, we hear vibrations in the air, a temporally bound transmission of energy. Yet we also hear those vibrations taking shape within our imaginations (inflected by culture, discourse, technological paradigms and, not least, the physiology of our embodied experience); and in that sense, in listening, we hear those same vibrations "again" as meaningful sounds. At the same time, meaningfulness and imagination precede and produce the moment when we actually tune into these or those vibrations and hear them as sounds in the first place. When we listen critically, as aware as possible of sound's "feedback loop of materiality and metaphor" (Novak and Sakakeeny 2015: 1), we do not so much hear sounds as "always already" culturally constructed, rather we hear sounds as part of an *always again* process. We listen to a sound, and listen to ourselves listening, and so listen *again*, at the same time, to how the material and the metaphorical co-precede each other. For listeners, sounds play themselves back as themselves; they have a capacity for self-remediation that is inseparable from the processes by which they transmit energy and affect.

As affective and self-affective entities, sounds could be said to have a special status in recent new materialist philosophies and ecologies. Graham Harman, for example, has founded an influential philosophy of objects based on Heidegger's conception of equipment from *Being and Time*, which divides objects into the purposive, apparent, ready-to-handness of tools, on the one hand; and the "subterranean," "unearthly," and "otherworldly" ontological depth (i.e. tool-being) of objects themselves on the other (2002: 2). Objects are marked by an ambivalence or ambiguity that is ultimately grasped as an inner "reversal between the withdrawn tool-being of the world and its present-at-hand fragments" (26). Every object is, in a sense, two objects: it is what it appears as or what it can used for by some (presumably human) agent, but it is also what it cannot be grasped as or reduced to. In this way, Harman structures objects like sounds: they are feedback loops for themselves, oscillating between different dimensions or scales of presence and materiality, appearing and withdrawing in a kind of relational rhythm. Jane Bennett's concept of *Vibrant Matter* (2010) resonates in a similar way, drawing on Gilles Deleuze, rather than Heidegger. Bennett is interested in rethinking the anthropocentrism that has historically framed materialist philosophies. While acknowledging the "elusive recalcitrance" of matter, she also wants to describe the ways in which matter is suffused with (non)human qualities and capacities like vitality and agency (3). Her aim is to retune philosophy to attend to the vibrancy of matter, which both eludes our conceptual grasp, yet observably works in the world, albeit in unforeseen or unheard-of ways. From the perspective of sound, vibrant matter vibrates. The conceptual oscillation of things (between "recalcitrant" materiality and vibrant affectivity) makes all things literal/metaphorical oscillators, transducing conceptual or

ontological dualities into physical, affective vibrations that demand listeners (e.g., philosophers and theorists) to redouble their attention, *always again*, to the material.

This is by no means an exhaustive survey of post- or neo-Deleuzian and Heideggerian trends in contemporary theory, but it is enough to suggest that relational ontologies and new materialisms share a deep (if largely implicit) affinity with sound. If sound is a process that self-mediates (for listeners) between its materiality and its meaning, then it is fair to say that a similar process is played out in the self-interfacing of things, which grants (philosophically-minded) users limited access to and control over a materiality that otherwise works with an inscrutable logic of its own. In a certain way, we have come back to John Cage's ashtray, which—under the right technological circumstances—turned out not to be an object at all, but a process. It may well be that all objects are, like sounds, not fixed entities, but vibrant/vibratory processes, and new materialist and relational ontologies suggest that we retune thinking to the hidden processes underlying the object. But what are the philosophical equivalents of a microphone, or an anechoic chamber? And how can we think and listen critically to the world of things without disavowing the technical set-up? And where is the earth in all this talk of worlds, sounds and "subterranean" things?

In parallel to (and in some cases inspired by) the turn away from anthropocentrism in new materialist and object-oriented theories, media studies has already been rethinking the relations between objects and processes through reinvigorated conceptions of media, environment and mediation. John Durham Peters reverses "the old idea that media are environments" into the claim that "environments are also media," which entails an examination of the dialectical ways that media tools and infrastructures

are built into and out of natural environments (2015, 3). His concept of infrastructuralism fuses the legacy of (post)structuralist thought on language and culture with a media materialism that embraces the elemental (e.g., earthly, watery, airy) and infrastructural dimensions of media. For Peters, media theory needs to inquire into the "subterranean" depths of media, only not in the form of an anti-Kantian object-oriented ontology like Harman's, but as the historical study of media infrastructures, environments and meanings. Peters writes: "The questions of how to define nature, humans and media are ultimately the same question. We know and use nature only through the artefacts we make—both out of nature and out of own bodies—and these artefacts can enter into nature's own history" (51). Just as sound remediates its physical reality (as energy in a medium) into its equally valid realities as technical artefact and cultural experience, so do media, for Peters, exist and operate in (and reveal something about) nature and culture simultaneously. The philosophy of elemental media attends, always again, to the feedback loops of media artefacts, environments and the bodies and imaginations of the humans who make them.

The idea that media "enter into nature's own history" is inverted into the jumping-off point for Jussi Parikka's *A Geology of Media* (2015), which theorizes how "nature's own history" (i.e., geology) enters into contemporary media arts and artefacts. Parikka conceives of media on a geological timeline and measures its effects on geophysical (and geopolitical) scales: "Geology becomes a way to investigate [the] materiality of the technological media world. It becomes a conceptual trajectory, a creative intervention to the cultural history of the contemporary" (4). Parikka is certainly inspired by aforementioned speculative realist and new materialist approaches, but I would argue his

geological take on media has more in common with Peters: geological media pose not speculative, but concrete questions about the historical and material entanglement of technology and nature. The "subterranean" ontological depth of an object like, say, a cell phone, becomes, in the media-geological framework, literally subterranean (i.e. a question of the deep-time formation of rare minerals; their mining and manufacture; the carbon footprints of their use in the circuitry of the phone; and their after-life as e-waste in a landfill), showing the continuity between everyday media objects, geological time, the geophysics of digital infrastructures and the geopolitics of labour. Parikka is not interested in uncovering the hidden affordances and agencies of, say, coltan ore, and celebrating a "life of metal;"[7] rather the geological angle opens a critical perspective on the geopolitics of resource extraction, manufacturing, energy consumption and disposal that infrastructurally mediate how we use media. Media use is also earth use, and whenever we connect to a device, we also connect, in specific ways, to the earth, soldering the world-making capacities of media artefacts to the real and imaginative geology of the planet.

Media concepts, like infrastructuralism and the geology of media, would seem to pick up where more new materialisms and ontologies stop short, transforming philosophical speculation about vibratory and subterranean ontologies into technocultural questions about sensing and recording instruments installed at particular places and times on/in the earth; and about culturally contingent ways of knowing, experiencing and imagining the data such instruments provide. The implicit sonicity of being(s) and matter as they oscillate, resonate and vibrate in contemporary theory may be listened to, always again, in a geologically-minded theory of media. Geosonics, then, understands the

mediation between matter and being(s) as sound, i.e., as a material and metaphorical energy that human instruments, bodies and imagination transduce into culture and experience. Such transductions are grounded literally/metaphorically in/on the earth, not as depth or background, but as an element that is immanently implicated in mediation itself. From the perspective of sound, mediation is always again geological, just as the geological is always (re)mediated.

Part III. Escaping the Soundscape

"After all, the earth itself has always been the ultimate immersive environment."
--Brian Massumi, *Parables for the Virtual* (142)

Murray Schafer's notion of soundscape has been instrumental in conceiving of sound and listening as descriptive and analytical tools for understanding the (historical) relations between humans, technology and the natural environment (1994**)**. But as Emily Thompson has elaborated, the soundscape is more of a mediation than Schafer might want to recognize: "Like a landscape, a soundscape is simultaneously a physical environment and a way of perceiving that environment; it is both a world and culture constructed to make sense of that world" (2012 [2002], 117). If the soundscape only emerges insofar as it is perceived in cultured acts of listening, then it is fair to say that the soundscape is more of a filter than an index of the environment. For every sound heard in the soundscape (whether perceived as sonorous or noisy), there would necessarily be other sounds that go unheard, that are effectively excluded from each culturally and technologically contingent act of listening. This is less a problem of "sound-" than of "-scape," a Germanic suffix that enters the English language precisely through the word "landscape" and is tied etymologically to notions of creating, controlling and shaping. A

soundscape is already always a shaped, cultured sonic "view" that scales down the sonic environment to fit the human ear and imagination.[8]

Thompson tracks the evolution of the modern American soundscape via new audio technologies in the early 20th century, noting that "[a]s scientists and engineers engaged increasingly with electrical representations of acoustical phenomena, sounds became indistinguishable from the circuits that produced them." (118) Rather than serve as a means of capturing and representing a soundscape, new audio technologies (e.g., microphones and loudspeakers) and their electrical infrastructures could effectively take the place of the soundscape, and the electrical-technical criteria for evaluating the quality or experience of sound as *signal* became the de facto criteria for listening to the soundscape as a whole: "The desire for clear, controlled, signal-like sound became pervasive, and anything that interfered with this goal was now engineered out of existence" (118). The soundscape, in other words, was no longer an environment to be listened to (with varying degrees of culturally specific selectivity), but was to be actively crafted by engineers listening across the physiology of the human ear and the physics of electrical signals. Thompson's argument that the modern soundscape be understood within a generalized technocultural framework of a modernity bent on the elimination of time and space reinforces the idea that soundscapes exclude as much as they include. In a perverse way, the engineering problem of noise elimination and the acoustic-ecological task of noise abatement are both instances of how the notion of soundscape eliminates or denies the experience of the sonic environment precisely in avowing to listen to it.

No longer "outside" in nature or environment, the modern engineered soundscape retreats into a seeming interiority of circuits and signals. Yet it might also be possible to

listen through or across those technological instruments and hear the earth in which both instruments and listening bodies are embedded. Composer Pauline Oliveros has developed the concept of sonosphere as a kind of counterpart to the narrow conceptual bandwidth of soundscape (2017 [2011]). The sonosphere, a neologism analogous to words like biosphere or technosphere, is:

> the sonorous or sonic envelope of the earth created by all the vibrations set in motion by natural or technological forces that travel through earth from its core to beyond earth, air, fire and water as waves and phonons to receivers. Receivers are humans, all creatures perceiving and using earth bio and technological systems. Vibrations within the range of hearing may be processed consciously or unconsciously; vibrations beyond the range of the human ear are nevertheless received by the body and processed unconsciously or by other inhabitants of the earth and beyond. (115)

Expanding, perhaps exploding the notion of soundscape, the sonosphere encompasses a range of biological perspectives beyond the human and considers a planetary sonic field that extends from the core of the earth to the outer reaches of the atmosphere. In the sonosphere, "[a]ll cells of the earth and body vibrate," (113) and those vibrations—whether acoustic or electromagnetic, cellular or seismic, animal or machine, conscious or unconscious—draw listeners into a kind of complex vibratory unity with/on/of the earth. If the soundscape expels the earth from the practices and technologies that purport to listen to it, the sonosphere takes the earth in its totality (including all the technological and biological entities on it) as its object of listening. Yet here we seem to encounter the same problematic of the soundscape in inverse form: if our listening does not actively shape what we listen to, how can we make distinctions within the vast vibratory field in which we are immersed? How do we establish the spatial and temporal intervals within a vibratory unity in order for sound to *be* sound (literally, as propagation across space and

time) and be heard as sound? What are the specificity and place of the listener in the sonosphere? Oliveros tends toward the mystical in this regard[9], but the paradox remains that sonic environments involve differentiation as much as immersion and that "[i]n the experience of sonorous immersion, one is on the outside of what surrounds one; one is sheltered in a space which one nevertheless oneself suffuses" (Connor 2011 [2005], 134). Is there a way to listen to the sonic environment of the earth that acknowledges how listening itself actively shapes what it hears, but can somehow attend to the outside of its techniques and tools, sounding, at the same time, what listening necessarily occludes?

The answer may be a transductive model of listening that understands how listening does not take place (in a pre-established soundscape or a primordial sonosphere), but rather *makes* place by etching out a mediated, mutually constitutive set of relations between listener, instrument, object and environment. Stefan Helmreich has argued for such a concept of transduction at work precisely in an environment of literal (and ostensible) immersion (2007). He offers an ethnographic account of a dive on a deep-sea submarine and attends to the rhetoric of immersion (as immediacy, presence, merging of inside/outside) from the auditory perspective of the control and communication systems on board the submarine: "It takes techniques and cultural translation to carve a soundscape for humans out of the subaqueous milieu, to endow submarine space with sonic distance and depth, to create immersive space" (624). What Helmreich calls the submarine's "pinging sonarscape"—the pings detected from submerged transponders at fixed points on the sea floor and other sonar data—mixes with the air-pocketed acoustics of the vessel itself (wherein are heard the radio chatter between the submarine pilot and the surface vessel, not to mention the rock music from the pilot's

MP3 player) and coalesces into an intimate auditory experience of immersion: "Submerging into the ocean almost seamlessly merges with a sense of submerging into sound—and into a distinctively watery soundscape" (621).

Immersion thus conceals a cyborgian experience of transduction. Listened to transductively, the seeming immediacy of the sub-marine soundscape becomes for Helmreich a highly mediated experience of boundaries, networks and communication systems that locate the cyborg body of the submersible, direct its outer movements and regulate its inner environment. Immersion in a soundscape does not happen just because one happens to be immersed in water: immersion is a technocultural experience that is transduced across a particular ocean environment (measured by depth, temperature, ocean currents etc.), the vessel's technical systems, and the bodies and behaviours of its human cargo. To experience (a soundscape of) immersion means to inhabit multiple physical, technical, geographic and cultural locations simultaneously: to be (inside) a human body; inside a submarine chamber; inside the circuits of its cybernetic systems; immersed in particular location in the ocean environment; and finally immersed in a cultural rhetoric of "immersion" that structures how one imagines (and does ethnography about) immersion in the first place.

Helmreich effectively adapts the concept of soundscape into a self-reflexive model of transduction that distributes the experience of a soundscape across layers of material, technical and cultural systems. A soundscape is thus more and less than a sonic environment: *more* in the sense that it is a multi-scalar ensemble of environment, instrumental infrastructure, cultural rhetorics and embodied practices of listening; *less* in the sense that a transduced immersive soundscape only reminds us of the partial,

mediated and culturally constructed ways we can listen to *any* sonic environment. What about the earth, the immersive, vibratory field that is somehow still "out there" beyond or beneath the technocultural interiority of the soundscape? To answer this question, we might change the emphasis of Helmreich's argument: the soundscape is not only composed of multiple technocultural transductions, but the soundscape is also a transducer itself.

The submarine on which Helmreich is conducting his research is itself an oceanographic research vessel tasked with mapping an unmapped portion of the sea floor (the Mothra Hydrothermal Vent Field in the Canadian Pacific). As the vessel moves out of the mapped territory and into the as-yet unmapped zone, the on-board scientist announces to Helmreich, "'We are merging with our data'" (630). Helmreich notes the potential here for a kind of Borgesian merging of the map with the territory, where one could imagine the transductive experience might open onto some kind of genuine immersion after all, in the "real" of the "un-scaped" unknown. Yet in the next paragraph, Helmreich abruptly displaces the scene of this merging/immersion from the deep-sea threshold to the water's surface:

> A couple of days later, at a science meeting on *Atlantis* [the surface vessel], Delaney [the scientist] enacts his sense of merging corporeally. As he reviews the topography of Mothra, he directs a postdoc—the person who painstakingly created the final graphic—to pan and tilt a three-dimensional computerized map, projected on a video screen. He moves his body like a conductor and even says, "Music please," embodying the orchestrating, directing relation of professor to postdoc so characteristic of the natural sciences. In this synesthetic dance, his body fuses with the map; he merges with the data. (630)

Immersion happens paradoxically at a temporal and spatial remove. What seems at first like the ground-zero moment of a transductive process, that off-grid encounter that will

summon a topography out of the unknown and into being, generate a territory out of chaos etc., in fact emerges as yet another proleptic encoding of data that will only enact further transductions: the "painstaking" visualization by the unnamed postdoc; the embodied performance of the data by the scientist; and the overall re-gridding, re-scaping of the earth as one more puzzle piece is slotted into the oceanographic map by the scientific community. Merging with the data and immersion on the uncharted ocean floor do not happen *in situ*, but rather days later when a scientist engages verbally and bodily with projected images of a data visualization. The underwater soundscape aboard the submarine vessel is more of a sound*ing*scape, a transducer in its own right that transforms sonographic data into visualized data into an embodied performance of scientific knowledge. The earth is heard in—or emerges from—the soundscape, but only belatedly and insofar as it is transduced by the datic and bodily transformations that map out what it was in the first place. Put another way, the soundscape is less an environment than an instrument, which transduces geology into a communicative embodied human experience across space and time.

Helmreich's take on transduction amounts to a deconstruction of the rhetoric of immersion, yet with an emphatically materialist twist. Considered transductively, immersion does not dissolve into an ocean of metaphor and textuality from which there is no outside; rather, immersion is a (deconstructible rhetoric of) *presence-with-an-infrastructure* that conjoins whatever cultural fictions we may ascribe to it with material instruments and bodies, transducing an environment out of a technocultural feedback loop. Following John Durham Peter's concept of infrastructuralism, we might think of transductive analysis not as deconstruction, but infrastruction: how an experience of

(auditory) presence is buried in a technological infrastructure that disappears from our senses precisely in the moment when we experience "unmediated" immersion in an environment. The analytic of transduction thus helps both to conceptualize and listen to the outside of the soundscape, to the tools and spaces that are displaced and deferred by techniques of listening to the sonic environment.

Helmreich has elsewhere pointed out that the concept of transduction has played precisely this role of uniting the material-technical with the cultural-semiotic in the field of sound studies (Helmreich 2015). Echoing Jonathan Sterne's work on transduction in *The Audible Past* (which I discuss in Chapter 1), Helmreich suggests that transduction serves as the conceptual intersection of science and technology studies on the one hand, and media and cultural studies on the other, all under the auspices of the study of sound (Helmreich 2015: 223). The world of culture, lived experience and meaning is inseparable from the earthy infrastructure of tools, materials and, ultimately, geology itself. Analytically, transduction audits the ways that the world of the soundscape is embedded in the earth, but experientially, transduction *is* the mediation that makes the earth disappear after all into the seeming immersion of our auditory experience.

For Helmreich, this means that subjects, objects, media and environments do not precede, but rather are constituted by the transductive processes they animate.[10] Even the seeming indexicality of mapping (as in Helmreich's dive) must pass through the relay of a transductive fiction. The presumed fixity of the earth—not just on a map, but literally "on the ground"—is less a categorical given than a state of affairs that must be continually (re)established by transductive listening. The earth (qua that parcel of hydrothermal vent to be mapped), we might say, comes into being through a transductive

process of *enlistenment*. Tim Ingold has written of the phenomenology of weather and of sound, and, playing on the phenomenological concept of embodiment, describes the body's enwindment and ensoundment in breath. He stresses that as the living body breathes and participates in the airy atmosphere, it does not so much embody the wind as become enwinded. The sounds of breathing (qua enwindment) draw the body outwards into the sonic environment, rather than internalize a fixed soundscape, and the body is thus ensounded as it breathes (Ingold 13). Considering this reversal of the soundscape transductively, soundscapes are transducers that enlisten the earth and enearth listeners. If the earth really is the ultimate immersive (auditory) environment (as the epigraph from Massumi suggests, albeit in a different context), this means that our ways of attending to that environment must follow a circular or spiralling logic of transduction in which the earth is perpetually unsettled and resettled in and by sound:

> Sound flows, as wind blows, along irregular, winding paths, and the places it describes are like eddies, framed by a circular movement *around* rather than a fixed location *within*. To follow sound, that is to listen, is to wander the same paths. Attentive listening, as opposed to passive hearing, surely entails the very opposite of emplacement. We may in practice be anchored to the ground, but it is not sound that provides the anchor. (Ingold 12)

If we substitute "transductive" for "attentive" listening, it becomes clear that immersive concepts like soundscapes (and even immersive audio technologies like sonar) do not so much locate bodies in space as they distribute bodies across time and space, and those temporal and spatial coordinates circularly coalesce into the sonic environments that they were in the first place. Soundscapes are not acoustic or vibratory emanations of environments, but rather passages that reveal/conceal the infrastructures by which emplacement and embodiment seem to coincide in our experience.

Part IV. Interfaces Again: Geosonicks

Geosonics, as the mediation between sonic elements (i.e., bodies, instruments and the earth), implies transductive listening, that is, attending always again to the material embedded in the cultural, and vice versa. Such listening always entails listening across a particular transductive infrastructure at a particular time. The geosonic earth, then, is special kind of technocultural construction that is always again enlistened, that is, produced in and by technical acts of listening. Likewise, from a geosonic perspective, the experiences of bodies are not only embodied in relation to a world, but enearthed, that is, they participate in processes, relations and infrastructures of mediation that are earthly through and through. Here (and also in more detail in Chapter 3) is where I part company with some philosophical and phenomenological conceptualizations of transduction that have a particular currency in the Deleuzian materialisms I discuss above. For Maurice Merleau-Ponty, for example, transduction refers to the mutually constitutive processes of identification and differentiation between a self and a world (Hansen 2006). The mediation of the senses is a kind of structural gap that gives the body its interiority in transductive interplay with the exteriority of the world. For Gilbert Simondon, transduction names the process by which milieus or territories are ceaselessly generated and transformed by individuals who are themselves unfolding and becoming in the self-same, ontogenetic flux of the transductive process **(**1992**)**. Merleau-Ponty presumes a world as a neutral backdrop, just as Simondon (and later Deleuze) presume an infinitely available, expandable supply of territory-generating matter. In contrast, I see "world" as a limit to transduction and transductive thinking, rather than the medium or site where the process occurs. As Timothy Morton has argued in *Hyperobjects: Philosophy and Ecology*

after the End of the World (2013), the philosophical concept of world undermines serious earthly and ecological conceptualization. For Morton, worlds cannot link the immanence and finitude of the earth to the being and experience of objects; worlds only perpetuate the asymmetrical reign of subjects over objects, risking blindness to the hyperobjects (like earth, climate, capitalism) that upset the figure/ground, subject/object, culture/nature dichotomies that frame the phenomenology of self/world, or of expansionist milieu: "What ecological thought must do, then, is unground the human by forcing it back onto the ground, which is to say standing on a gigantic object called *Earth* inside a gigantic entity called *biosphere*" (18). Following Morton, I would replace the human/world dyad with body/earth, and attend to the ways that bodies are enearthed, that is, embedded not just in themselves, but in aesthetic experience of the (hyperobject called) earth.

The earthly (rather than worldly) aspect of geosonics can contribute to contemporary critical thought on related geo-scaled topics like anthropogenic global warming and global capitalism because it substitutes the ultimately binarizing conceptuality of immersion (in a system, in a world) with a critical concept of transduction that can tune into the scales, infrastructures and affects that transduce planetary processes into our imagined and lived experience. *Geosonics* is not an environmentalist or ecological study by any means, though the concept takes as a significant point of departure the literal/metaphorical "end of the world," as well as the "daunting, indeed horrifying, coincidence of human history and terrestrial geology" that follows it in its wake (Morton 9). Expanding on Morton's move to counteract the "bad" Heideggerianism of, well, Heidegger, with the "good" Heideggerianism of OOO and

speculative realism, I try to think the geologization of the human in the context of a critical media studies of sound.

Jacob Smith's *Eco-Sonic Media* (2016) approaches similar concerns around sound and media, but from a different angle. His approach is a "green-media archaeology" of sonic media inspired by ecocritical media studies that examine the environmental impact of media consumption, holding media studies accountable, methodologically, for the carbon footprint of its object of study. Key studies in this direction include Richard Maxwell and Toby Miller's *Greening The Media* (2012); Allison Carruth's "The Digital Cloud and Micropolitics of Energy" (2014); Nicole Starosielski and Janet Walker's *Sustainable Media: Critical Approaches to Media and Environment* (2016); and Sean Cubitt's *Finite Media* (2017). In stressing the imaginative and experiential dimension of mediation (even if that dimension is also always earthly, planetary, geological), I depart from the methodologies (if not the concerns) of more ecologically-minded media studies. The difference between the eco- and geosonic might be described by the difference between media and mediation invoked by Alexander Galloway (2012). Studying media means examining the symbolic and material affordances intrinsic to specific media artefacts, while the study of mediation looks at the practices and techniques that link users and artefacts to a socially inflected media system**.** Mediation is a question of interfaces and processes, not objects. Translating Galloway into ecological terms, the compression and consumption of earthly resources in and by (audio) media artefacts (i.e., eco-sonics) is distinct from the symbolic and material interfacing of (audio) media users with the material and symbolic earth (i.e., geosonics).

In that sense, geosonics conceives of the earth less as a hyperobject, and more like an interface. I have already suggested, via Peters and Parikka, that all media artefacts are earthly *and* interfaces with the earth, and that media (like sounds) both refer us to cultural meanings and earthly materiality simultaneously. But the term "interface" here requires more nuance beyond its conventional meaning as intersection between technological device and user, or point of operational connection/synchronization between machines. One of Parikka's theoretical interlocutors is German media archaeologist Siegfried Zielinski, who developed the "deep time" approach to the history of media that informs Parikka's *Geology*. For Zielinski, media are "spaces of action for constructed attempts to connect what is separated" (2006 [2002], 7), and the crucial problem of media is the interface (*Schnittstelle*), the place (*Stelle*) that marks the cutting and joining (*Schnitt*[11]) of human worlds, realities and scales of experience with some kind of alterity that is, at different points on the media-archaeological timeline, imagined as the alter-interiority of machine worlds or the alter-exteriority of geological time. Either way, media offer a "cut through the world, which enables it to be experienced" (32). Zielinski continues:

> [W]e swim in [media] like the fish in the ocean, it is essential for us, and for this reason it is ultimately inaccessible to us. All we can do is make certain cuts across it to gain operational access. These cuts can be defined as built constructs; in the case of media, as interfaces, devices, programs, technical systems, networks, and media forms of expression and realization, such as film, video, machine installations, books, or websites. (33)

There are, in a sense, two interfaces at work in this passage: the specific interfaces of media devices and media arts, and the general interface of any artefact with the larger, unknowable totality on the other side of our experience. Parikka's take on that totality is, as I understand it, to implicate the earth as the ultimate interface, in and by which all

particular media devices are to be constructed, conceived of and critiqued. Media always imply a technical and imaginative construction of the earth by virtue of the same earthly materiality that gives rise to them. But Zielinski stresses a paradoxical aspect to this self- or re-mediating process: the more media try to access or imagine the whole, the more cuts they make in it. Media, as interfaces, hack the erstwhile earth into pieces, building smaller media worlds out of the ever-increasing fragmentation of the whole (whatever that whole might be). Any discussion of the "world-making affordances of media" must also acknowledge that media work by breaking up the earth, one piece at a time, with each world they construct.

It is in this sense of interface that I want to write geosonics again as geosonicks. Nick is a tricky English word (like sound, for that matter).[12] To nick means to make a notch or groove in something, cutting into or chipping away at a surface either accidentally, or for the purposes of keeping score, or indicating ownership. It can mean to shape, or to deform. In the context of mining, to nick means to remove coal from a seam. The word can refer to a fortuitous or precise moment in time (in the nick of time); a favourable condition (in good nick); or a winning play (in dice, cards or the game of squash). But it can also mark how the fortuitous devolves into the appropriative: in slang, to nick means to steal, cheat or defraud; to take into custody or under arrest. There are three aspects of geosonicks that I want to stress with this portmanteau formation: (1) mediation of any kind (geosonic or otherwise) nicks away at the earth: it burrows and borrows, shapes and disfigures, measures and steals. Mediation may be productive, but its infrastructure is always extractive and appropriative. Its success is always a little like theft. (2) Mediation implies a permanent and necessary partiality or incompleteness. Like

Zielinski's literal take on the interface as a cut, geosonicks implies a necessarily part-for-whole logic at work in mediation: we can only experience the "whole Earth" in the fugitive pieces of interfaces we build into and out of it. (3) Geosonicks marks a moment in time, a particular technocultural juncture of listening and media interfaces corresponding to a specific configuration of geology, technocultural imagination and geopolitics. In opposition to the Deleuzian notion of geophilosophy, in which the primordiality of the earth is encountered over and over in a perpetual refrain of territorializing flux, geosonicks aims to critically understand how earth is transduced into technology and experience, always contingently, in historically distinct and describable ways.[13] Geosonicks implies a time-stamping of earth, bodies and instruments by transductive listening.

Part V. Breakdown of the Chapters

Chapter 1: The Sound Beneath Our Feet: Earthquakes and Ear Quakes

It is a truism in geology that the object of its study, its literal substance, is not earth, but time.[14] A body standing on the earth is already engaging in a geosonic time-stamping. In this chapter, I turn to the field of geology that is most closely linked to sound, namely seismology, analyzing seismological transductions between the earth and the human ear from the mid-20th century to the present. I consider technical instruments (seismographs) and processes (audification) that conjure distinct geosonic listening practices out of a perceived fit between seismology and the tympanism (following Jonathan Sterne) of sound recording and playback. I also explore how certain avant-garde and digital musical practices co-evolve with seismology in distinct configurations of the

geosonic imaginary, from the geopolitics of Cold-War military-industrialism to the global infocapitalism of the present.

Chapter 2: A Planet Made of Beethoven: Audio-Stretching, Transductive Listening and 24/7 Aesthetics

The "globality" of capitalism opens up that concept to critical analysis by geosonics. As much as global capitalism is a world-system with its own discrete logic or logics, it is also an experience that can be approached geosonically though the following questions: what does global capitalism sound like? How do we listen to capitalism? I try to answer these questions in chapter 2 by analyzing an artwork: the sound-installation *9 Beet Stretch* by Norwegian artist Leif Inge, which audio-stretches a recording of Ludwig van Beethoven's 9th Symphony to a length of 24 hours. The audio-stretch technique of granular synthesis enlistens the world of 24/7 capitalism, digitally rescaling the embodiment of listening to an unlistenable and unlocatable planetarity. I approach the 24/7 aesthetics of such artworks as literal and metaphorical transductions of global capitalism, exploring the geopolitics of geosonics with tools borrowed from musicology (Susanne Cusick); media theory (Mark B. N. Hansen); and critical theory (Jonathan Crary).

Chapter 3: Now You See It. . . : Hearing Colours in the Cyborg Soundscape

This chapter scales the problem of geosonics back down to the human body. I take a critical listen to the art and activism of cyborg artist Neil Harbisson, whose creative work derives from an antenna implanted in his skull that sonifies colour frequencies. Overcoming a disability (congenital total colour-blindness) through technology, Harbisson is a self-appointed spokesperson for cyborg rights and an advocate for a trans-species cyborgism. I approach Harbisson by situating him critically in the

history of cyborg concept, reaching back to 20th European modernism, and moving through cybernetics and postmodern body art to 21st century transhumanism. The cyborg has proven to be a figure for rethinking ability, prosthesis and embodiment, as much as it becomes (as I argue in Harbisson's case) a prop for a neoliberal, techno-deterministic concept of the body. I use Adrian Mackenzie's work on transductive bodies to critique the seamless interfacing that Harbisson posits between environment, body and technology. Listening, especially to Harbisson's mishearing of the gap between colour and sound, becomes a way to conceptualize the frictions and indeterminacies in the otherwise smooth and fluid 21st century digital soundscape.

Chapter 4: Sound Asleep: Sleeping, Listening and the Politics of Nonconscious Experience

Harbisson effectively reinvents cyborg-ness as the prosthetic interfacing of brain and environment. In this chapter, I build on that idea to question how the brain interfaces not just with the immediate, sensuous environment, but also with the entire planet. I approach sleep as a geosonic interface, which synchronizes the brain and body to planetary rhythms that are enlistened even—indeed, *precisely*—while asleep. This entails a shift toward nonconscious cognition (following N. Katherine Hayles) and a renewed conceptualization of what Catherine Malabou calls neuroplasticity, the brain's co-evolution with the body and the lived (though not necessarily consciously experienced) environment. Sleep is also a biopolitical terrain fraught with cultural, environmental, economic and technological forces, among which are sonic media and music designed to induce, prolong, or be experienced while sleeping. I listen critically to sleep as a soundscape, transducing the geosonic (and biopolitical) forces that conduce and constrain how bodies sleep on earth in the 21st century.

Chapter 1: The Sound Beneath Our Feet: Earthquakes and Ear Quakes

Part I. Listening Beneath The Soundscape

Any discussion of the earth, whether in a scientific, cultural-theoretical or everyday sense, is marked by a slippage: earth sometimes refers to a planetary totality spanning from the earth's core to its outermost atmosphere, including every thing and element in between. At other times, the term has a more local, terrestrial cast, implying the specificity of rock and soil, as opposed to water and air (not to mention organic life). But geology is the study of the long-duration interactions of earthly elements with watery and airy atmospheres, so invoking the earth from this perspective necessarily entails a continuum of earth-as-planet with earth-as-territory/-terrain. In a similar vein, I have set up the term geosonics to engage a multiplicity of technical and imaginary sonic constructions of the earth as: (1) a planetary or global field of sound; (2) the vibratory specificity of singular (geological) sites and events; (3) *and* the technical and imaginative transductions that allow human listeners to inhabit corporeal, terrestrial and planetary fields simultaneously.

Soundscapes are, as we have seen in the Introduction, ambiguously tethered to specific sites on the earth, even as, experientially, they swirl around in the fluid atmospheres of air and water, eardrums and instruments. Yet roughly in parallel with Schafer's coinage of soundscape in the late 1960s and the development of acoustic ecology, the field of seismology developed tools and techniques for listening to the earth by detecting and displaying the seismic vibrations of earthquakes, underground nuclear testing and other geophysical activity. If soundscapes have infrastructures that are both

geological and technological, and if those infrastructures are, literally or metaphorically, buried underneath our embodied experiences of listening to them, then the sonics of seismicity explicitly shifts our listening to the technological and earthly outside or underside of the soundscape.

Indeed, as we will see in detail below, it is a curious short-circuit of the technocultural feedback loops of modern seismology that earthquakes were initially recorded, conceived of and listened to as (musical) sounds, with clearly describable acoustic contours. In seismology's coupling of earthquakes with the human ear, there is a kind of echo of what Jonathan Sterne calls the "tympanic function" (2003). For Sterne the tympanic function of the human ear (i.e. the eardrum's status as a transducer of sound waves in the air) was crucial in the evolution of sound recording around 1900, serving not only as the mechanical basis of recording and playback technologies, but indeed as the conceptual underpinning for understanding what sound, hearing and listening were at all. But that function very quickly "would take on a life of its own" as "the technologies [it gave rise to, e.g., telephone, phonograph, microphone and radio] were gradually organized into media systems with their own distinctive industrial and cultural practices" (84). In a certain sense, seismology belongs to the technological afterlives of the tympanic function because, especially in the mid-20th century, it attempts to render the earth intelligible by recording it and playing it back as sound. In this chapter I sketch out how the epistemological stakes of seismology (i.e., what it can claim to know of the earth by studying how it vibrates) are folded into technical questions of sound and signal processing. The construction of the earth as an epistemological object has been and continues to be shaped by pre-existing ideas about sound, recording and human listening.

To a certain extent, it is not unreasonable to assert that we know the earth through our eardrums. This assertion, at the same time, opens up the earth (qua seismological entity) as a field of activity for sound artists, composers and musicians. The aesthetic reimagining of geophysical data and the (literal or metaphorical) artistic engagement with earthquakes can reveal, with varying degrees of critical awareness, the on-going transductive processes that make up the ground beneath our feet.

Since the seismic vibrations of earthquakes usually have a frequency of 1Hz and rarely, if ever, move into the audible range,[15] they present us with an example of a sound(scape) that cannot be experienced through (a rhetoric of) immersion, but rather which foregrounds technical transductions and signal-processing as part and parcel of its sonic material. To listen to an earthquake means to listen to a sound that can both claim to have a solely transductive existence as a phantom of circuits, scales and ratios, and at the same time be heard as the vibration of the entire ground and infrastructure of sound itself (on earth). If Helmreich's analytic of transduction aims to "listen for that which we only usually hear" (2007, 629), that is, to the instruments and the environments at the outside of the soundscape, then to listen to earthquakes qua sound(scape)s is an ideal case to practice listening through transduction.

Earthquakes—as transduced and imagined by scientists and technicians—do away with the notions of ambience, atmosphere and immersion that permeate the concept of soundscape. There is no background hum against which "keynote" sounds gradually distinguish themselves in an acoustic version of the figure/ground relationship, nor is there a fluid ambience into which listening can dissolve or disperse. The earthquake presumes no environmental backdrop or container in which acoustic or vibratory events

unfold; rather, the earthquake is *all* event, inside and out. John Durham Peters has written of seafaring vessels as media and metaphors, and notes that "[i]n an extreme situation [at sea] everything on a ship is cargo, including the ship itself" (2015 104). Something of that logic applies to the extreme situation of earthquakes, where the figure *is* the ground, where the soundscape is all sound, no scape. In the likewise extreme situation of anthropogenic global warming, climate is less and less a diffuse background of our habitation, and increasingly an event unto itself. There is thus a kind of homology between our experience of sound(scapes), earth(quakes) and climate (crisis): we cannot make an absolute distinction between ourselves as subjects, the environments we are in, and that which we think we are listening to/standing on/living in because in moments of crisis the medium, the environment, the subject and the object are all (in) the same boat, as it were, drawn together into an infrastructural unity punctuated by extremity or catastrophe.

Although the concept of soundscape is intrinsically bound up with an ecological stance against (noise) pollution, Steven Connor has suggested how it may actually be mid-century avant-garde composers who have more presciently anticipated contemporary ecological concerns than Schafer's acoustic-ecological paradigm. His talk "Strings in Air and Earth" shows how the airy possibilities of Cagean "sounds themselves" and the push toward open-ended, indeterminate and long-duration compositional styles developed alongside an exploration of the more "down to earth," densely textural sounds of Ligeti, Xenakis and Stockhausen. A piece like Ligeti's *Atmosphères* (1961), for example, "seems to involve some mutation or crisis in the imagination of air, which has for so long provided the metaphorical support for imagining the materiality of music" (Connor 2006

6). Rather than conceiving of the air as a limitless space for the transmission and reverberation of sounds and soundscapes—a space where listening might expand infinitely as well in its potential attentiveness to any and all sounds as music, Connor suggests that the atmosphere of late 20th century music is not just finite, but crowded, colonized, polluted: "[post-War m]usic is conceived, presented and experienced as clustering, congelation, swarming, aggregation" (4). He continues: "Diffusion implies a space into which sound, like any other waste product, can expand and slowly vanish. During the twentieth century, the air has gradually been finitised. For us, the air has lost its inviolability, its capacity to dissolve and diffuse any pollution. Itself finite, and therefore vulnerable to damage and corruption, the air no longer provides the promise of universal purification" (10). Music, via the composers Connor singles out, can both prefigure and respond to this crisis of the air with sonic practices that intensify, rather than by-pass, those soundscapey thresholds when music aims to step out of the foreground and lay claim to a taken-for-granted, diffuse background. Although he does not use the term transduction, Connor has in mind precisely that concept when he calls for the "intensification and thickening of the transactions between foreground and background, signal and noise, hearing and listening" (11) as a means of sounding out the complexity of finite musical material previously taken for granted as atmospheric, immersive, infinite.

The earth's atmosphere, as Tim Morton reminds us, "contains throughout its circumference a thin layer of radioactive material, deposited since 1945," not to mention all the spent hydrocarbons deposited since the invention of the combustion engine by James Watt in 1784 (2013 4). Connor's account, via Morton, shows how music

presciently conceives of atmosphere as Anthropocene: not an ethereal escape from the man-made world here on earth, but an element that is already populated with human traces. The musical air is, in effect, enearthed by pollution: it is neither a vast, empty space into which our waste products can somehow disappear, nor, metaphorically, an uncluttered musical ambience where composers and musicians can unproblematically discover alternatives to historically encrusted musical forms and listening habits. Consider the contrast between a piece like *Atmosphères* and a seminal work of ambient music, Brian Eno's *Music for Airports* (1978). While Ligeti's piece, via Connor, seems to stage a struggle between sound and its medium (the air itself), Eno's ambient approach simply suspends the crowds, noise and tension of airports, as well as the massively congested traffic and debris of the upper atmosphere itself.[16] The music—minimal, unpulsed, looping, ethereal—presumes there is an ambience somewhere out there and offers musical and affective cues for its sonic habitation, but the conceptual stakes of the piece do not grapple with the material and ecological dimensions of the site or situation it wants to address. Aesthetically, then, *Music for Airports* is both a Muzak-like, affective regulator and a concert-hall piece that foregoes the environment for a transcendent musical domain (an ambiguity I discuss further in music for sleeping in Chapter 4); but it does not engage music, listening and environment geosonically. It does not thicken the transactions (i.e., transductions) between what counts as foreground and background (as Connor has it), but rather smoothes and rarefies the foreground into the background. In this chapter I am interested in how the underground fits literally and metaphorically into this problematic. If the underground (of modern seismology) is recorded, played back and

apprehended as sound, then how do artists working with sound appropriate that ultimate sonic territory?

Part II: Earthquakes: Music to Sounds

As mentioned above, earthquake sounds are not sounds per se in that the seismic vibrations caused by earthquakes almost always propagate at frequencies below the threshold of human hearing. But earthquakes and sounds share a similar structure as waves, and seismologists have long exploited a kind of proto-sonicity of earthquakes through techniques of auditory display. A counterpart to data visualization, auditory display refers to the scaling and playback of complex data sets in audio formats as an analytical and pedagogical tool (Kramer 1994). Technicians usually make a distinction between audification and sonification. In audification, a data set is regarded as already "shaped" like a sound wave and can thus be played back without any other manipulation than tweaking the frequency range and time scale. This is how seismographic data is typically audio-displayed, according to geoscientist Chris Hayward: "[s]ounds transmitted through the air (acoustic waves) have similar physics to seismic vibrations transmitted through the earth (elastic waves). The physics is similar enough that mathematical models that describe sound transmission through gas are successfully used for seismic modeling" (Hayward 1994, 370-1). Sonification, by contrast, involves transposing data values onto a predetermined set of musical frequencies or sounds, as a way of making certain patterns audible, rather than visualizable. Sonification, not audification, would better characterize the cyborg interface I describe in Chapter 3**,** where Neil Harbisson "hears" colour frequencies as a more or less arbitrary, but consistent (i.e.

sonified) range of musical tones programmed into his prosthetic antenna. The distinction between audification and sonification is deconstructible to an extent: audification, as in the audio seismograms I discuss below, implicitly or explicitly understands itself as listening directly to "raw" data, whereas sonification appears more as a translation across media formats, a mapping of data into sound for display purposes, but without a perceived intrinsic connection between recorded data and audified playback. The catch is that the "raw" data of seismology has already been already cooked by pre-existing technocultural constructions of sound (as mechanical wave energy) and hearing (as tympanic transduction). When we listen to a highly composite technical artefact like an audio seismogram and imagine that we are hearing the earth quake in our loudspeakers or in our ears, we indulge in a transductive disavowal that bypasses the multiple technical and conceptual interfaces that comprise a sound in the first place, let alone the sound of an earthquake.

In any case, in the context of the seismological discourse I engage below, earthquake audification is less a transformative feat of data processing than it is like the editing of a pre-existing sound. After the initial moment of transduction (in which seismic vibrations are registered as movement by seismometers or geophones and transcribed into seismograms), the data set of an earthquake is already like a sound with a clear pattern of attack, sustain and decay. Chris Hayward argues that earthquake audification is a unique fit between geological and human scales and "can take advantage of the vast human experience in interpreting noises" (371). If the audification process preserves the shape and the structure of the seismic waves amidst the processing techniques necessary to transpose it to the audible range (e.g., time compression, frequency doubling, automatic

gain control, etc.), then it will sound "like a recording of natural, environmental sounds." Hayward goes on to describe the initial attack of an earthquake as "two sharp sounds (reminiscent of a heavy door with a latch closing)" (398) and stresses that "a low pianolike sound must remain pianolike when shifted in frequency" (398) and that the overall process "must preserve the characteristic attack and decay of impulsive sounds as well as harmonic relationships" (384). For geoscientists like Hayward (and Florian Dombois), the geological scale of the earthquake is surprisingly at home in the human ear. His descriptive metaphorical register ("reminiscent of a heavy door") blurs into a prescriptive mode of apprehending the data in the first place: the data is already "pianolike" and characterized by "harmonic relationships" *before* audification, and that technical process is understood as preserving, rather than embellishing, the inherent sonicity, even musicality of the earthquake.

For Hayward, earthquake audification has an immediate practical value for seismologists in carrying out routine diagnostic testing of their equipment. Non-earthquake-like sounds (caused by malfunctioning equipment) are much more readily and efficiently heard through audification than read off of the squiggles of seismograms. Indeed, the first scientific paper on earthquake audification hinged the scientific value of the process on another kind of geosonic pitch discrimination, that is, on making accurate distinctions between the seismograms caused by earthquakes versus underground nuclear explosions. Written at the height of the cold war, when global nuclear test monitoring was a matter of keen national and military-industrial interest, Sheridan Speeth's "Seismometer Sounds" (1961) demonstrated that listeners (in this case, a group composed of Bell Labs technicians and some local high school students) could be rapidly

trained to distinguish with ninety percent accuracy the sound of an earthquake from a nuclear bomb. Listeners would hear recordings juxtaposing earthquake sounds with explosive sounds in a regular pattern. After a few listening sessions, they could then accurately discriminate between quakes and explosions when listening to a random sequence of audio seismograms. In a section of the paper titled "Transformation of Explosive Sounds to Earthquake Sounds," Speeth writes that "[t]he subjective distinction established by the experiment described above must rest ultimately, of course, upon physical differences between the classes of events" (912). In other words, the specific seismicity of an underground nuclear explosion (about which relatively little was actually known to seismologists) could be hypothesized as fundamentally different from that of earthquake only through audification, that is, through "subjective distinction." The differences were not otherwise available to scientists using visual or computational tools alone. Speeth goes on to suggest that adding filters to the earthquake sounds to make them sound more like explosions would be a way of investigating the seismic patterning of the explosions themselves. Tweaking audio data into a simulation of an explosion for a human listener could be used to deduce an understanding of seismic events. Altering the audified model, then, could be effectively treated like a new data set, as if it came from underground. Epistemologically, this suggests that planetary structure is revealed in and by the human ear. Just as the sonar data of Helmreich's dive to the sea floor did not effectively generate a map until it was re-transduced offsite by human embodiment and data visualization, so does the transductive logic of seismic audification suggest that underground explosions become not only identifiable, but also understandable as such when they are simulated before discriminating human ears.

There are three geosonic aspects of Speeth's paper to stress here: (1) we are invited to think of the earth as, all at once, an artist, composer, performer, instrument and body. The earth composes or performs sounds which resonate in its own body like the resonant body of an acoustic instrument; (2) we think of seismologists as recording engineers who are shaping and aestheticizing the material in very specific ways according to preconceived notions about how it is supposed to sound, indeed, of how sound is supposed to sound. Just as a recording engineer might use certain kinds of microphones in a certain spatial disposition to simulate an ideal (or an actual or historical) acoustic space in recording, so do seismologists manipulate data to conform to sonic conventions even as they evaluate them; and (3) the transduction of these particular subterranean sounds (especially the *timbral* differences between quake and bomb seismograms) is unthinkable without Cold War-era military-industrial research. The geosonics of earthquakes ca. 1961 is also a geopolitics of earthquakes, and as geopolitical realities evolve, so do the very sounds of the earth qua earthquakes.

Before audio seismograms became a data display tool of serious scientific interest, they were a kind of musical curiosity among seismologists and even found their way onto an experimental LP put out by Cook Laboratories titled *Out of this World* (1953).[17] On the record, Caltech seismologist, and inventor of the modern seismograph, Hugo Benioff presents and narrates a series of earthquake sounds recorded from a seismological center in Pasadena, California. His narration, interjected dramatically amidst obscure rumbling, crunching and booming sounds, begins, "This is a record of actual earthquakes."[18] The word "record" might refer simultaneously to the archiving of seismic events, the recording output of the seismograph and the vinyl disc rotating on the

listener's turntable. It almost seems, via Benioff, that earthquakes were conceived of as musical recordings even before they were conceived of as sounds.[19] Benioff's narration goes on to give a lesson in geosonic scaling. First he explains how time-compression transposes earthquake waves into the audible range, and how factors like playback speed and the distance of the quake from the recording station in Pasadena affect the timbre of the seismogram. While Benioff does not explicitly use the word timbre, his descriptions of earthquake sounds under different time-compression or distance factors (e.g., "the brittle, bone-crushing texture of these sounds" or "a sort of feathery tone about an octave below middle C on the piano") invite our musical, rather than scientific listening to the geosonic material. The juxtaposition of different earthquakes by distance factors (a local quake off the coast of San Clemente; a more distant quake in Hawaii; a third quake on the other side of the planet, south of Madagascar) lends itself to what Benioff calls "a sort of perspective of the earth's acoustics," and the aftershocks of the Madagascar quake are "like reverberation, like echoes in a canyon, but here the canyon is the whole interior of the earth."

But just as the narration begins to move toward a kind of soundscape of the earth's "acoustics"[20]—a resonant space of foreground and background, of sonic texture suspended in immersive depth—the earthquake sounds are brought back abruptly to their transductive and medial status as a record. Benioff says, "Now we're going to try to reproduce on this record the big San Clemente shock at nearly the original speed. It won't be audible, but by bending over the phonograph and watching the arm very closely, you will see it move from side to side, actuated by the original movement of the indicator of the seismometer in Pasadena." There follows ninety seconds of relative silence during

which we hear the occasional hiss and pop of the vinyl and perhaps the faintest hum of some impossibly low-frequency tinnitus—a sound that may be buzzing in our own ears more than it is coming out of the speakers.[21] Benioff transforms the seismogram into a spectacle of pure mediality, suspending the audio output of the record player in favour of a silent, visual display of audio media as mechanical motion. The movement of the record player's arm literally reproduces the same movements of the seismograph's arm during the San Clemente quake, and if we connect the squiggles from one stylus to the next, it is as if the record needle is tracing directly the vibrations of the earthquake on vinyl. This is a record of actual earthquakes, indeed, and the album's liner notes joke that a sufficiently loud playback could result in actual earthquake-like damage to the listener's stereo equipment.[22]

The "silent" recording of the earthquake creates two opposite, yet maximally transductive moments. On the one hand, we are made to perceive—inaudibly, yet operationally—the voltage differences, mechanics, materials and instrumental design that underlie our listening. The sonic environment shrinks down to the size and shape of the turntable, the equipmental infrastructure of our listening. On the other hand, the listening imagination expands outward to a geological scale, transducing seismic vibrations to our listening ears that we experience no less vividly for their inaudibility. This geosonic transduction recalls Friedrich Kittler's media-theory-famous discussion of Rilke's essay "Primal Sound" (1919) in *Gramophone, Film, Typewriter* (1999 [1986]). In Rilke's essay, the poet recalls a kind of science project from his school days in which his teacher and classmates construct a crude gramophone out of a bristle from a clothing brush joined to a paper cone and suspended over a manually rotated wax cylinder. The adult Rilke

speculates as to what would happen if that needle were displaced from the wax grooves made from speaking into the cone and were made to trace and "playback," as it were, other grooves that were never recorded in the first place.[23] Benioff's record foregrounds the transduction of Rilke's speculative procedure, inviting us to imagine the stylus of our record player tracing the groove of an earthquake, while showing us that same stylus moving right before our very eyes, producing no sound, yet filling an imagined space the size of the planet. It is probably no coincidence that Kittler was also a fan of earthquake audification because of the extreme mixing of metaphors, materialities and temporal scales involved in such transductive listening.[24]

In Benioff's analogy between the arm of the record player and the seismogram, the audio transduction of earthquakes brings our attention to the listening instruments themselves. Here the concept of instrument could be expanded beyond scientific sensing and recording playback to include musical instruments as well. For all the percussive hits involved in earthquake sounds, it is strings and piano keys that invite the most apt analogical and metaphorical couplings of earthquakes to earthquake instruments. The musicality, not just sonicity, of earthquakes implies that all seismological instruments—and even the earth itself—are at least potentially musical. Composer Gordon Mumma, one of the key figures in American avant-garde and electronic music, used the piano (and perhaps the earth) as a kind of geosonic musical instrument in a series of remarkable compositions based on seismographic data called the *Mographs* written in the early 1960s. During this time Mumma worked as a research assistant at Willow Run Laboratories in Ypsilanti, Michigan, nearby to Ann Arbor where Mumma had studied at the University of Michigan. The lab, a former B-24 bomber factory, was a site for Cold-

War era government research, and housed the Acoustics and Seismology Lab where two seismologists, Gordon Frantti and Leo Leverault were expanding Speeth's work on earthquake audification and bomb/quake discrimination.[25] Mumma developed an informal working relationship with the Lab, where he was able to listen to audio seismograms and was struck by the musicality of earthquake sounds. Of particular interest to him was the temporal delay between two main types of waves caused by earthquakes: so-called primary waves (P-waves) which are compression waves that propagate through rock; and secondary waves (S-waves), shear waves that travel along the surface of the earth at slower rate, arriving to the seismometer after the P-waves with which they co-originate. Audio seismograms thus have a kind of double attack, or a staggered beginning (almost surely what Hayward had in mind with his image of a heavy door, with a latch, closing). For Mumma that interval opened up compositional possibilities: "The structural relationships of the time-travel patterns of P-waves and S-waves, and their sound reflections, had for me the compositional characteristics of musical sound spaces " (Mumma 2006 18-9). If we turn to Mumma's *Very Small Size Mograph 1962*, we might clarify how exactly the composer hears musical sound spaces in a seismogram. This piece is written for four pianos, four hands and was recorded by Mumma and David Tudor, the avant-garde pianist and composer known especially for his collaboration with John Cage. The recording is under thirty seconds in length and consists of single, three-note chord, but the elaborate set-up is worth noting in detail. On a Midwest tour with the Merce Cunningham Dance Company, Tudor and Mumma came across a large recital hall next to one of the dance venues. Mumma recounts:

> The recital hall had four grand pianos and Tudor suggested we do some more recording experiments with them. Those "experiments" involved elaborate

> spacing of both the pianos and the microphones. We made there several recordings of the very simple—only one three-note chord—*Very Small Size Mograph 1962*. The four pianos were not all well in tune, thus encouraging us to arrange them far apart. Each of us would have two pianos that we could each perform, with wide arm-stretches, at nearly the same time. We assigned ourselves the task of playing the single chord on one hand for each of the four pianos, almost, but not exactly simultaneously. For this situation we arranged ourselves so that we couldn't see each other. The performance assignment was that one of us would play the chord, and the other would respond to the sound with that same chord, then the first would respond again, and the second to the first. All very quickly so that the chord sounds became as close together as possible without being exactly together. (22)

One version of the piece consists of the four, near-simultaneous bursts of that "simple" three-note chord (B♭, D♭and E♭ above middle C[26]). The first two chords are staccato, the last two sustained for over twenty seconds until the sound dies out on its own. We hear each pianist in a different stereo channel, thus reproducing their spatial distribution in the recital/recording hall, and there is some warbling interference produced by the repeated striking of the same chord on four slightly out-of-tune pianos. The *Very Small Size Mograph* embodies seismographic data in the way it foregrounds the reaction-time of the performers, who, working out of sight of each other, have their ears and their widely-stretched arms trained to respond to each other as quickly as possible, but with an inevitable delay. The concept of the piece (its "performance assignment") and the spatialization of the recording situation and the stereo playback are all structured to reproduce the lag between P- and S-waves. As intensely as the piece concentrates on a dense cluster of sound, it also aims to emphasize the otherwise barely perceptible delays and doublings within that seemingly unitary event.

The performance also reinvents the piano's function as a musical instrument into a dual functionality as a seismic sensing instrument (seismograph) and transmission

medium (earth). The striking of the chord on the first piano sets up a kind of relay, with each piano then registering and responding to the initial event in real, embodied time. The pianos both transmit vibrations, as earth and rock do during an earthquake, and register those vibrations like seismographs, scrawling their readouts onto the magnetic tape of the recording equipment, as opposed to the paper printout of a Benioff seismograph.[27] In this way we could think of the *Very Small Size Mograph* as re-instrumentalizing and enearthing the piano. The performers themselves sit seismometer-like, waiting to be set into motion by distant vibrations, which arrive twice (first as a staccato chord, then as a sustained chord), even though they both originate from the same event (here, Mumma's score, or Mumma's and Tudor's "performance assignment"). The recital/recording space is transformed into something that it already is—namely a space to listen to or to record vibrations make by musical instruments—but it becomes such a space (again) only through the geosonic scale that aligns the vibratory events of the recording process with the earthy infrastructure of quakes and seismology. The *Very Small Size Mograph* simulates not only an earthquake, but also the seismographic recording of an earthquake. Moreover, each of the elements constituting the performance (composer, performer, piano, microphone, recorder and the hall itself) function, within the transductive geosonics of the piece, like earth (as transmission medium), earthquake (as vibratory attack and propagation) and seismograph (as sensing/recording instrument), and may even take on multiple functions, simultaneously or consecutively, depending on the listener's perspective at any given point. The listener, with his vibrating eardrums and embodied audition, participates in this geosonic-tympanic equalization, too. This is *another* recording of actual earthquakes, indeed, in which "recording" encompasses the

geosonic entirety of the concept, performance and recording processes. In the *Very Small Size Mograph*, the enaction of seismographic material coincides with its own infrastructure (geological, technological, embodied) precisely in the gaps between P- and S-waves, which open up "musical sound spaces" for geosonic and tympanic resonance.

Mumma's opus designation *Mograph* is obviously a play on "seismograph," and the factor of time-compression is crucial in determining the "size" (i.e. "seis-") of each *Mograph*: in addition to *Very Small Size Mograph 1962* and *Very Small Size Mograph 1963* (the former about twenty seven seconds long, the latter just fifteen), Mumma also composed *Small Size Mograph 1964* (two minutes and nine seconds); the *Medium Size Mograph 1964* (just over six minutes); and the *Large Size Mograph 1962* (just over eight minutes, the only *Mograph* written for a single performer on solo piano).[28] The larger the "size" of each *Mograph*, the smaller the factor of time-compression becomes in Mumma's compositional procedure. Less compression opens up more complex "musical sound space" in Mumma's interpretation of the seismographic data, increasing the texture and nuance of each piece in proportion to its performance time, or "size." The smaller, highly compressed *Mographs* usually have a single, quite loud dynamic range and consist of clusters of notes (single notes, sometimes chords, often staccato chords resolving to a single sustained note). Sounds are usually paired in rapid succession, recreating the dual attack of P- and S-waves at various pitch intervals, yet otherwise Mumma is careful to avoid repeated rhythmic figures, or any other structuring elements that would detract from the overall arc of each piece, which, regardless of size, traces the slow decay of a complex onslaught of sounds. On the selection of musical pitches in the *Mographs*, Mumma writes, "One compositional decision was limiting the pitch-vocabulary and

intervals for each work, allowing more attention to the complex time and rhythmic activity of the sound events" (18-9). Mumma is not attempting a systematic sonification of a particular seismographic data-set, that is, he is not mapping a range of seismic frequencies onto a corresponding frequency range of piano notes as his composition. The pitch selection is designed to convey the complexity of rhythmic events. The *Mographs* thus invert the convention of European concert music whereby rhythm is used as a means of organizing melodic or thematic material (i.e., musical pitches). By contrast, in the *Mographs* the musical notes function more like musically differentiating placeholders that allow us to perceive the rhythmed unfolding of "sound events." The *Mographs* thus generally avoid tonality and repetition so that nothing like a theme, melody or harmony can emerge. At the same time they avoid ambience and soundscapeyness. It would be unfair to call the *Mographs* an Eno-esque "Music for Earthquakes," composed with the intention or effect of smoothing out the turbulence of an earthquake into an imaginary sonic ambience. For all the meandering of the notes, intervals and chords, the rhythms feel precise and, although they are sporadic, they punctuate our attention. The constantly shifting "pitch-vocabulary" moves the pieces forward, without cyclicality or structure, so that the overall effect is of inhabiting a dwindling texture of sonic time, listening as the sounds inevitably grow quieter, shorter and spaced further and further apart. While audio seismograms consist of a carefully processed display of earth-scale vibrations (precisely calculated via time-compression, playback speed etc.), the *Mographs* render scale or "size" more loosely as an aesthetic experience. In a sense all we here is *scale* when we listen to the *Mographs* arranged from small to large. The variations in the notes matter less than a sense of density unfurling into spaciousness. We hear the earth, or the earth is

enlistened, in the duration of the *Mographs*, where the quaking of piano strings in a room merges with seismic resonance on a geosonic scale: not background music, but transductive underground music.

Part III: Earthquakes: Sounds to Music

Toward the turn of the 20th century, as seismographic data becomes digitized and more readily processed with audio digital tools, there is a general tendency to reverse the sonic/seismic trajectory traced by Benioff and Mumma. That scientist and composer proceed from the epistemological starting point of the earthquake's musicality—its timbral texture housed within an acoustic wave-like structure—and, in different ways, use recording tools and musical instruments to break up that musicality by introducing durations of silence, uncertainty or indeterminacy. I have argued that it is in those cracks or gaps where a kind of geosonic transduction takes place, that is, where the imagination couples with techniques and tools of listening and with audio material derived from the geophysical data to listen across media, bodies and the earth. Geological time and space are ambiguously figured and felt in these intervals between and below audified earth sounds, which aestheticize the inaudibility of the sonic material both technically and musically. These audio seismographs use music to make the earth sensible as sound, or sonic events. Neither audio seismograms nor *Mographs* constitute soundscapes: they are discrete, particular geosonic events transduced by machines, bodies and the listening imagination. They mark a moment in time as a juncture, otherwise unimaginable or imperceptible, of human and geological scales of time and space. They also trace, often literally, the fault lines where human technocultures encounter and re-imagine their

geological, material substrate. Yet moving into the 21st century, several artists and musicians are more inclined to use seismic data as a more readily exploitable musical resource. Digitization—with its capacity to work with vast data sets of synchronized global seismometric networks, and to stream data in real-time and play it back automatically via custom algorithms—replaces the tape-based transductive processes that previously converted earthquake "music" into singular sounds. The easier access to geophysical data and the more or less instantaneous conversion of data into sound lends itself to seismic soundscaping, a kind of re-backgrounding of the underground. I turn now to some key contemporary digital seismic installations and performances that offer a kind of tectonic shift in the geosonic imaginary, that is, a dubious digital environmentalism of earth as immersive background, ambience and atmosphere.

Ryan McGee and David Roger's work on the "Musification of Seismic Data" (2016) highlights new digital techniques and platforms for earthquake audification that the authors have put to use in contemporary musical compositions and media installations based on seismographic data. Beyond techniques of time-compression and frequency doubling associated with tape manipulation, McGee and Rogers use granular synthesis and phase vocoding to alter the duration, pitch and timbre of the percussive hits of "natural" earthquake sounds. Granular synthesis (which I discuss in the context of 24/7 audio culture in Chapter 2) here involves fragmenting digital sound samples into smaller pieces or "grains." In the case of synchronous granular synthesis, the grains are essentially copied out a number of times and pasted back together to increase the duration of a sound without altering its pitch. The technique has the effect of "repeatedly emphasizing each grain, which emphasizes the unique decay of each earthquake"

(McGee and Rogers 2). Asynchronous granular synthesis is a similar process, but which imbricates different grains, rather than repeating and pasting together the same grain, with the effect of "creating stuttering rhythms unique for each event" (2). The spaciousness and staggered attacks of Mumma's *Mographs* here become, respectively, a kind of digitally smoothed time-stretch and a regularized rhythmic pulse. Phase vocoding is another technique that breaks apart, filters and resynthesizes digital sound samples. It can be used to edit out undesired frequencies to "de-noise" a sound: "This de-noising can be taken to extremes to leave only a few partials in each sound, ultimately producing unique tones and chords for seismic events" (2). Vocoding can thus introduce clean tonality into a noisy frequency spectrum so that we can hear precise musical intervals (minor thirds, fifths etc.) emerge out of the audio spectrum.

McGee has produced two electronic compositions, "Haiti" and "Christchurch" (2012), each based on seismographic data from the deadly, high-magnitude quakes in those cities in 2010 and 2011 respectively. The opportunities for stretching, layering and filtering the sounds create a distinctly musical ambience characterized by an interaction of "instrumental" timbres and harmonic intervals, as well as moments of pulsed rhythm that beat a kind of 4/4 time. One user on Soundcloud (where McGee has uploaded both recordings) writes of the "Haiti" piece, "It's like a surreal dubstep sampler;" and another user writes, "that drop is filthy," referring (approvingly?) to a dubstep-like beat drop in the "Christchurch" piece. If Benioff was trying to make the seismographic data sound "like" an earthquake (whatever that might mean, and even if that meant recourse to an inaudible sound), then McGee and Rogers clearly want to make earthquakes sound not just like music, but like a specific subgenre of contemporary electronic dance music.

"Haiti" and "Christchurch" played continuously as part of a seven-month installation titled "DOMUS" at Materials and Applications, Los Angeles (October 2014-April 2015). The authors describe the project as "an experimental architecture installation incorporating spatialized seismic sound and light within a [two-storey] hexayurt [equipped with] 6 mid-range speakers, 4 subwoofers and a 360 degree LED pixel chandelier" (2-3). The loud, low-end playback resonating within the space of the yurt emphasizes what they call the "seismic nature" of the compositions in the context of a "biophilic design model that responds [sic] and reflects the natural world" (3). Like Benioff 's *Out of This World*, the installation aestheticizes inaudible data. But where the reality effect of Benioff's audifications derives from explicit and implicit ideas about the materiality of sound and recording, the reality effect of the DOMUS installation appeals instead to "nature" and to unscrutinized sonic expectations of earthquakiness. DOMUS simulates what people think an earthquake sounds like, rather than using sound to make people think about earth(quakes), full stop. The assumption that audio seismicity has a "nature" or is "natural" and would thus slot into our culturally constructed listening habits of what "nature" sounds like is as problematic as the aesthetic possibility that seismicity also happens to sound like dubstep. But in effect both propositions downplay, if not outright ignore, the transductive nature of audification. They emphasize either a smooth, regularized sonic product (dubstep) or a soundscape of "natural" earthquake sounds, rather than foreground the indeterminacy of geosonic processes that cut across earth, instrument, body and imagination, simultaneously making, equalizing and unsettling all the elements in the transductive loop.

McGee and Rogers have also developed an ambitious project called "Sounds of Seismic" (SOS) which they characterize as an "infinite computational earth system soundscape" (4). SOS uses custom software applications to collect data streaming in real-time from global seismographic monitoring networks and automatically generate live-streaming music out of the data, with the help of algorithms processing the data through the synthesis and vocoding techniques outlined above. Seismic data remains "the original, sole sound generator" for this automated, 24/7 data-processed soundscape. While this may sound like the ideal seismic audification of the 21st century, the conceptualization of the project brings us oddly back to the mid-twentieth century avant-garde. McGee and Rogers cite Pierre Schaeffer's tape experiments and *musique concrète* as inspiration, and more significantly, John Cage's *Variations VII* (1966), an ambitious performance/installation staged at the Armory in New York and incorporating live electronic transmissions of deep-space radio waves, ionospheric "whistlers" and Bell telephone lines, mixed with on-stage amplifications of the sounds of blenders, fans and footsteps on the contact-microphoned stage platform, not to mention amplified readouts of electroencephalographs and cardiographs of some of the performers (which included Cage himself and David Tudor).[29] The Cage piece is a multi-scalar festival of intra-corporeal, infrastructural, everyday and extra-planetary sounds premised on the idea that using technology to tune into otherwise inaccessible sounds is of inherent aesthetic value.[30] Rather than question how we perceive these sounds and what kinds of technocultural and ecological relations they enact, the piece works like a conventional concert hall performance: virtuosically choreographed sounds produced live by trained technicians working with specialized instruments resonate in a large interior space before

a paying audience. Only here the musical raw material to be appropriated is "natural" (if highly mediated), rather than "musical" in any conventional sense. The piece takes for granted a vast background or atmosphere of hidden sounds that are presumably available, first as electronic signals, then through a transparently understood process of transduction, as (musical) sounds. Such an atmosphere of availability is problematic on its own terms (which does not, I should stress, necessarily diminish the aesthetic impact of Cage's piece), yet becomes even more problematic in case of SOS, when it goes underground, that is, when seismic sounds are literally and metaphorically grasped and instrumentalized as musical atmosphere. McGee and Rogers conclude the presentation of the work on musification with a nod toward the ultimate background, instrumental music (which I discuss in chapter 4**):** Muzak, writing "The ultimate goal of this research is to create a generative, dynamic audification-based musak [sic] which can highlight resilience and awareness of the natural world in which we inhabit [sic]" (4). Given that historically Muzak is linked to environments of docility and distraction rather than resilience and awareness, this aesthetic choice is as contradictory as the idea that we can be brought into contact with the earth by an "infinite computational system."

A project like the SOS is marked by a number of contradictions: it draws inspiration from the mid-century Cagean assumption that because certain distant signals can be captured as sounds, therefore they also *should* be. It also wants to smooth out and regularize those jagged signals into music, while preserving their "natural" qualities at the same time. To return to Connor's argument from above, music's claim-staking to atmosphere and ambience overlooks/overhears the "down to earth" trafficking between foreground and background (i.e. transduction) that any conceptually- or experimentally-

minded music must continually negotiate. Just as Eno suspends the very sonic environment he composes ambient music for, so does a project like SOS bracket out the earth—and the earthly infrastructure of listening—by transforming it into a database of Muzak-able material. In SOS and similar projects,[31] 21st century earthquakes are thus assimilated, via a detour back to the mid-20th, to the contemporary technocultural model of the networked computer: they are streaming in real-time, easily and ubiquitously accessible, and they increase our awareness of "nature" insofar as they serve as an ambient soundscape available 24/7. Another artist, Moon Ribas further adapts the earthquake to another contemporary technocultural model, that of the online mobile device. Ribas, a Barcelona-born collaborator with Neil Harbisson (discussed in chapter 3) and co-founder of the Cyborg Foundation, is a self-proclaimed cyborg artist who works with seismographic data transduced through a sensory prosthetic-cum-implant. Ribas initially used a wearable wrist sensor that transmitted seismographic data to her body via vibrations in the wristband, creating what she calls a "seismic sense." But as she mentions in a 2015 TED talk in Munich, "I didn't want to wear my sense, I wanted to have my sense." Since then a version of the sensor has been implanted directly into her left arm, just above the elbow, linked to the internet via Bluetooth. A second implant in her right arm transmits vibrations from seismographic monitoring systems on the moon, so that in addition to the "earthbeat" (Ribas' term for the heartbeat-like buzzing that represents the real-time aggregate of global seismicity linked to her implant), Ribas can also sense the fainter pulsations of moonquakes. In a 2016 TED talk at McGill University, Ribas called herself a "senstronaut" whose lunar- and geoseismic senses allow her "to be here and in space at the same time." Like Harbisson, Ribas promotes her

cyborg identity through the aforementioned TED talks and other YouTube-friendly presentations/interviews. Her signature performance piece is titled "Waiting for Earthquakes" and involves spontaneous choreography—Ribas trained as a dancer—in response to vibrations of the seismic sensor as transmitted in real time during the performance time. In a highly edited version of a performance of the piece (uploaded to YouTube in 2013), we see Ribas dancing solo with apparently no musical or sound accompaniment. She wears a sleeveless dress to enhance the visibility of her pre-implant wrist sensors, a visibility emphasized throughout the performance with vigorous, flailing arm movements. Early on in the video, we see Ribas falling to her knees, torso undulating smoothly, or sometimes jerking spastically, as she attempts to jump up, only to fall back to her knees. There is a vague sense of narrative in the performer's struggle to stand, to locate some kind of choreographic *terra firma*. The piece overall is characterized by fluid movements and abrupt transitions, occasionally pulsed, yet without a persistent rhythm or pattern.

In a 2017 interview, Ribas explains, "My artwork is happening inside my body. I'm the only one who perceives it. So in order to share my experience, I create external artwork related to my new sense." Related to "Waiting for Earthquakes," Ribas has also created performances of "seismic percussion, where the score and the rhythm I play [are] dictated by the rhythm of the tectonic plates. In this case, earth is the composer of the piece." As with Harbisson, the set-up of the cyborg performance involves conjoining the extreme solipsism of an absolutely interior, subjective experience with the conceit of the unmediated operation of "technology" or, in Ribas' case, "the earth." In "Waiting for Earthquakes," we see, theoretically, the earth's seismicity transduced in real time into the

movements of the dancer's body. In the percussion piece, we can hear the cybernetically enhanced rhythm of the "earthbeat" communicated to our eardrums by Ribas, as interpreter and conductor of the earth. Now, setting aside the looming technical questions and doubts that such performances might bring up,[32] we encounter in Ribas' work a version of earthquake audification that wants to bypass the ear altogether, vibrating and resonating directly on/in the body. Her prosthetic displaces the tympanism of the eardrum onto a tactile interface. Earthquake sounds here become a prototype of a wearable device or a mobile app. Even if we take Ribas for her word and believe that a small, magnetic vibration in her arm is capable of conveying, in real time, the massive, and massively complex data sets of global seismometry (which involve thousands of sensors, each of which move vertically, north-south and east-west, and register vibrations from multiple, simultaneous events, time-traveling via reflection and refraction through a barely mapped-out planetary geology), we still have to accept the proposition that earthquake sounds are not only streaming 24/7, but that they should also be integrated into our bodily senses and rhythms as well, like a Fitbit or an Apple Watch. The overall effect is, as in McGee and Rogers' work, a superficially "seismic" environmentalism: "I feel closer to nature because I can feel my planet. And I feel closer to other animals that can perceive earthquakes, too. Adding new senses to the body can help us to rediscover the planet where we live [and] bring us closer to the planet, to nature and to other animal species" (Ribas 2017). And from the McGill talk, we hear the slogan, "Let's try not to change our environment and be brave enough to change ourselves" (2016). Like Harbisson, Ribas advocates a cyborg identity in which the individual aesthetic imperative toward bodily enhancement is imagined as a step toward ecological awareness and a kind of fight

against climate change. If we all just had the bravery to change our bodies, we could both preserve the environment *and* feel closer to nature, other species and the planet all at the same time.

What these recent experiments in digital seismicity suggest is a pseudo-environmentalist updating of the mid-century aesthetics of audio seismograms. At the technical level there is a kind of paradigm shift from the tape-based tympanism of Benioff and Speeth's recordings and Mumma's pianistic re-imaginings to a computer/mobile device paradigm. Sounds, seismic or otherwise, no longer have to be recorded (by a machine, or an ear) in order to exist and be listened to. Rather, sound is reconfigured as a matter of algorithmically facilitated access or connectivity: seismic sounds exist to the extent that, at least potentially, they can be streamed in real-time 24/7, as earth-generated Muzak or as Stelarc-esque prosthetic ears vibrating on our arms. But such sounds are literally out of their element in that they presume earth can be listened to as atmosphere, or that the human body can "beat" like a planet. Transduction is bypassed conceptually (but not technically) in favour of a rhetoric of environmental awareness and connectedness to nature and the earth. Where Benioff and Mumma emphasized attack, decay and inaudibility as fundamental to the idea of seismic playback, digital seismicity connects to a smooth flow of continuous access. Perhaps the imminent threat of nuclear destruction—and indeed, underground nuclear explosions were being audified along with earthquakes—marked those Cold-War-era sounds with a sense of inevitable finitude; or perhaps the finitude of magnetic tape itself contributed to a mid-century geosonic imagination of earthquakes as singular, time-stamped events. And perhaps the diffuse, on-going phasing of climate crisis in the 21st century lends itself to a re-imagining of

earthquakes not as dramatic individual events, but a vast, global soundscape without beginning or end. The difficulty with the latter proposition would be its denial of the literally earth-devastating impacts that underlie global 24/7 digital culture, its recasting of global seismicity as a soundtrack for climate crisis.

The point of my intervention is not necessarily to condemn or praise one historical moment over another, but rather to trace this fault line in the geosonic imaginary, where one set of technical, scientific, aesthetic and geopolitical circumstances collides with another. My conclusion is theoretical, more than critical: there is no sound of the earth per se, only the myriad and fleeting configurations of technology and imagination by which we transduce a necessarily partial and fleeting earth. I do not mean to say that the earth does not exist, that there is no outside to the human technocultural habitation of the planet, and from there to make a wholesale critique of "earth" as inflated anthropomorphism. But I do mean to say that any facile geomorphism—any claim to authenticity, organicity or priority resulting from a technological or aesthetic set-up on/in/under or as "the earth" does not, indeed cannot reveal the earth, but only refer us back to the aesthetic and technological crafting of an environment in historically specific, contingent ways.

Chapter 2: A Planet Made of Beethoven: Audio-Stretching, Transductive Listening and 24/7 Aesthetics

"Are sounds just sounds or are they Beethoven?"

--John Cage

From a geosonic perspective, whenever we are immersed in a soundscape, the earth disappears and can be, at best, partially recovered through transductive listening, that is, through a critical analysis of the processes of enearthment and enlistenment that mediate between bodies, instruments and the earth-as-interface. At the same time, transductive listening takes place within historically and technoculturally contingent moments (i.e. geosonicks) that always interface with a *particular*, historically variable earth, never the earth as such. In Chapter 1 I discuss the geosonics of earthquakes and argued for a kind of paradigm shift in audio seismology from mid-20th century, tape-based audification techniques to 21st century digital synthesis. The shift is technical (moving from the finitude of tape recording and editing to the fluidity of data aggregation and simulative software tools), but also aesthetic in that instruments (e.g., a Benioff seismographic with piezoelectric sensors verses a software program like Instaseis) contain aesthetic and epistemological premises built into their material affordances. We when listen to the earth (quake) through instruments, we listen to the premises of the instruments at the same time that we listen to the sounds that those instruments transmit.

In the recent flourishing of new materialist approaches across disciplines, contemporary musicology has seen a renewed theoretical interest in musical instruments. Departing from the dry, taxonomical procedures of conventional organology, instruments are increasingly being approached as tools of sensing, transmission and knowledge production, and as forms of agency and mediation that co-evolve across the history of

music and the sciences (Dolan and Tresch 2013). Alexander Rehding argues for the "theory-bearing dimension" of musical instruments, demonstrating that instruments (both scientific and musical) produce theoretical and epistemological insights precisely through their materiality (2016). From the perspective of a media arts history of sound, earth and transduction, Douglas Kahn traces the fluidity by which instruments shift between sensing, monitoring and transmitting functions to spontaneous and creative sound and signal productions (2013). I stress, with Kahn, the literal and metaphorical transductive capabilities of instruments, which in Chapter 1, reveal the unexpected isomorphisms of earthquakes and eardrums, and pianos and seismographs. But unlike the new-materialist musicological approach, I do not ground instrumentality in an entity called music, science or knowledge, but rather in the earth, attending to instruments as modes of mediation that ultimately derive from and attempt to model or playback the earth. This is why attempts by performance artists and composers to reimagine, say, the sound of geophysical data contribute as much to the geosonic imaginary of a particular moment as the scientific work of seismologists. Each participates in an instrumental circuit of mediation that is infrastructurally grounded in the earth—and that attempts to reground itself in the earth through technical and aesthetic means.

Returning briefly to Tim Morton's notion of hyperobjects, it is fair to say that the earth is a hyperobject, but the mere facts we are "on" it and have some embodied experience of it do not contribute to our understanding of the earth's multi-scalar immensity. Morton says as much about other hyperobjects like capitalism and global warming. For Morton, we are immersed in these hyperobjects, but their dimensions elude the grasp of conventional phenomenological and critical tools. Following Morton, via

Helmreich, I am arguing that immersion is always an effect of transduction, never an immediate, embodied experience, and that the geosonic transduction of the earth begins where the phenomenology of the world ends.

In this chapter I focus on an artwork called *9 Beet Stretch* (2002) by Norwegian artist Leif Inge. The work uses the digital process of granular synthesis (mentioned in Chapter 1) to extend and smooth out the duration of a recording of Ludwig van Beethoven's *9th Symphony* to a length of twenty-four hours. The conceit of the *Stretch* is to transform Beethoven's symphony (which can stand, pars pro toto, for the totality of European concert music) into a soundscape and an immersive listening experience. Here I offer a critique, or a critical "infrastruction" of the *Stretch*, that is, the simultaneous deconstruction of presence *and* transduction of infrastructure within the rhetoric and experience of immersion. The more (digital) media are operationally untethered from space and time, the more they are rhetorically (and infrastructually) grounded in the earth. The geomorphic earthquakeyness of seismic soundscapes is one instance, and the *Stretch* is another. There is no intrinsic formal reason why the audio-stretching of the 9th symphony should be twenty four hours long. The otherwise arbitrary choice of duration attempts to fuse two kinds of immersion: immersion in the stretched soundscape of the symphony with immersion in/on a planet that rotates once every twenty our hours. Geosonically, the immersiveness of the listening experience entails the temporal enearthment of the listener, remediating the symphony and rescaling acoustics and concert-hall aesthetics to an earthly dimension. At the same time, the immersiveness of that experience displaces or omits the infrastructure of audio streaming and 24/7-ness, namely 24/7 capitalism and the geopolitics of labour. I attempt to "infrastruct" the

moments where the immersive listening experience reveals/conceals its economic underpinnings.

I argue that Inge's installation suspends the listener in an geosonic elsewhere that is uneasily situated between the transcendent musical spaces of European art music and the grim reality of 24/7 environments recently sketched out by Jonathan Crary (2013). The *Stretch* pulls us impossibly close to the materiality of the orchestra and the voice; the archival reality of a recording; the imaginary mechanics of a digital process; and the compositional structure of Beethoven's masterwork. At the same time the piece constantly pushes us away toward a soundscape of "sounds in themselves" that we may experience variously as sublime, ambient, boring, annoying. In search of aesthetic solutions at formulating the seeming incommensurability between a technical process of non-stop duration and the human act of listening, I build on John Cage's notion of indeterminacy (2011 [1966]) and Mark B. N. Hansen's (2004) theory of affective embodiment, critically situating the latter against the 24/7 world of digital apparatuses outlined by Crary.

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Nine minutes into the final choral movement of Beethoven's 9th Symphony, we encounter a remarkable rift in the musical fabric. It consists first of an extended fermata—in which the orchestra and chorus sustain a single chord for a seemingly endless interval—followed by an equally long silence, or caesura. In the moments leading up to this break, we hear the delicate elaboration of that famous "Ode to Joy" theme by the solo singers, interspersed with grand entrances of the entire choir. The orchestral playing emphasizes the upbeats of each measure, moving against the dominant flow of

the vocal theme, and creating a powerful, if also powerfully imbalanced sense of dynamism and energy.

Just when it finally seems that the orchestra and the voices will coincide on the downbeat and restore balance to the piece, there are two abrupt key changes. Repeating the lines "und der Cherub steht vor Gott," the singers resolve a cadence in the tonic key of D, but swiftly move back to the dominant A and then, unexpectedly, to F, where the fermata takes hold. In the first shift to A, it is as if the piece attains a new height, and though we may not have expected it, the move from tonic to dominant works harmonically, and the elevation of the overall tone works musically as well. Yet the shift from A to F is more radically unsettling, even jarring. All the upper voices hold the same high note, the A, but the lower registers all drop to F. It is as if the bottom has dropped out from under the piece, as if the newly modulated A had become distorted, stretched itself to a kind of breaking point. And it is precisely here that the piece rests, sustaining that F chord for seconds that may feel like hours, forcing us to question if this is the new musical ground on which the piece will stand, or if it is a mere interruption or deviation which will eventually take us back to familiar territory. After the challenging pause comes an equally challenging silence, refusing to resolve any of our questions, suspending us in a stunning cessation of musical time.

If we add to this pause not just the preceding nine minutes of the choral movement, but also the entire forty-odd minutes of the first three movements of the piece (already in themselves longer than most entire symphonic works), we begin to feel the truly crushing weight of musical energy and time that has come to rest on this moment of sustain and pause. An entire piece has derailed itself, and the listener—whether novice or

expert—may, at each listening, have virtually no idea how the piece could continue after such a monumental disruption.

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I have just written nearly 500 words about a passage that occupies 12 bars in the score (319-30) and roughly 30 seconds of empirical time (Beethoven 1997, 126-7). It is one of the great privileges in writing about music that you can allow yourself a potentially infinite time for reflection and analysis (not to mention all the literary resources of metaphor) to express thoughts on mere seconds of actual music. Writing about music depends on the fantasy that you can fully separate the aesthetic time of the piece in question from the empirical time of its performance, and dwell, seemingly indefinitely, in a frozen moment of musical time, safe from the ticking-away of the clock that only moves you further and further away from the sounds that initially captured your attention.

Listening to music is far more difficult than writing about it because, from the position of the listener, the piece always rushes ahead in empirical time, and indeed, in musical time as well. If we choose to linger in our minds on a particular passage, we risk missing what follows it and thus lose the flow of the piece. And indeed, the more I think about this particular passage without regard for the whole, the further I am from what it actually sounded like, the more I am filling it out in my memory. Even if I use a recording to find it and play it back, I would notice that breaking and resetting the flow of empirical time also compromise the aesthetic effect of the musical time. When I play back a passage half a dozen times, it loses the effect it has when it comes only once in the temporal flow of all that precedes and follows it.

This deficiency in listening to music, its built-in belatedness, is of course also what makes listening and re-listening to music endlessly fascinating and productive for thinking. The belatedness is, as I suggest in the Introduction, also intrinsic to the "always again" remediation of sound through listening. But, to come to the technique of audio stretching, and the *9 Beet Stretch* in particular, it also leads to a series of questions: What if we had more time for listening to music while we were in fact already listening to music? What if we could adjust the ratio of aesthetic time to empirical time in a piece of music so that we could more substantively integrate the time of our musical reflection into the actual empirical time of listening? Rather than speeding up our thoughts, what if we could, in effect, slow down the music, but in such a way that we could still hear it and think with it at the same time? And what would such a piece sound like, anyway?

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Norwegian artist Leif Inge's *9 Beet Stretch* is a composition/installation that digitally "stretches" the length of a recording of Beethoven's 9th Symphony to a duration of twenty-four hours. Conceived in 2002, the work premiered in Madison, WI in 2004, with subsequent performances in Vienna, Shanghai, New York, and Toronto, as well as a 24/7 webcast streaming since 2005 and a free app available for download. The "stretch" uses a technical process called granular synthesis to essentially break apart, replicate and smoothly recombine the digital samples of a recording with the effect of extending duration without pitch distortion. The listener can hear Beethoven's symphony extremely "slowly," yet without losing the tonal frequencies and other sonic qualities of the recording played at its normal speed. The result is an impossible listening experience, a

clash of temporalities in which a piece originally scored for a performance of roughly seventy minutes can be experienced as a twenty-hour-hour event.

The immense scale of the *9 Beet Stretch,* along with the unrelenting, "time-release" uncanniness of hearing accurate musical pitches vibrating with physically impossible (yet digitally possible) slowness, force the audience to reconsider its fundamental assumptions not only about sound, time and listening, but also about the limits of live performance and the hidden depths of recorded sound. Yet, as an experimental work, Inge's piece stands out for two more reasons: (1) its insistence on a *fixed*, if radically extended, performance time and (2) its explicit reintroduction of classical European musical content into the field of experimental music and sound art. In turning away from temporal indeterminacy (as theorized and practiced by John Cage, among others) and in turning back to a 19th century masterwork, the *9 Beet Stretch* seems to demand an uneasy synthesis of two incompatible sonic aesthetics: the structured, time-objective, individual-expressive qualities of Beethoven's composition with an ambient, time-arbitrary sound environment. Inge seems to ask us to rethink the fundamental nature of listening while, at the same time, listening *to* a fixed, and indeed quite famous piece of music; or, to put it in the terms I used previously, to integrate listening and reflection into a single sensory-intellectual experience that unfolds in a continuous timeline.

Yet the integration of listening and reflection already has a powerful precursor in 20th musical aesthetics, namely John Cage's notion of indeterminacy, and it is Cage's playful, yet incisive distinction between "just sounds" on the one hand and "Beethoven" on the other that marks the point of departure for my notion of transductive listening. For Cage, the single proper name "Beethoven" evokes the entire tradition of European art

music, with its emphasis on individual authorship, teleological form, subjective expression, and the performance conventions of the concert hall. In seeming opposition are "just sounds," that is, the notion of "sounds themselves" produced through compositional techniques involving chance and experimentation, as well as performance practices that subvert the aesthetics of the concert hall. Indeterminacy, for Cage, names the processes that sought to liberate time, space and indeed sound itself from the constraints of Western music,[33] processes that culminated famously in *4'33* (1952),*"* the "silent" piece that effected a redirection of audience attention from the structure of performed music to the incidental ambience of the environment. Rather than listen merely to "Beethoven," one can listen to literally any sound, and discover a hidden musicality, an implicit aesthetic dimension to any experience that emerges out of the perceptual act itself. Indeterminacy is, then, as much a mode of listening and a form of attention as it is a process of composition and performance. When Cage composed a kind of sequel to *4'33"*, namely *0'00" (4'33" No. 2)* (1962), he expanded the perceptual field from the hall to the world of everyday life, inviting an open-ended, potentially infinite merging of perception, aesthetic experience and the act of living under the auspices of indeterminacy.[34]

In his 1958 lecture "Composition as Process II: Indeterminacy," Cage writes, "It is high time to let sounds issue in time independent of a beat in order to show the necessity of time [. . .]" (2011, 40), a somewhat paradoxical statement I would interpret as follows: Cage would reject from the outset the duality of aesthetic to empirical time, insisting on only a single, unified but indeterminate time (what he calls "the necessity of time") in which musical sounds should be organized, performed and heard. The more a

musician or composer work in fixed units of time and under the compulsion to make sounds go somewhere in time—to endow them with a temporal teleology—, the more time itself recedes from the experience of composition, performance or listening. Rather than rendering time inaudible by subordinating it to musical form, composers should strive to make time something we can hear along with sound.

Some of the more notable compositions to follow in Cage's theoretical footsteps emerged from the Fluxus moment, such as Takehisa Kosugi's composition *South No. 2 to Nam June Paik,* in which the word "south" is pronounced extremely slowly, for a duration of at least 15 minutes; or La Monte Young's *Composition 1960 #7*, for which the only scoring is to hold a B and an F sharp "for a long time." Douglas Kahn has remarked that these Fluxus experiments reveal that "any single sound contain[s] exceedingly complex processes of production, of internal configuration: that a single sound's interaction with corporeal and environmental space transform[s] it from one moment to the next; and, therefore, that a simple musical structure of repetition or sustainment [is] not simple at all" (2011, 37). In other words, the indeterminacy of time, or merging of musical time and empirical time, lets us hear a hitherto unheard-of complexity in the production of simple or repeated sounds. Musical content organized in time in fact obstructs our sensation of sound, and a composition for which musical time is irrelevant, or which fuses musical and empirical time, gives us a wider, deeper knowledge of sound's materiality.

If Cagean indeterminacy blurs the distinction between art and life, between a world of mere noise (including "Beethoven") and a world of silence populated by aestheticized sounds, then transductive listening introduces a third term into the fluid

dualism of "Beethoven" and "just sounds:" the technical process itself (here, audio stretching) which both enables our listening and stands in as its object at the same time. I would argue, in other words, that when we listen to the *9 Beet Stretch*, we listen to three things at once: Beethoven, just sounds and audio stretching in and of itself. The stretch process paradoxically virtualizes *and* concretizes the sounds and the music into an excess that our listening ears ceaselessly sample in a frustrated attempt to connect with a process that defies the psychoacoustics of listening. Ordinarily, when we listen to the complex sounds that compose a piece like Beethoven's 9th symphony, the ear is not so much absorbing the totality of the sound, but rather constantly filtering, simplifying, aggregating or, to use Aden Even's (2005, 1-7) term, *contracting* the infinitely more complex layerings of sound waves that make up the tone of a single violin, let alone a full orchestra, or the concert hall itself.[35] Listening both reduces and synthesizes a far more complex materiality comprised of a continuum of sound and noise, contracting it into the timbres that we may experience as pleasing, and the melodic or harmonic configurations that we find expressive. Yet when we listen to a stretched recording, there takes place a particular kind of reversal of the usual "contraction" that our listening ears make. Rather than contract an infinitely complex acoustic materiality into distinct timbres, that is to say, rather than move from noumenal noise to organized sound, audio stretching allows us, or forces us, to move from organized sound back to noise. As we listen in to a given segment from the *9 Beet Stretch*, we may hear sounds that we initially recognize as human voices, violins, trumpets, etc., but that initial recognition slowly dissolves into an indeterminate timbral texture. The individual tones that are, from the compositional point of view, the building blocks of the piece, are revealed to be unstable, uneven and highly

composite acoustic entities. In an unstretched audio world, we may know this to be case—that erratic, recalcitrant and boundless sounds compose the acoustic reality underlying the fiction of expressive music—but we cannot hear it directly. Yet in a stretched audio world, we can hear the very material conditions of hearing itself; we can listen to the psychoacoustics of listening via a technical process that both reverses *and* plays back the very process of listening.

When indeterminacy is accomplished in this way—not at the level of composition or performance, but rather through a technical process of remediation—we encounter the form of transductive listening characterized not just by the fluidity of music/sound, but also that of object/process. To return, in stretched form, to Beethoven's 9th, and in particular, to the fermata of that dramatic key change I described earlier, the "sudden" shift to the key of F would take on a completely different character, approximating the purely sonic and leaving behind the merely musical. We would hear not just a dozen sopranos hitting a high A; we would hear the protracted whirring and warbling of dozens of voices as they searched, in the microseconds of their vocal attack, for the precise pitch, followed by the meandering flux of volume and pitch as uncountable hidden rhythms appear and disappear in the micro-fluctuations of the voices (not to mention the ever-so-lurching crossfade from one granulated sample to the next). Likewise, instead of hearing the strings drawing double *forte* on the F chord, we would hear (or imagine ourselves hearing) the skittering of hundreds of thousands of strands of horse hair pulled at minutely different speeds with minutely different degrees of friction and tension across a hundred steel strings, each string scraping and coming to life in a sonic cluster of vibration that we are otherwise accustomed to call, merely, "playing in tune." We could

similarly break down the sonic contribution of each section of the orchestra, as that extended F chord surges and trembles in prolonged transition. Even the "sudden" break from sound to silence in the ensuing caesura would be rendered into a gradual process, an turbulent gray area of sound decaying, unevenly, in fits and starts, into a silence that lasts for minutes, pulsing and hissing with echoes and room-tone. The abruptness of this passage of the symphony—its syncopated build-up, rapid key changes, and the fragmentation of the fermata—would be transformed into a murkily gradual transitional process, the stark musical contours softened into an ambient flux. The fixed, written score of Beethoven would thus yield an excess of spontaneous sounds, rhythms and textures that co-originate with the performance of the notes on the page, but could not themselves be reduced to Beethoven's composition.

But we would go too far to say that the *9 Beet Stretch* effectively transforms "Beethoven" into "just sounds" because we are not dealing with infinite or variable duration, but rather a fixed, if distorted scale of listening (in which one second of Beethoven's 9th is stretched to roughly 22 seconds of *9 Beet Stretch*). In other words, the piece still moves "forward" in time and as it does so, we hear not so much music-as-sound, but rather the becoming-sound of music. Within the fixed temporal parameters of the piece, we can hear the hidden depths, the micro-tonalities and accidental rhythms of the stretched recording, we hear the sound *within* Beethoven's music, not just the sound *of* it.[36] For this reason, it would also be unfair to assert that the *9 Beet Stretch* completely eliminates Beethoven as the author the work, for we are still immersed in his composition, and are merely being asked to listen to it on a different scale or listen for different things in it than we other otherwise would.[37]

Yet the immense scale of the *Stretch* would seem to defy the human ability to attend to the interstitial excess of sound for its programmed duration of 24 hours. Gaston Bachelard's (1958) notion of "intimate immensity" might give us a way of formulating the symmetry between the technical process of audio stretching and our process of listening. Bachelard describes the experience of immensity as a day-dream, as a particular form of contemplation in which the thinker does not approach a particular object with his consciousness, but rather recedes from it and finds himself in a distant "elsewhere," the space of the day-dream. He calls this state "phenomenology without phenomena; or stated less paradoxically, one that, in order to know the productive flow of images, need not wait for the phenomena of imagination to take form and become established in completed images. In other words, since immense is not an object, a phenomenology of immense would refer us directly to our imagining consciousness. In analyzing images of immensity, we would realize within ourselves the pure being of pure imagination." (184). Adapting Bachelard's language to listening and sound, we could say that Inge's piece allows us to recede from Beethoven's masterwork, situating us in a sonic "elsewhere" in which we listen to an unformed, yet constantly forming flux of sounds, and, in effect, listen to listening itself in the interstices of music and sound that Inge's piece reveals.

Mark B. N. Hansen (2004, 197-232), in his discussion of Robert Lazzarini's *skulls* (2000), elaborates a similar model of the feedback loop of perception and reflection (here mediated by a digital process). But whereas in Bachelard the redirection of perception folds back on the imagination itself in a strictly imaginative elsewhere, Hansen describes how a short-circuit in digitally mediated perception takes place paradoxically in the body, not the mind. *Skulls* is a sculptural installation consisting of four skull-like objects

mounted at eye-level on four walls of a room. The objects are physically realized sculptures based on digitally distorted CAD scans of an actual human skull. They appear, as Hansen notes, initially as anamorphic images that recall Hans Holbein's famous anamorphic skull in *The Ambassadors* (1533). Yet, unlike Holbein's skull, Lazzarini's *skulls* presents *three*-dimensional objects derived from a two-dimensional distortion in the computer. As such, the very physical depth of the objects constantly interferes with the eye's effort to undo the distortion: "*Skulls* confronts us, in short, with a spatial problematic we cannot resolve: with the 'fact' of a perspectival distortion that can be realized (and corrected)—and that 'makes sense' visually—only within the weird logic and topology of the computer" (202). For Hansen, *skulls* "furnishes what amounts to a cipher or index of a process fundamentally heterogeneous to our constitutive perceptual ratios" (204). And yet the strangeness of this irruption of the digital into the human sensorium produces an embodied, rather than abstract response. We *feel* the skull-like forms in our bodies precisely because we cannot see them in human-scaled visual space. The work "functions by *catalyzing* an affective process of embodied form-giving, a process that creates *place* within our bodies. And since it is through such a *creation* that we get a sense for the 'weirdness' of digital topology, we might well think of it as a correlate to the impossible perceptual experience offered by the work" (203). *Skulls* is exemplary of the reconceptualization of the digital image that Hansen develops throughout the book, whereby the image no longer refers to fixed objects or forms, but rather to the very perceptual process by which the body "gives form to, or *in-forms* information" (10). Paradoxically, it is precisely as a digital *image* that *Skulls* is also essentially a "post-visual" work because the response it provokes is proprioceptive,

haptic, and bodily rather than the disembodied abstraction that one might initially associate with the digital. Hansen will later go on to link that bodily response to Gilles Deleuze's cinematic concept of "any-space-whatever" and Marc Augé's "non-place," elaborating his thesis that digital art catalyzes a hapticity that both supplements the (incommensurability of) the digital world with human sensation, but at the same time creates an originary space in the body itself.[38]

It is tempting to see in Hansen's discussion of the digital distortion of the visual a direct analogy both to the aural logic of the *Stretch* and the imaginative flux of Bachelard. By manipulating the duration of the recording, but otherwise leaving the pitches and timbres intact, the *Stretch* allows us to listen to sounds that are, outside of a computer, physically impossible to produce and thus otherwise acoustically impossible to hear in the first place. When, in the *Stretch*, we listen to the full chorus sustaining single notes for minutes on end, we cannot help but become aware of the regularity of own respiration against the sound of human voices vibrating in a breathless digital beyond. We feel the incommensurability of those two worlds *in* our bodies, and even as our mind explains to us the 1/22 ratio of the audio stretching, our body hovers in a corporeal elsewhere of embodied listening. At times, it is unsettling, uncanny; at other times, it approaches a kind of sublimity, the kind of transcendent reflexivity that Bachelard describes. But the sheer scale of the piece would seem to complicate Hansen's aesthetic of digital embodiment because the duration is beyond the span of human attention and indeed beyond with limits of what the human body can endure.[39] Built into the very structure of a 24-hour duration are moments of inattention, distraction—not to mention the need for food and sleep—that are at odds with the relentless physical and aesthetic continuity

demanded by the installation. A theory of affective embodiment can only exclude the real bodily needs that are the necessary obverse of a technical process of 24 hour duration.

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Searching for the *9 Beet Stretch* online, one will encounter images or videos shared on social media of the various performances of the piece over the past dozen years. And among those images, one will invariably see young people in sleeping bags, on couches, reclining with blankets and pillows. Because no one can stay awake for 24 hours, not even when they attend a 24-hour music installation. Yet following Crary's argument in *24/7*, which at the outset invokes military research into sleeplessness as well as torture techniques of sleep deprivation, one cannot help but think of some of the other great 24/7 "sound installations" of the early 21st century, namely US military bases and various "dark sites" hidden around the globe where 24/7 high-intensity lighting and loud amplified music are the conditions of an excruciating reality of enhanced interrogation (Cusick 2008). Such sites are, for Crary, both extreme and exemplary of "the expanding, non-stop life-world of 21st century capitalism," the temporality of which "can be characterized as the generalized inscription of human life into duration without breaks, defined by a principle of continuous function. It is a time that no longer passes, beyond clock time" (8). Crary further formulates the temporality of 24/7 as "time without time, sequence or recurrence" and "non-time" (29). What is at stake is the unprecedented intrusion of the incessant access and availability afforded by digital technologies into the social, intimate and bodily dimensions of contemporary life. For Crary, digital technology transforms the traditional forms of alienation associated with industrial capitalism into a round-the-clock environment that seeks to unmoor the individual from

any other rhythm (even that of day and night) that does not beat at the same pace as global capitalism. The result is a new version of modernist alienation in which the individual, completely cut off from any meaningful social context, must manage his own alienation through the technological apparatuses, which have assumed dominance over the social.

Visually, and with an eye to the round-the-clock illumination of US torture facilities, Crary argues that a 24/7 logic eliminates shadow and light, texture, ambiguity. It introduces a constant glare in which we all live: "Glare here is not a phenomenon of literal brightness, but rather of the uninterrupted harshness of monotonous stimulation in which a larger range of responsive capacities are frozen or neutralized" (34). Glare is thus the enemy of indeterminacy in that its effects amount to the equalization, reduction and foreclosure of responsiveness, exactly the opposite of what someone like John Cage surely meant by his open-ended durational processes. Crary's notion of a constant glare, beyond the rhythm of day and night, is crucial for the sensory, metaphorical and (ultimately) political significance of 24/7. It is intrusive, homogenizing, paralyzing, and it reveals a chilling continuity between the political infrastructure of round-the-clock torture and the economic infrastructure of digital capitalism. Translating Crary's glare into sonic terms— and imagining what it might be like to listen to "Enter Sandman" or the Sesame Street theme at full volume for days on end—we might begin to a hear the din of a 24/7 world.

According to Crary's thesis, I have to admit that there is contradiction at work in my notion of transductive listening (and arguably, in the *Beet Stretch* itself), namely the fantasy that you can separate a technical process from the technological (and thus

geopolitical) infrastructures that make it possible. In her discussion of the militarized use of 24/7 music as torture, Cusick (18) points out the "[e]very amplified sound in the camps, and therefore every bit of music, *is* the United States' transformation of the energy in Middle Eastern oil into violent, violating sonic energy aimed directly at the people whose land yielded that oil" (emphasis in the original). In other words, it is ultimately impossible to think of 24/7 music(al torture) separately from the exploitation of the resources that sustain it because the music *is* that very exploitation. The geosonic infrastructure of music(al torture) is literally geopolitical in this instance. As much as transduction blurs the distinction between an object of listening (i.e., sounds, Beethoven) and the process of remediation itself, it can also reveal the structures of global capitalism in which digital technologies are ultimately embedded. Geosonically speaking: transductive listening is itself *determined* in the last instance by the economic, that is, by the 24/7 earth-extractive logic of late capitalism. The elsewhere in which we are situated by the *Stretch* is necessarily also the *everywhere*, the total environment of global capitalism. Likewise, when Mark Hansen develops a notion of embodiment in response to the alienness that digitally distorted works like *skulls* impose on human perception, what is missing is the larger structure of technological alienation that such artworks derive from, even if they attempt to mirror it back critically. Technical processes can be separated from the larger technological apparatuses that dominate social life only at the risk of creating a fetishizing fascination (e.g., an experience of immersion) that obscures the banality and violence of their operation. Holbein at least had the sense to project an anamorphic skull—that is, a cipher of violence and human finitude—as the foreground

and frame of the tools of world domination (globes, sundials, astrolabes) depicted in the painting.

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Looking back over the multiple senses of indeterminacy I have employed in this chapter, I would characterize their interrelation as follows: if the indeterminacy of *4'33"* revealed the hidden musical continuity between sound and "silence" and if *0'00"* sought to uncover a hidden aesthetic continuity between art and life, then the 24/7 logic of the *9 Beet Stretch* discloses a continuity between life and digital technology whose sheer possibility is already implicated in the latter's necessary domination over the former. The aesthetic suspension of time accomplished by the 24/7 duration of the *9 Beet Stretch* (and other cyclical, continuously streaming, 24/7 digital works) is in fact not incompatible with the scale of human experience, but on the contrary constitutes precisely the ceaseless, (a)temporal environment of global capitalism.

There is a philosophical precursor to Crary's argument that draws together time, technology and musical aesthetics into a sustained critique of modern capitalism, namely Theodor Adorno. In moving to a conclusion, I want to make explicit the Adornian/Frankfurt School underpinnings of Crary's sweeping critique[40] by first turning to Adorno's (2006) prescient formulations of 24/7 time in his *Philosophy of New Music*, and then returning to the dramatic caesura from Beethoven's 9th that initiated my analysis. According to Adorno, 20th century music had already given up on time with the debut of Stravinsky's *Rite of Spring* in 1913, a work which heralded a new compositional style that sought to replace the experience of musical time by a technique of musical spatialization. For Adorno, musical spatialization involves a series of structural shifts in

the art of composition: repetition replaces development; modality replaces tonality; form is suspended in favour of excessive coloration; and counterpoint gives way to a diffuse musical atmosphere. Stravinsky is not original in this regard, for he merely radicalizes a tendency toward spatial composition already seen in Wagner (where the concept of the musical drama predominates over musical time) and in Debussy (where atmosphere absorbs temporal progress into an impressionistic stasis). Stravinsky intensifies this trend by subordinating all other musical effects to the sole aim of spatializing musical time. Adorno writes, "One trick defines every manipulation of form in Stravinsky and is soon used to exhaustion: Time is suspended, as if in a circus scene, and complexes of time are presented as if they were spatial" (142-3). Practically, this means that, in Stravinsky, we here a music that has "renounced all possible means for the production of time-relationships—transition, intensification, the distinction between the field of tension and the field of release, further of exposition and continuation, and of question and answer [. . .]" (143). The montage-like process of composing music in rhythmic and melodic complexes without any organic connection or development has the result that "the musical continuum of time itself is dissociated," abandoning "the dialectical confrontation with music's temporal progression" (138).

For a thinker like Adorno, for whom art, society, history and technology are in permanent dialectical interaction, this is no mere stylistic deviation. The musical abandonment of time expresses the profound impasse of culture in the era of high capitalism and may be linked to the—at the time of his writing (ca. 1948)—newly emerged and even more aggressive forms of domination associated with totalitarianism and fascism. Commenting in the same essay on Wagner's tendency toward spatialization,

Adorno writes, “The suspension of musical time consciousness corresponds to the entire history of the bourgeoisie, which, no longer seeing anything in front of itself, denies the process of history itself and seeks its own utopia through the revocation of time in space” (140). Indeed, the fantasy of a spatialization of (musical) time could only emerge out of a social class that believes it has itself triumphed over history, that sees time as a given and space as the only dimension in which it exists, spread out before it like some open territory waiting to be claimed. Yet the flipside of that triumph is the paradoxical domination of the middle class by the very capitalist processes that ostensibly empower it. And that domination extends most sinisterly into the domain of time, for Adorno seems to suggest that the most dangerous outcome of bourgeois ideology is an individual who cannot think for himself because he has no time to think for himself.

In an earlier text, the famous chapter on the culture industry from the *Dialectic of Enlightenment*, Adorno and Horkheimer (1972) write, “The bourgeois whose existence is split into a business and a private life, whose private life is split into keeping up his public image and intimacy, whose intimacy is split into the surly partnership of marriage and the bitter comfort of being quite alone, is already virtually a Nazi, replete with both enthusiasm and abuse [. . .].” The individual who is forced to subdivide his life into increasingly smaller units and “time-manage” his own alienation has in fact forfeited his individuality to a system that dictates his actions at all times because it has eradicated the spontaneity of “unscheduled,” free thought. Even when he is alone, the bourgeois is still on the clock, his solitude sterile and unproductive because it beats time to a rhythm prescribed by a system he obeys without question. Turning back to Adorno’s essay on Stravinsky, we note an astonishing link between the reified, proto-Nazi consciousness of

the culture industry and the rarefied products of European art music, for Stravinsky's music produces almost exactly the same attitude of distraction and submission. Adorno insists that Stravinsky's abandonment of musical time must be understood not so much as aesthetically motivated, but also as the result of "the pressure of a system whose irrational superiority over everything subjected to it maintains itself exclusively on the basis of estranging people from the effort of thinking and reducing them to mere centers of reaction, to monads of conditioned reflexes" (146). The listener of Stravinsky finds himself in the same position as the consumer of the products of the culture industry in that all his reactions are calculated in advance. The music, spatially conceived, does not allow for a becoming in time, for the free play of subjective thought in dialectical tension with the objective act of listening. His music produces a passive listener, at best, and taking that passivity to a dialectical extreme, Adorno writes: "Stravinsky's *fabula docet* is versatile compliancy and obstinate obedience, the model of that authoritarian character that today proliferates on all sides" (146).

Adorno's treatment of Stravinsky may be heavy-handed and polemically charged, yet what underlies it is a distinction between two modes of listening that will help us to understand what the *9 Beet Stretch* does with time, and, perhaps not by chance, with Beethoven. Adorno names an "expressive-dynamic" and a "rhythmical-spatial" mode of listening and suggests that the two modes interact throughout the history of Western music, with either one predominant at a given time:

> The former [expressive-dynamic] has its source in singing; it aims at surmounting time through its fulfillment and, in its supreme manifestations, inverts the heterogeneous movement of time as a force of the musical process. The other type obeys the beat of the drum, intent on the articulation of time through its division into equal quantities that virtually abrogate and spatialize time. The two types of listening diverge by virtue of

> social alienation, which tears apart subject and object, separated by force of that social alienation which separates subject and object. [. . .] The idea of great music consisted in a reciprocal interpenetration of these two types of listening and compositional categories that conformed to them. (144).

Adorno defines listening not so much in relation to our perception of musical form unfolding in time as to our understanding of music's interaction with time itself. In this regard, he estimates, in the *Philosophy of New Music*, Beethoven's 7th Symphony most highly as a work, both in its formal construction and at the level of his dual typology of listening, which offers a musical and philosophical synthesis of expression/rhythm, song/dance, and subject/object. Yet, in passing, he remarks that the late works of Beethoven (which would include the 9th symphony), renounce precisely the dialectical synthesis attained in the 7th: "[Beethoven] himself in his late phase surrendered this paradoxical unity and, as the highest truth of his music, allowed the absence of reconciliation between the two categories to obtrude baldly and eloquently" (145). What is crucial for the polemic is the contrast between Stravinsky's cheap, pseudo-dialectical spatialization of musical time as montage, and the more profound fragmentation of time in the late Beethoven.

Though Adorno remains focused on Stravinsky for the remainder of his *Philosophy of New Music*, the short essay "Late Style in Beethoven" (2002) dilates upon the breakdown of dialectical time in Beethoven. Here Adorno argues that "late style" in Beethoven and other artists, is characterized by a kind of abandonment of the subjective shaping of artistic material that we normally think of as "style." What emerge are not smooth interpenetrations of form and content, style and idea, but rather radical breaks, which interrupt the work of the artist like death itself:

> The caesuras, the sudden discontinuities that more than anything else characterize the very late Beethoven, are those moments of breaking away; the work is silent at the instant when it is left behind, and turns its emptiness outward. Not until then does the next fragment attach itself, transfixed by the spell of subjectivity breaking loose and conjoined for better or worse with whatever preceded it; for the mystery is between them, and it cannot be invoked otherwise than in the figure they create together. [. . .] He does not bring about their harmonious synthesis. As the power of dissociation, he tears them apart in time, in order, perhaps, to preserve them for the eternal" (567).

Bracketing for now the difficulty of what Adorno implies in the late work's imbrication of form, matter, life and death, we can at least say that the relentless continuity of a 24/7 work like the *9 Beet Stretch* indicates a world that radically denies the possibility of fragmentation, cessation and release from its otherwise unendurable duration. The ultimate indeterminacy of listening would not be sought in Cagean continuities, Hansen's embodiment or Bachelard's imaginative elsewhere, but perhaps in that exemplary caesura from the fourth movement of the 9$^{th.}$ As the pause slowly unfurls into and interrupts the soundscape of the *Stretch*, the sonic gap transduces and audifies the earth that is otherwise inaudible in 24/7 capitalism.

Chapter 3: Now You See It. . . . : Hearing Colours in the Cyborg Soundscape

Of the three aspects of geosonic mediation that I consider in this dissertation (bodies, instruments and interfaces), instruments are focal point of the first two chapters. I attend to how instruments like seismographs, tape recorders, pianos, and audio stretch software transduce the earth through technical and imaginative playback and remediation. Bodies appear thus far only in the form of ear drums, the arms of piano players and seismic dancers (Chapter 1) or as the bulk of flesh that resists, but also capitulates to the 24-hour immersion of digital soundscapes (Chapter 2). In Chapters 3 and 4 I shift the focus to bodies, retuning geosonic transduction to the cyborg operations of the senses and brain.

In this chapter I turn to the art and activism of Catalan-raised, London-based cyborg artist Neil Harbisson. In the first part of the chapter, I develop a concept of the *trans-modern cyborg*, recasting the figure of the cyborg as simultaneously (post)modern, (hyper)disabled, transhuman and transpecies. Harbisson's brand of cyborgism, I argue, points to the ways in which Donna Haraway's striking definition of the cyborg as a disruptive and radically non-identitarian cultural force has evolved into an identity of its own, trading its oppositional feminist politics and critique of technocapitalism for a paradoxically vitalist embrace of the machine. This contemporary cyborg, I argue, problematically mobilizes 20th century modernist and cybernetic fantasies of the cyborg with the increasingly pervasive transhumanist rhetoric of augmentation, extension and optimization, all under the aegis of a neo-vitalism that seeks to draw its political legitimacy by an arguably tenuous analogy to transgender movements. Harbisson's work can show us, ambivalently, what is old, new and, above all, troubling in the figure of the

cyborg now. I argue that the cyborg figure itself is, like a soundscape, a kind of transducer that facilitates a certain experience or a certain rhetoric, while dispelling the infrastructure that underlies it. Harbisson embodies a neoliberal, neo-vitalist cyborg identity, but disappears the critical politics that are part of the cyborg's historical and conceptual infrastructure.

In the second part of the chapter, I look and listen more closely to the techniques and processes that underlie key aspects of Harbisson's creative practice, which relies on an implanted antenna that converts colour into sound. The technical achievement of Harbisson's work lies not so much in the synesthetic premising of his visual and sound compositions, but more in the explicit and performative interfacing of his brain and body with the environment. In seeming contradiction to how he stages himself, I argue that Harbisson shifts the location of cyborg-ness from techno-bodily prosthesis to a model of networking: the body is (re)connected to the environment by technical processes of transduction and transposition that amplify the indeterminacy of being (in) a body, rather than merely augmenting the body's experience of reality. In this sense, he seems to articulate cyborgness to essentialist concepts of colour, sound and nature, raising questions about listening, bodies and geosonics in a distinctly post- or trans-human milieu.

Part I. Old Cyborgs in New Bodies

"I don't feel that I'm using technology. I don't feel that I'm wearing technology. I feel that I am technology."

Neil Harbisson

Neil Harbisson is a self-styled cyborg artist and claims to be the world's first officially recognized cyborg person, owing to the Wi-Fi-enabled antenna that has been

permanently attached to his skull since 2004.[41] Harbisson was born with a rare eye condition called achromatopsia, a kind of total colour blindness whereby he can accurately perceive the intensity and saturation of light, but otherwise sees the world in total grayscale. The antenna (which he sometimes refers to as an "eyeborg") detects the electromagnetic waves that our eyes normally register as colour and converts those waves into sounds which vibrate in Harbisson's skull and which he thus hears through bone conduction. A prototype of the antenna was externally attached to the back of his head and powered by a laptop computer, but a subsequent version has been surgically drilled directly into his skull and carries out the light-sound conversion with its own built-in electronics. And so, through the implant, Harbisson can essentially "hear" colour: a cybernetic chip converts information from the environment into physical sensations he can experience. The particular tones he hears at any given time depend on the frequency of the light transposed onto a "sonochromatic" scale (which I discuss in more detail in Part II), and the volume of the tone correlates to the measured saturation or intensity of the colour. Infrared and ultraviolet frequencies, that is, frequencies that are otherwise invisible to humans, can be detected and sonified by Harbisson's antenna. The antenna also allows Harbisson to receive phone calls and listen to music via satellite uplink, and he can also "hear" videos and photos sent by select friends on five continents, even in his sleep. Most recently, he has collaborated with NASA to link his antenna to solar cameras orbiting the earth. Harbisson insists that he has invented a new bodily sense, a kind of synaesthesia or, as he calls it, sonochromatism, and that the sonified perception of colour has become completely integrated into his everyday life, and his perception of people, faces, cities and natural environments.

I will focus on Harbisson's use of the antenna for his creative practice in the second part of the chapter, but here I want to dwell on Harbisson's cyberactivism. For it is arguably less as an artist and more as an activist that Harbisson wants to make his mark, and all his cyborg art can be seen as a promotion, indeed a self-promotion, for a particular kind of identity (and identity politics). In 2010 Harbisson co-founded the Cyborg Foundation to (1) defend cyborg rights; (2) promote cyborgism as an art movement; and (3) support people who want to become cyborgs (https://www.cyborgfoundation.com.) An offshoot of the Cyborg Foundation is the Transpecies Society (launched in late 2017), with similar interests in raising awareness and creating collaborative and social spaces for persons with technologically designed non-human identities (https://www.transpeciessociety.com). A promotional video from (the November 2017 version of) the front page of the Cyborg Foundation's website announces that "We have the freedom to merge technology with ourselves, honouring our transpecies origins, reconnecting with nature and creating a more balanced relationship between us and the universe" and further down the page we read "It's time for transpecies to come out of the closet." And indeed, the first step to becoming a cyborg is "IDENTIFY," by which the site means to identify or choose the particular capability or body part one would like to modify, but which also implies choosing "cyborg" as an identity.

These snippets from the website already give us some orientation toward what I am calling the trans-modern cyborg, that is, the solidification of the volatile, boundary-blurring figure of the cyborg into a stable identity category premised on the unproblematic union of technocapitalism, information and the body. Such an identity

entails repressing at least a century of cultural history that has consistently presented the cyborg as a violent, uncanny figure living out socially the incommensurabilities and violence inflicted on human bodies and senses by capitalism.[42] In the place of this cultural history, the trans-modern cyborg substitutes a transhumanist and transpecies rhetoric that reinstalls an autonomous liberal subject at the helm of a monolithically unnuanced concept of "technology." These posthuman and post-post-modern cyborgs are wedded to progress, optimization and augmentation, while fighting to overcome prejudices borrowed selectively from the transgender and disability movements. By analyzing the rhetoric of Harbisson's activism (and, in part II, the aesthetics of his cyborg art), I show that the "trans" of the transpecies and transhuman points ultimately to the trans-modernity of the cyborg, that is, the cyborg as trans-historical figure that can either reveal or smooth over the shifting gaps, cracks and contingencies of human-technological ensembles as they are experienced at particular historical moments.

The notion of the "transpecies" is rapidly evolving and subject to widely varying interpretations,[43] but for Harbisson it seems to suggest a deep, if somewhat vague link, through morphology and evolution, between human and other animal bodies. If evolution is a process that proliferates differentiation among species, then cyborgism is the movement that seeks to emphasize or re-establish connections. In technologically modifying the senses, Harbisson's cyborg does not become "super-human," but rather reveals affinities between the human and other animal forms, thus opening up a transpecies terrain beyond and between conventional human-animal relations. Harbisson has already indicated as much about his own antenna, describing how he initially hit upon the idea of a chromosonifying prosthetic: "I kept searching for ways to create a new,

independent body part, and I found what I was looking for in nature. Many animals, especially insects, are equipped with antennae. So why couldn't I be?" (2015). But it is important to note that, for Harbisson, such trans-species affinities can only be experienced by technological modification of the human body, specifically the development of new sensory capabilities. Those affinities are not revealed by building new kinds of relationships with animals or enacting a different kind of ethics regarding the treatment and rights of animals, but rather only by the human becoming transpecies through technology: "Technology as a tool estranges us from nature. If you yourself become technology, you can use your expanded senses to feel connected to other animal species and get to know nature from another angle" (2015).

When we read that it is time for transpecies to "come out of the closet," the invitation is clear to view cyborgism as a marginalized identity analogous to LGBTQ identities. When asked how many people could currently be called cyborgs, Harbisson responded, "That question's just as impossible to answer as a question like how many men feel they are really women. In both cases it's a matter of identity" (2015). He goes on to compare the legal and bioethical resistance encountered by contemporary cyborgs with gender reassignment surgeries of the 1950s and 1960s. Just as LGBTQ groups have met with discrimination, repression and violence, so too do cyborgs face similar political struggles and social antagonism. The rhetoric of Harbisson's website is clearly trying to establish the legitimacy and indeed urgency of cyborg politics by analogy to LGBTQ politics, suggesting that a person's right to construct his own gender and sexual identity (even, and especially, in the case of extreme body modifications like gender-reassignment surgery, hormone therapy etc.) is analogous to a person's right to design

and modify his sensorium through surgery, implantation, neural interfaces, etc. On a legal and/or ethical plane, these rights to fluid identities and body modification may indeed be analogous, but it is crucial, I think, to raise the objection that, socially, the cyborg and the LGBTQ may not be so commensurable after all. In an era when even the most basic aspects of social, professional and domestic life require a hand-held, networked device and when digital technologies have so radically permeated and rewritten the functioning of markets, institutions and administrative life, it seems absurd to claim there are *any* forces out there (social, political or otherwise) bent on repressing the individual's personal relationship with technology. On the contrary! One could argue that the coercion to be a consumer of social media and the ever-proliferating array customizable digital technologies (gadgets, devices, platforms, apps, etc.) is as strong as precisely the coercive, heteronormative mechanisms that still continue to regulate gender and sexuality. And when real homophobia and the very real risks and dangers assumed by those with LGBTQ identities are likened to the discriminations cyborgs may experience because of their "out" relationship with "technology," it is clear, I think, that not all marginalizations are commensurable. But in any case, from the perspective of Harbisson's cyborg, and under the general figure of the trans-modern cyborg I am describing, there is an assumption of equivalence between how a body relates to gender and how a body relates to technology. For the trans-modern cyborg, gender fluidity does not pertain to a domain of bodily life that is separate or distinct from technology; rather the very concept of gender fluidity would seem to entail (the possibility of) technological body modification.

Yet what is disavowed in positing the cyborg analogy of gender and technology is the question of disability. Harbisson self-identifies as a cyborg, a transpecies, an artist merging body and technology to create new senses and experiences; yet he also has a disability, the congenital colour blindness whereby he cannot experience the visual sensation of colour. As much as his antenna enables a synesthetic transformation, it is also, on some level, a means of overcoming or compensating for a disability. Thus the cyborg configuration of body/*ability*/technology is potentially more compelling than body/*gender*/technology. Moreover, given the conspicuous nature of Harbisson's antenna, the kinds of vulnerabilities and antagonisms he is routinely subject to in his daily life are perhaps more closely aligned with the experiences of disabled, rather than LGBTQ individuals. At a 2011 demonstration in Catalan, Harbisson's antenna—and thus his body—was damaged by police, who suspected Harbisson was filming them. Here Harbisson was at greater risk and an easier target for police mistreatment solely because of the conspicuousness and vulnerability of his disabled/hyper-abled body, not his gender or sexuality.

Whether deliberate or unwitting, Harbisson makes a clear choice to downplay, if not exclude altogether, the experience of disability from the rhetoric of his self-presentation. This is perhaps less a question of (dis)identification with disability and disability movements than it is a matter of what Mack Hagood calls audibility (2017). Writing about tinnitus, Hagood argues that disabilities require mediation to become *legible* diagnostically, *visible* as part of a distinct community, and *audible* as a meaningful fit between a person's sense of self and a broader public discourse: "Audibility means being able to include one's physical experience in an interior

monologue that makes sense within public discourse. It also means being able to express one's experience in terms that will be sensible to others, whether though dialogue or activist invective. Without audibility, there is no creation of disabled publics and thus less agency for disabled people" (2017, 317). Disability is thus triply mediated by (1) medical discourses and diagnostic instrumentation; (2) social rhetorics of the visualization of distinctive bodies; and (3) communal discourses with which a person identifies by hearing and speaking himself into a particular identity position—a recognition and identification through audibility. The case of tinnitus as a disability, as Hagood recounts, is problematically a question of audibility alone, since the medical diagnosis and the visualization of a tinnitus-suffering body do not readily accompany the tinnitus's audibility as both an embodied experience *and* a communal narrative with which tinnitus sufferers can identify. Harbisson inverts the tinnitus example of mediated disability: his disability is medically legible and his prosthetic renders him exceptionally visible as a distinctive body; yet in rejecting the audibility of disability, that is, of hearing/speaking himself into a socially recognizable identity position as disabled, Harbisson ambiguously turns away from an embodiment and a politics of disability that he otherwise invites. Precisely in trying to sonify colour, Harbisson renders disability inaudible.

Numerous disability scholars have remarked on the critical potential of disability to expose the mechanisms of ableist ideology (Siebers 2008); social and corporeal normativity (Davis 2013 and Garland-Thomson 2017); the exercise of Foucauldian biopower on individual bodies (Tremain 2015); the neoliberal flexibility that increasingly constrains individual and collective agency in the 21st century (McRuer 2006 and Hagood 2019); and the diminishment of non-human materiality associated with neoliberal

subjectivity (Mitchell, Antebi and Snyder 2019). In bypassing the critical potential of disability, Harbisson arguably upholds a kind of ableism, propped up on the crutch of a pseudo-queer identity politics, not a disability politics. Tobin Siebers writes that "the emerging field of disability studies defines disability not as an individual defect, but as the product of social injustice, one that requires not the cure or elimination of the defective person, but significant changes in the social and built environment" (2008, 2). Rather than conceive of his achromatopsia as a means of questioning the normative assumptions around the experience of colour and the ways it is codified in institutional and daily life; in built and natural environments; and in the conventions of the visual arts and aesthetics, Harbisson sees his "defect" as in need of correction by an all-powerful technology that restores his normality by enhancing it. For Harbisson, the cyborg effectively silences, or renders inaudible, the complex embodiment and critical epistemology inherent to the experience of disability (Siebers 2008, 25) as well as the critical affinities between queer and crip identities and experiences (McRuer 2006).

Harbisson's casting of the cyborg as potentially closeted, entitled to the same kinds rights and recognition as LGBTQ individuals, and his use of the term transpecies evokes the cyborg body of another trans-movement: transhumanism. Transhumanism is a kind of life-philosophy or vitalism for the 21st century that promotes the active transformation of the human body—and the human species—through technology. It may have started as a somewhat marginal, arguably new-agey cultural movement, but has increasingly become an area of serious academic and entrepreneurial interest.[44] Some of its key objectives include radical life extension, the uploading of human minds to computers and the creation of "substrate-independent minds," that is, minds that are not

confined to a single human body, but can be distributed and synchronized across an ensemble of digital and corporeal platforms. Both transgenderism and disability are fundamental to the transhumanist concept of the body. Martine Rothblatt has argued that an individual's right to freedom of gender is "the gateway to *freedom of form* and to an explosion of human potential. First comes the realization that we are not bound our sexual anatomy. Then comes the awakening that we are not limited by our anatomy at all" (More and Vita-More 318). Rothblatt envisions a cyber citizenry of *persona creatus* [sic]: avatar-like entities living in and reproducing through a multiplicity of flesh and digital forms. That the transhumanist mind is deeper than bodily matter is an insight Rothblatt derives directly from transgenderism: "Consciousness will be free to flow beyond the confines of one's flesh body as gender is free to flow beyond the confines of one's flesh genital" (322).

Rothblatt is both a high-profile transhumanist (a multi-millionaire CEO with interests in satellite communications, aviation and biopharmaceuticals) and herself a transgender person. And yet, at the non-corporate, DIY end of the transhumanist spectrum, we find a similar link between transhumanism and the transgendering of the body. Tim Cannon, a DIY body hacker, runs a biotech start-up out of his basement on the outskirts of Pittsburgh. In an interview recounted by Mark O'Connell, he writes, "I'm trapped in this body. [. . .] But that's not just a religious idea, man. Ask anyone who's transgender. They'll tell you they're trapped in the wrong body. But me, I'm trapped in the wrong body because I'm trapped in *a* body. *All* bodies are the wrong body" (O'Connell 158). In Cannon's case, as in Rothblatt, the specificity of the body's relationship to gender leads to a general claim about the relationship of all bodies to

technology. Whereas Rothblatt's gendered body is a source of potential, Cannon's gendered body is a source of constriction, a trap. In either case, technology steps across the conceptual threshold of gender to alter or expand the body.

Disability enters the conceptual language of transhumanism through the notion of "morphological freedom," which Anders Sandberg defines as "an extension of one's right to one's body, not just self-ownership but also the right to modify oneself according to one's desires" (More and Vita-More 56). Sandberg's version of transhumanism is more traditionally liberal than Rothblatt's in that his rhetoric of creativity and self-expression relies on concepts of happiness, self-ownership and personal autonomy. For Sandberg, a creative drive toward self-expression is to be preserved in a legal framework that guarantees freedom for all individuals to pursue their happiness to the fullest, without the interventions and interests of governments, health care and insurance industries, etc. For him, the right to morphological freedom amounts to a right to a differently abled body: "It should be noted that the disability movement has been a strong supporter of the right to determine one's body just for this reason. This seems to be a natural point of agreement between transhumanists and the disability movement [whose] postmodern critique of the normal body also supports the right to be differently bodied" (More and Vita-More 62).[45]

For other transhumanists, the recognition of—and right to—bodily difference becomes an imperative to transcend the body altogether. Max More's programmatic "A Letter to Mother Nature" enumerates the deficiencies the human body has inherited from genetics and evolution (among them the compulsion of "to age and die" as well as "limited memory, poor impulse control, and tribalistic, xenophobic urges"), coupling that

with the will to use biotechnology and computation toward the "complete choice of our bodily form and function, refining and augmenting our physical and intellectual abilities beyond those of any human in history" (More and Vita-More 449-50). Natasha Vita-More's essay "Life Expansion Media" argues for a notion of the prosthetic body as the ultimate outcome of human-machine interfaces. She reconceptualizes prosthesis (as a supplementary part of an embodied whole) to a notion of the prosthetic as a whole unto itself: the prosthesis becomes the whole of what it was designed to supplement partially and, in the case of fully prosthetic body, its "structure—its robotic electronics, AI-generated programming, light silicone, titanium, aluminum, plastics, and carbon-fiber composites, and aesthetic streamline design—and its future varied formations of bodies and other platforms for existence—have already altered the realm of the 'normal'" (More and Vita-More 78). The body, for Vita-More, More and others, is merely a medium for the existence of consciousness on the cusp of achieving its technological transcendence of bodily form, or its technological singularity, as Ray Kurzweil would have it. This vitalistic notion of consciousness—which establishes implicit hierarchies of mind over matter, and recasts any concept of form as a constraint, limitation or shackling of a dynamic vital impulse—extends its predominance over the body to the planet itself. The "Transhumanist Declaration" (2012) mentions overcoming humanity's involuntary "confinement to planet Earth" (More and Vita-More 54) and More's "Philosophy of Transhumanism" claims that transhumanists "look to expand the range of possible future environments for post-human life, including space colonization and the creation of rich virtual worlds" (4).[46]

There is a strange, totalizing logic at work in the vitalism of the transhuman body, which leaps to the following kinds of conclusions: because some (transgender) people experience their body as the "wrong" body and choose to modify it, therefore *all* bodies are inadequate and in need of modification; or, because some groups have been victims of oppression and marginalization for their bodies (e.g., through race, sex, gender or ability), *all* people are in some way victims of their bodies. There is a further danger of positing dubious equivalences: to link the historical specificity of, say, slavery or the subjugation of women to the quasi-universal experience of being "slaves to our genes" (More "Letter" 450) or incarcerated, as Rothblatt has it, in a "prison of sex" (324) is to simultaneously obliterate, appropriate and tokenize the particular violence of, say, racism and misogyny in order to set up a false continuity between struggles for civil rights and struggles for cyborg rights.[47] The struggles for civil rights took place historically (and still take place) in racist and sexist societies that were/are radically hostile to the rights of women and black people. The same simply cannot be said for the struggle around transhumanist and cyborg rights because the contemporary West is not fundamentally hostile to technology in ways even remotely commensurable to how the West has historically been hostile to women and blacks, among other marginalized groups. The absurdity of the part/whole totalizing logic that infuses the transhumanist concept of the body is seen in the imperative to space exploration: not only is embodiment a prison, but indeed the whole terrestrial habitat is a confinement to be abolished by a hierarchical, quasi-imperialistic expansionism of consciousness that calls itself, quite tellingly and with palpable historical and cultural amnesia, colonization.

Here is it worth mentioning that, despite obvious affinities with transhumanist philosophies of technology and the body, Neil Harbisson does not explicitly describe himself as "transhuman" nor does the term appear on the websites of the Cyborg Foundation or the Transpecies Society. For the matter, Harbisson is not mentioned in any of the literature on and by self-identifying transhumanists that I have read. One point of distinction may be Harbisson's favouring of concepts like RR (revealed reality) and AS (artificial senses) in explicit contrast to discourses of augmented or virtual reality, and AI (artificial intelligence) respectively. What ultimately distinguishes Harbisson's cyborgism from transhumanism is an *aesthetic*, rather than a technological and (pseudo)political view, which I discuss in Part II.

The transhumanist body (and the dubious, neo-vitalist rhetoric and politics that undergird it) is perhaps an extreme case of the more general category of the trans-modern cyborg. The "trans" part of my definition refers to the ambiguity of transgender/transpecies/transhuman that permeates how we might think of the body in the early 21st century, in which discourses of transgenderism and disability are almost literally being colonized by technological and neo-vitalist imperatives. Yet "trans-modern" also emphasizes quite simply the transmodernity of the cyborg, that is, the persistence of a "classic" modernist notion of the cyborg through the postmodernism of the late 20th century and into the present (whatever its epochal designations may be—or may have been). The trans-modern cyborg suggests that cyborgness is itself a palimpsestic, trans-epochal phenomenon, in which cyborg figures of various moments (modernist, cybernetic, postmodern, trans- and post-human etc.) recur and overlap. The cyborg figure thus self-remediates and self-interfaces in ways similar to my discussion of

sound and listening from the Introduction. Cyborgs playback earlier "versions" of body/technology coupling even as they anticipate and adapt to new technologies, transducing bodies out of contradictory ideological and imaginary technocultural forces. Here is where Harbisson's notion of the cyborg has a special valence for geosonics: although like many transhumanists, he has his eye on outer space (literally, through NASA satellite uplink), Harbisson's cyborg is also down to earth, recasting the cyborg identity as a geosonic connection to nature and the planet.

It may be an anachronism to apply the term "cyborg" not only before its coinage in 1960, but even before Norbert Wiener's foundational work in cybernetics in the 1940s and 1950s. Yet as the early decades of the 20th century bore witness to unprecedented industrialization, urbanization and the spread of mass media, a number of artists and thinkers began to think of the increasingly technologized human body in terms that subsequent scholars have described in cyborg and techno-prosthetic paradigms. Matthew Biro analyzes figures of the body in the art of Berlin Dada to develop a notion of hybrid, mutable and performatively constructed subjectivity that is proto-cyborgian: a figure of embodied subversion that anticipates Haraway (2009). For Biro, the term cyborg denotes "a type of perceptual locus or framework" that can be applied to the early 20th century "to delineate or explain how our senses have been transformed through different forms of technological prostheses and through mass media" (9). Cyborgness is less a matter of an explicitly technologically enhanced cybernetic organism, and more a question of how changing configurations of body, sense, media and environment construct new forms of subjectivity; and the grotesque bodily mash-ups of Dada art can be read as figures of a proto-post-human body.

The perceived "newness" of these forms of subjectivity oscillated between a utopian and constructivist optimism (and optimization) on the one hand, and alienation and loss on the other. For Hal Foster, the modernist cyborg emerges specifically as a cipher of the damage done to the human body by capitalism and the vulnerability of the body in a mechanized world (2004). Foster's examinations of the art F. T. Marinetti and Wyndam Lewis in particular trace the radical responses of artists to the alienating, fragmenting effects of technology on the (male) body. Haunted by the "spectre of the damaged body of the worker-solider," Marinetti and Lewis' art is obsessed with the incorporation of death, the machine and the inorganic into the human body as a paradoxical preservation of life and desire. Foster identifies a paradoxical extension/amputation logic in modernist art (borrowed and retrofitted from McLuhan) and links it to contemporary developments in psychoanalysis to demonstrate how (male) psychosexual anxieties around the phallicization of the body dovetailed with social anxieties of the body's technologization. In Foster's reading of modernist art, the body is both too much and not enough of a cyborg, and technology is the prosthetic/fetish that supplements—while also threatening to supplant—the damaged or impotent body.

Tim Armstrong's concept of "prosthetic modernism" explores a similar logic at work in the literature of European modernism (1998). He argues that the body around 1900 came to by defined as a technically penetrable complex of biomechanical systems, the limits or thresholds of which could be quantifiably calculated, and therefore also potentially extended. The techniques by which scientists and physicians analyzed and treated the body became at the same time the metaphors which writers used to write (about) the body in literature. Modernist literature was "characterized by the desire to

intervene in the body; to render it modern by techniques which may be biological, mechanical or behavioural" (6) and as such was explicitly envisioned and enacted as both as a supplement of modern scientific bodily techniques *and* of the body itself. Literature—both writing it and reading it—became operationally part of the feedback loop between the body, science and technology, indeed became a means for the (self- or re-)construction of the body.[48] In short, for Armstrong (modernist) art is a prosthetic technology.

Armstrong, like Foster, also notes the crucial role played by gender in the modernist technologization of the body, though the former's approach is more historicist than psychoanalytical. In a chapter devoted to the "Steinach Operation," Armstrong describes the famous rejuvenation surgery developed by Austrian physiologist Eugen Steinach. The procedure—a kind of vasectomy—was understood to derive its rejuvenating effects from a logic of amputation/extension: the severing and suturing of one part of the male genitals (the *vasa differentia*) was to provoke a corresponding stimulation in another part (the testes), and the increasing production of sexual hormones was to lead to an overall rejuvenation of the body. W. B. Yeats underwent the procedure in 1934, and Armstrong shows how the great poet conceived of it as a kind of self-insemination, an internal rebirth (albeit enabled by an intervention from the outside) that literalized through science and surgery the poet's theories of masculine and feminine creative energies, culminating in artistic self-begetting (147-50).

Armstrong also treats the history of gender reassignment surgery via Lili Elbe's *Man into Woman: The Authentic Record of a Change of Sex* (1933) to show how, in the first decades of the 20th century, the notion of the social construction of gender was

developing in step with surgical techniques and scientific understanding that rendered gender physically (re)constructible as well. In a kind of literalizing of the Pygmalion myth, modern man could make (himself) a woman, and this transgenderism took shape within a larger and more traditionally masculinist logic of domination in which becoming a woman paradoxically amounted to a modality of dominating women. Foster notes an extreme version of this logic in Marinetti, "an imaginary transsexual" whose fantasy of the body as a "technological phallus" frequently integrates the imagery and rhetoric of self-castration with the self's rebirth through the machine (125). Marinetti's shrill and hyperbolic writings of 1910s and 1920s proved not too far afield from actual developments in the medical science of gender re-assignment surgery by the 1930s: in both cases gender was tied to bodily organs and processes that could be intervened with, and as such, gender was both a cause and an effect of the malleable, technologized cyborg body.

The biologism that underpins the modernist conception of gender (and its susceptibility to surgical intervention and reconstruction) participates in a broader vitalism that dominated thinking about the body and organic life altogether. Early 20th century vitalism saw all organic life as cyborgian, and we can reinterpret the "single-celled organism" explanatory narrative made famous by Freud (among others[49]) as a cyborgian, rather than speculative-evolutionary parable. Foster explicitly invokes Freud's *Beyond the Pleasure Principle* to characterize modernism's prosthetic logic, and it is worth noting how, in this wildly speculative text, Freud famously manages to fuse notions of vitality and organicity to deadness and the inorganic. Organic life begins, for Freud, with the incorporation of an inorganic layer of dead matter as a kind of membrane

or buffer to insulate and protect the living, organic matter underneath. In short, life requires prosthesis in its very origins, and a living body is defined as that which externalizes itself mechanically into a kind of shell, while simultaneously incorporating that outside into itself through sensory organs conceived of as "feelers" or antennae. As Freudian speculation would have it, the body is fundamentally cyborgian, that is, already always outside itself and already always a mediation between an organic inside and the surrounding environment via the inorganic mechanism of the senses.[50]

Though Freud's speculative model may point to a certain anti-modern primordiality of the cyborg body, another famous essay of the period suggests precisely how modern such in/organic rewirings of the body were. George Simmel's "Metropolis and Mental Life" (1903) examines the strains on the individual nervous system and the ensuing reorganization of perception and personality to accommodate the stimulus-rich and money-driven environment of the modern city (1997 [1902]). In order to compensate for a sensory overload that threatens to overwhelm the nervous system, the city dweller develops a new "organ" to protect him from "the threatening currents and discrepancies of his external environment which would uproot him" (176). Reading further, it becomes clear that Simmel intends "organ" as a kind of metaphor for the mode of heightened rationality and impersonality that he sketches out in the remainder of this essay; yet there is no good reason not to take him at his word: the new organ is literally a cyborg prosthetic insofar as it simultaneously exposes, compensates for and transforms the (vulnerability of the) individual's sensory and perceptual apparatus. For Simmel, the modern city dweller, "which, of course, exists in a thousand individual variants" emerges as a modernist cyborg as well.

The modernist notions of atrophy and hypertrophy in the cyborg body are as imaginative as they are literal, and thus they directly anticipate notions of ability that are perhaps disavowed, yet nevertheless implicated in the transhumanist body. The modernist cyborg body is often explicitly damaged and disabled, as much as it is constantly overcoming its defects through technology. In the Dada representation of WWI soldiers, for example, the extension/amputation ratio is skewed alarmingly toward amputation. Georg Grosz's portrait *Ein Opfer der Gesellschaft* (Remember Uncle August, the Unhappy Inventor) [A Victim of Society] (1919) depicts the surgically reconstructed face of a soldier. The eyes are mismatched: one is pasted onto the face upside down, with a third eye attached to the head where the right ear should be. The forehead is literally buttoned down onto the skull, and the whole head is propped upright on a rolled up Goodyear inner tube. An industrial hose fitting seems to have replaced or been superimposed on the nose, and a bared straight razor hovers against the throat, as if to suggest either that the surgery (a monstrous grafting of human, machine and handicraft materials) is still on-going and that the figure will now exist in a state of permanent operation; or that the ultimate step of the surgery is suicide, a slitting of the throat. Indeed, the rolled-up inner tube now seems to be unfurling, pushing the head onto the upturned blade as it much as it may also appear to hold it in place.

Otto Dix's 1919 painting *45% Erwerbsfähig (Die Kriegskrüppel*) [45% Ready to Work (The War Cripples)] shows us four crippled soldiers marching (that is, wheeling themselves or limping with crutches) down a city street, their faces each a grotesque mask of scars, burns, and shrapnel wounds, marred by missing eyes, ears and jaws, or else in the grips of debilitating, shell-shocked tremors. The image is a visceral satire of

government programs intent on rehabilitating wounded soldiers for the workplace, and for all the buttoned-down tidiness of their military uniforms and their tight, linear formation, the bodies of the soldiers are horribly exposed. If one of the hallmarks of the cyborg body is its plasticity and its blurring of inside and outside, then these Dada cyborgs, in their permanent state of maim and exposure, show us the real monstrosity of the body's plastic potential. The two images' shared emphasis on the senses—at least one of each figure's major sense organs (mouth, eyes, ears, nose and skin) is either mutilated, amputated or replaced with machine or surgical prosthetics—also literalize McLuhan's notion of sensory amputation *avant la lettre.* The whole concept of the cyborg is unthinkable without industrial warfare, and not just because Wiener's foundational work in cybernetics was military-funded, but also because machine violence was one of the key factors that exposed the vulnerability of the human body as much as it promised its machine optimization.

If there is a modernist cyborg artwork that most closely "resembles" Neil Harbisson and anticipates the concept of the trans-modern cyborg, it might be Raoul Hausmann's 1920 sculpture *Mechanischer Kopf (Der Geist Unserer Zeit*) [Mechanical Head (The Spirit of Our Times)]. The sculpture consists of the wooden head of a mannequin with various mechanical objects affixed to it. Most prominently a long, antennae-like ruler is nailed to the left side of the head in the place of an ear, secured by a mechanism of dials or knobs. On the crown is perched a telescoping metal cup, with a piece of measuring tape stretching from the cup's base, down the forehead, and stopping just between the eyebrows. On the right side of the head where the other ear should be, we see a leather eyeglass case with typewriter equipment inside it. Just above the case is

a pocket watch mechanism, and next to that, a small placard bearing the number 22. The decorative array of mechanical props stands in contrast to the blankness of the mannequin's unisex facial features where the brow, eyes, nose and tightly pursed lips are just minimally rendered. Each of the objects suggests the quantification of experience and expression: rulers, tape measures, clock mechanisms seem to have replaced any inward or organic sense of time and space, and the piece of typewriter equipment symbolizes a speedy, precise and, above all, standardized mode of expression. The sensory and expressive functions of the face have been displaced onto the ensemble of gadgets, which take over the tasks of perception and expression in a kind of mechanical synaesthesia. The head suggests that it cannot see or hear anything, yet can measure everything. Hausmann's *Head* bespeaks a cyborg body whose permanently open and externalized senses paradoxically close off and atrophy its inside. The number 22 crystallizes the satiric potential of the piece: it is as mass-produced and commoditized as it is "unique:" the head bearing the number 22 is only nominally and numerically different than all the other heads presumably for sale in a market where cyborg bodies and labour represent the unprecedented quantification and commodification of the human.

This detour into modernist figures of the cyborg body shows us the uncanny relevance of modernism for the trans-modern cyborg.[51] The early 20th century's technologized body—its human/machine ambivalence; its disability and hypertrophy; its prostheses and lacks; its transgenderism—bristles with a creative energy that is matched only by its capacity to be ravaged and disfigured. Science and technology offer the potential for unheard-of bodily transformations as much as they increasingly penetrate and analyze the body, expanding and dissecting in the same gesture. Crucial aspects of

the modernist cyborg—the vitalist desire to transcend gender; to rewrite and rejuvenate and even reproduce the body; to "become" technology rather than just merely use it; and to merge art, technology and the body into new forms of embodied techno-aesthetic experience—replay themselves prominently in Harbisson's aesthetics and in the transhumanist movement I have surveyed above, yet what is missing is the amputation that accompanies every extension. The trans-modern cyborg disavows the social context of violence (whether indirectly through capitalism and machine labour, or directly through industrial warfare) and the persistence of disability that constitute the figure of the cyborg from the outset.

Setting aside the extremity and grotesquery of these modernist examples, the disabled cyborg remains a figure to probe the co-constitution of bodies and media, both historically and critically. Mara Mills and Jonathan Sterne suggest a concept of dismediation—that is, "disability as a constitutive dimension of media and media as a constitutive dimension of disability" (2017, 366)—to analyze the ways in which media and disability co-evolve, without recourse to the ableism of prosthetic thinking or the titillation of amputation/extension imagery. Likewise, Mack Hagood's concept of biomediation names the complex interplay of media artefacts, discourses, bodies and experiences that coalesce around the concept of disability (2017). The emerging field of disability media studies seeks to look beyond disability as representation and discourse to understand it as a historically variable ensemble of technical artefacts, social meanings and lived experiences (Ellcessor and Kirkpatrick, 2017). And posthumanist disability theory seeks to emphasize the emergent agencies and affectivities of the nonhuman (that is, animal, technological and ecological) that are summoned in the experiential and

epistemological perspective of disability (Mitchell, Antebi, Snyder 2019). In short, disability transduces media, bodies and environments, and Harbisson's work sounds out the complex transductive potentiality of disability precisely to the extent that he renders it inaudible.

What I have argued here is that a compelling critique of transhumanism's notions of cyber avatars, prosthetic bodies, human/technological singularity need not be made at the level of the absurdity, impossibility or reductiveness of such projects, but rather inheres in the history of very concept of the cyborg that they mobilize. Transhumanism and Harbisson's advocacy for cyborg rights embrace the cyborg one-sidedly, ahistorically and without an explicit critique of the ableism that is the flip-side of the cyborg's prosthetic logic, and thus they miss its full aesthetic and critical potential.

In the next section I turn specifically to what Harbisson's artistic practice gives and takes away in aesthetic terms and transduce the relations of the cyborg to the soundscape.

Part II: The Cyborg and the Soundscape

"In cyborg art; the artwork, the audience, and the museum [are] all in the same body."
Neil Harbisson, cyborgfoundation.com

It is perhaps heavy-handed to fault Neil Harbisson for not taking the 20th century (pre-)history of cyborgism into account in his art and activism. But what of the immediately preceding generation of performance and body artists who explicitly incorporate and perform cyborgian themes in their work, and enact key technical and philosophical problems of bodies and technologies associated with postmodern and

posthuman discourses? Artists like Orlan, Eduardo Kac and Stelarc produced widely influential work in the 1990s and early 2000s that re-envisioned "classic" cyborgian themes in decidedly performative and postmodern terms, with a particular emphasis on the body's increasing entanglement with new media, the internet and digital infrastructures, biotechnologies, etc.[52] Such artworks, and the postmodern and posthuman theories that catalyze and/or explicate their work, transform the modernist dilemma of the cyborg from an exceptional case to an increasingly generalized or ubiquitous condition. If the classic modernist version of the cyborg regarded the body as a kind of unity and interiority that was to be either monstrously disfigured or triumphantly transformed by an exterior force called technology, the posthuman version regards the body as a heterogeneous entity whose porous inside/outside boundaries have been constitutively (re)drawn by technologies from the very outset.[53] Yet, as much as such discourses illuminate the history of the human body in and through technical systems, they also do little to dispel the fundamental strangeness and contingency of the lived experience of technology. That experience of the body—as technological interface, transducer and spectacle—is precisely what artists like Orlan, Kac and Stelarc attempt to capture and perform in their work. And as immediate precursors to a "cyborg artist" like Harbisson, their work offers a critical point of comparison for understanding what kind of experience of technology is embodied in Harbisson's art.

Harbisson's art plays on the convertibility of sound and colour as different forms of energy that can be described or processed as waves. Light is a wave (if also a particle), and the colour spectrum is characterized by the range of frequencies of light waves that interact with our eyes and brains to produce the sensation of colour. Likewise, sound is a

differential vibratory energy that propagates in waves, which, within a given frequency range, resonate in the human ear and brain to produce the sensation of hearing. Even if the mechanisms of these operations are far more complex (and they certainly are) than this crude sketch, it remains a fact that colour and sound are both vibratory energies transduced into sensation by the human brain. Harbisson's antennae effects a transposition of energy from one range to another along the frequency axis, revealing a fundamental continuity between vision and hearing, rather than an absolute or constitutive distinction. Harbisson has developed a Sonochromatic Music Scale that maps twelve colours of the visual spectrum (from red to violet) onto twelve tones of the Western musical scale (from F to E, respectively). Although the sonochromatic scale and the antennae allow for up to 360 microtones (to transpose 360 degrees of the colour wheel), it is basically works out that the colour red corresponds to the note F; green to A; blue to C-sharp, etc. Harbisson insists, somewhat problematically, that the transposition is "objective," based on cycles and intervals that are intrinsic to the quantities of energy that underlie tonality and colour.[54] Thus, in his view, the sonochromatic scale avoids the arbitrariness of other diagnosed synesthetes who experience colour as a sound (and vice versa) in their individual, idiosyncratic ways. Harbisson, by contrast, understands himself as approaching general formula or standard by which colour may be transposed to sound.

A number of Harbisson's artworks and performances depend upon the putative accuracy of this transposition. At the beginning of his TED talk we see Harbisson holding up different coloured cloths up to his eyeborg. The "corresponding" sine tone is piped in over the PA system, and Harbisson concludes that this cloth is purple, that cloth is green, and so forth. As non-colour blind audience members, we cannot help but verify the

accuracy of his transpositions and are invited to regard with wonder or insight that a purple cloth "really" is purple. There is a kind of tautology at work here that recalls Magritte's famous gesture in "The Treachery of Images" (1928) of painting a pipe with the caption "This is not a pipe." Only Harbisson seems neither to have gotten Magritte's joke, nor learned the lesson that there is an inexorable gap between representation and things. Indeed, the only caption we might apply to Harbisson's demonstration is, "A purple cloth is/sounds like a purple cloth." An arbitrary substitution or detour through sound brings us back to the self-evident starting point, and that cyborg feat is no more than a reappearing rabbit in a magician's hat that was really there all along. The antenna works like Cage's microphone in the anechoic chamber, only Harbisson's work does not entail the challenge to our attention that Cage's ostensibly does.

In his video/sound piece, "Colour Portraits" Harbisson takes a range of colour readings of an individual's face—Harbisson prefers to work with celebrities and artists like Prince Charles, Moby, Philip Glass, Nicole Kidman and others (2010). He edits together the composite colour-sound values of hair, eyes, skin, lips (etc.) into a kind of musical chord. Harbisson then further edits different portraits together into a kind of short piece of music. Each portrait plays for a couple of 4/4 bars, pulsed to the same rhythm each time, with a faint metronome-like beats in the background. The sounds are sine tones, yet bristling with dissonance from the overlaid microtones. The portraits are arranged in contrasting pairs according to pitch: we hear two bars of the high-pitched and particularly jarring face of Daniel Radcliffe, followed by the lower and mellower Gael García Bernal, et al. Altogether there are 13 portraits in the 52 second mix, and each portrait is accompanied by its subject's name as a white caption on the black screen.

Without the caption, we would have no other way to link face to sound, and there is, arguably, nothing especially revealing or unique about the sounds we hear as portraits, which is why the choice of celebrity subjects is decisive. They solidify the "accurate" and, indeed, auratic effect of the portrait, inviting us to believe in the intrinsic or essential relation of the sound to the absent referent in the same way we that we were invited to verify the accuracy of Harbisson's conclusions about the colours of pieces of cloth. We hear a resemblance that is neither real, nor virtual—indeed, it is not even a resemblance, but merely a sonic transposition of that most banal of images: the snapshot of a celebrity's face. The sound portraits suture a name to a sound in the performance of a pseudo-indexicality that covers up for the inevitable randomness of the connections. The portraits revisit Cagean ideas about microphone placement and the redirection of aesthetic attention, only here that attention is rendered as a gimmick.

Harbisson also builds musical compositions out of sound-colour correspondences. In a piece jokingly titled "Sock Sonata No. 1," Harbisson plays the sounds of different coloured socks and weaves the tones into a kind of electronic dance music composition (2013). He begins by holding socks one at a time to his eyeborg and letting a long sine tone resound throughout the hall. (Again, the sine tone is piped over the PA system from Harbisson's computer, which appears to be synced to the eyeborg.) After a couple of minutes of single, long tones, Harbisson puts his socks down, and a green box begins to flicker on an overhead screen like a kind of cursor. We hear a pulsed sine tone in sync with the flickering green box, which is soon joined by a pale blue box and a red box, and two new pulsing tones. The three tones/colours enter a repetitive pattern, and, with a whisper of beats and clicks in the background, a kind of crude rhythmic figure emerges:

pre-programmed beats from Harbisson's laptop. Every now and then a high-pitched tone and a purple box add a harmonic and visual accent to the beat. We are now in the presence of an audiovisual piece that is part Atari console, part minimalist EDM. Harbisson then begins deliberately picking up one sock after another, cuing in long tones in various consonance and dissonance with the looping triad. After a couple of minutes, the triad resolves to the single pulsed "green" tone from the beginning of the piece. Harbisson holds a white card to this eyeborg with one hand to silence it, while tapping keys on the laptop with the other, and as the piece comes to a close, the artist bows to the audience's applause. The performance has a structure of the performed banality of Cage's *0'00"*, only the seeming turn away from conventional notions of performance and audience is reversed and reinforced in the rituals of bowing and applause.

Beyond programmed and interactive beats, Harbisson has also staged a site-specific "colour-conducted concert" for choir and string quartet (2015). The piece relies on the colour palette of the mosaics and intricately ornamented ceiling of the Palau de la Música Catalana in Barcelona, where the piece was performed. Harbisson created a chord progression based on the colours he "heard" in the space and "scored" the progression by training a choir and quartet to sing and play precise pitches in response to different coloured lights. At the performance, various groups within the choir are illuminated at different times with different coloured lights, vocalizing their corresponding pitches to produce harmonies. Likewise, the quartet plays tremolo on different notes indicated by separate lighting cues. Harbisson, dressed in white tails, conducts the ensemble from a music stand at centre stage. It is hard to tell the duration of piece and get an overall musical sense of it from the heavily edited video; but after the crescendo of its

conclusion, Harbisson is moved to tears as he delivers a short speech on this experiment in which musicians "perform colour" for the first time. The banality of the performance combined with the compression of our attention back on the performer (instead of its expansion outward into post-Cagean indeterminacy) catalyzes a profound affective response from Harbisson as if to inflect the emptiness of the colour-concert with pathos.

Harbisson can also use the eyeborg to generate image-based art because his sonochromatic sense is a two-way process: he hears colour, but he can also visualize/colourize sound and create abstract colour patterns that correspond to pieces of music. He represents Mozart's "Queen of the Night" and Justin Bieber's "Baby, baby" as intricate arrangements of overlapping cubes of colour that radiate out from a visual centre that represents the first note of the piece. In addition to "painting music," Harbisson has made similar cube images of speeches by Martin Luther King Jr. and Adolf Hitler that depict the range and tonality of their voices in colour. In his presentations, Harbisson usually juxtaposes the two images (without captions) and makes a joke about how people usually change their preference for the images when they learn whose speech they represent. After all, who would want to like a speech by Hitler, colourized or otherwise? And yet the deeper joke is that Harbisson's art colourizes King and Hitler in exactly the same way. Setting aside the slightly different colour palettes, the two images are exactly the same; that is, their difference is, like the captions of the Sound Portraits, purely nominal, indeed, *literally* nominal. They are different because Harbisson says they are, and it this (in)difference that is the core limitation, the colour-blind-spot of Harbisson's cyborg art. Harbisson's cyborg body grounds the otherwise arbitrary colour-to-sound conversion into artefacts that may resemble works of art. But his artworks are

characterized by a false essentialism in that they reveal nothing intrinsic to configurations of colours and sounds being converted. Without the elaborate cyborg premise and the authenticating cyborg presence of Harbisson himself, the visual and musical works on their own terms offer very little that is new, experimental or transformative. Moreover, the pieces do not problematize or question the technical processes that underlie them. We cannot encounter or experience newness or alterity in Harbisson's work because we are too busy recognizing, again and again, the only tautological content that underlies it, namely, that purple really is purple, etc.

We might add to this Harbisson's seemingly deliberate omission of the actual technical specifications and operation of the antenna. Aside from the basic aspects of the design and structure, we know almost nothing of how the device actually generates sound or how it differentiates between distinctly coloured objects in terms of distance, intensity and saturation. Does the device only generate a single tone at a time, or can it, like the eye, perceive multiple colours simultaneously? Do colours beamed in over blue-tooth interact with sounds in Harbisson's environment, or is there a kind of toggling effect that allows Harbisson to tune into one channel and out of another? Moreover, Harbisson has recently collaborated with NASA to receive light data from a solar camera, claiming that he is able to see/hear directly into space, into the sun itself. How does solar light, unfiltered by the atmosphere, sound in contrast to terrestrial light?[55]

Another crucial problem is bone conduction. Harbisson hears colours as they resonate in his head. But these same colours can never coincide with the same colours his audiences hear at his performances. The latter are sine tones generated by his laptop and played over a PA system, and even if the laptop is connected to the eyeborg, the colours

the audience hears do not resonate in the same space as the colours Harbisson hears. Harbisson's artworks forfeit the possibility of shared or intersubjective listening. The artificial sense and the revealed reality are Harbisson's alone, and his audience is, by the very nature of the set up, always on the outside, taking his word for it.

Harbisson, consciously or not, avoids dwelling on the technical specifications that would interrupt the smooth operation of his device, and displace his cyborg body from its privileged role as the ultimate transducer of energies, translating without remainder from colour to sound, architecture to music, speech to image, and even outer space to earth. Yet transduction, as I have argued throughout these chapters, is a far more complex process than Harbisson is willing to admit. Transduction problematizes the energies and instruments that it simultaneously mediates, showing that it is impossible to think about sound without implicating the bodies, discourses, institutions that structure, disrupt and transform the seemingly mechanical transposition of acoustic vibration into electrical energy.

Adrian Mackenzie has devoted an entire book to the indeterminacies and contingencies that are built into the technical and philosophical concept of transduction (2002). He merges deconstructive approaches to the problem of technology with the work of Gilbert Simondon to develop a concept of transduction as a method for thinking (about) technical systems, in particular about the ways in which technical systems modulate differences and persist through time by holding open discrete margins of indeterminacy. Building from the technical notion of a transducer, Mackenzie understands transduction as a technical and conceptual process that operates across networks, infrastructures, and all technical systems broadly considered:

> In electrical and electronic engineering, transducers convert one form of energy into another. A microphone transduces speech into electrical currents. For the process of transduction to occur, there must be some disparity, discontinuity or mismatch within a domain; two different forms or potentials whose disparity can be modulated. Transduction is a process whereby a disparity or difference is topologically or temporally restructured across some interface. (25)

It is crucial to note that transducers modulate or restructure differences, but they do not equate or eliminate them. Differences remain, albeit in the form of a technical ensemble that reticulates them in space and time. For Mackenzie, following Simondon, cybernetic devices reiterate on the level of information the transductive function of simpler devices like microphones and speakers. "Devices transduce information, understood as a margin of unpredictability in a sequence of signals, into determined forms. Any device that retains a margin of indeterminacy can transduce information" (26). This retention of a margin of indeterminacy—or, in non-informational terms, a kind of receptive open-endedness that persists even within actual processes of communication—describes the way in which devices, machines and technical systems maintain a kind of discontinuity to themselves, a transductive gap or suspension that is nevertheless constitutive of their very operation: "Transduction arises from the non-simultaneity or metastability of a domain, that is, in the fact that it is not fully simultaneous or coincident with itself. Boundaries, singularities and differences underlie transductions" (17).

Among the numerous specific examples in the book is a lengthy discussion of Stelarc's *Ping Body*, a performance in which the artist wires his body to a complex array of internet infrastructure, biofeedback devices, audio-visual equipment, and muscle-activating electronic devices. Stelarc essentially generates a kind involuntary dance performance in which variable internet speed diagnostics (or "pings") cause certain

muscles in his arms, neck and upper body to contract, and these movements in term trigger certain kinds of pre-programmed sound effects. Biofeedback devices monitoring heart rate and blood pressure further inflect the sound effects as well as the movements. Several cameras—some mounted on the artist's body, others on constantly moving robotic arms—play back the performance and join the general cacophony of embodied audiovisualbiofeedback and internet data. Stelarc's body is undeniably *there* as the transducer that makes the whole performance happen. Yet his body is also buried, fragmented, dominated by the apparatus, sounds and images that seem to overwhelm him more than he controls them. Mackenzie emphasizes that Stelarc, on the one hand, meticulously diagrams the set-up of the performance (indeed, Stelarc makes a habit of foregrounding the technical and physiological set-ups as constitutive of, rather than supplementary to, his performances), while, on the other hand, having at best a vague, probabilistic sense of how the piece will actually unfold and what its aesthetic effects will be. This is crucial for performing the cyborg body as a transducer, that is, for the instantiation of a system that plays on the convertibility of the determinate and indeterminate, that exteriorizes or temporalizes itself in excess of, yet congruent to its very operation. That Stelarc uses diagnostics for calculating delays or lags in internet transmission speeds offers a kind of formal contrast to a piece that approaches an instantaneous fusing of the body and data, suspending yet animating Stelarc's body in an incommensurable machine world of voltage differences. The "meaning" or effects of the piece are difficult to articulate, yet this very open-endedness accomplishes the conceptual aim of staging the body as a transducer. By contrast, Harbisson's transductive art is conceptually thin, an affable and even charming attempt to render the cyborg palatable as

a personality, but not the disjunctive figure of instability and indeterminacy that Stelarc (with Mackenzie) emerges as.

Transduction plays an important role in phenomenological works on the body and the senses, suggesting that the amusing world of colour/sound equivalences that Harbisson creates does not grasp the depth of the transductive processes at the heart of body and world. Mark Hansen, in his extensive engagement with the work of Merleau-Ponty as a means of conceptualizing the body and aesthetics in digital art, uses the concept of transduction to describe the body's openness to the world through simultaneous and mutually constitutive processes of separation and joining; of activation across boundaries; and of the body's coupling of primordial tactility (a kind of ur-sense) with originary technicity.[56] Though I flag my reservations about Merleau-Ponty's phenomenology in the Introduction, I want to note hear that at the heart of Hansen's argument (via Merleau-Ponty) is the notion of *écart*, a gap, separation or hinge that structures sensation as the mutual becoming of body and world through transduction. The gap demonstrates that "the ontological principle of bodily life as fundamentally noncoincident with itself, as sundered by its essential openness to the world" (76). He elaborates:

> The *écart* in this sense is a marker of reversibility as a necessary condition of phenomenal experience, of sensation per se. It is nothing other than this fundamental dehiscence that explains the body's need for the world (and also the world's need for the body, being's need for manifestation or phenomenalization). As such, *écart* also prevents the body from achieving pure immanence; it is that which renders it an essentially incomplete "unity;" a process of individuation that will never be fully accomplished. (72)

Now the conceptual vocabularies between Hansen and Mackenzie do not exactly overlap, yet the incomplete unity of the body that Hansen describes has clear affinities to

Mackenzie's notion of the constitutive incompletion of technical ensembles (of which the living human body is certainly an example). Bringing these two discourses together, that is, *transducing* them, gives us something like a conceptual cyborg, a body as an interface with/in technical ensembles, which are themselves interfaced with a world (if not an earth, in their formulations) across the thresholds of sensation and information. In contrast to the trans-modern cyborg, it is this *other* cyborg—or the bodily otherness of mediation and/as earthly infrastructure, that I wish to explore in the following chapter on the cybernetics of sleep.

Turning back to Harbisson, we can see that the profundity and indeterminacy that thinkers like Hansen and Mackenzie bring to transduction are not sufficiently mobilized in the cyborg art. Beyond its promotional aspects for a brand of trans-modern cyborgism, Harbisson's art is interested mainly in closing gaps, finding perfect equivalences, creating synesthetic senses with paradoxically reductive, tautological effects. If anything, Harbisson sonochromatism reminds us of the fundamental incommensurabilities that structure our experience of being in the world (an incommensurability that reveals/conceals being's earthly infrastructure). His scale, after all, is based on an arbitrary conjoining of tones to transpose value that even Newton could not resolve satisfactorily. Rather than play on this problem and examine the ways in which sound and music both shape and elude quantification,[57] he brands himself the creator and owner of an artificial sense. Harbisson foregoes the transductive tuning beyond the soundscape in favour of the "private property" of customized listening.[58] His transduction of color to sound relies on a simple, even tautological formula that reduces rather than resounds the material, technical and aesthetic indeterminacies of the transductive process. As such,

Harbisson is less a cyborg artist (in the disruptive, contradictory sense of that term's history) than a cipher of neoliberal subjectivity and biopolitical enhancement, reinforcing a certain ableism of the body, instrumentality of the technological, and controlled homogeneity of the (sonic) environment.

Chapter 4. Sound Asleep: Sleeping, Listening and the Politics of Nonconscious Experience

My critique of Neil Harbisson's cyborg art is admittedly heavy-handed, coming close to, if not outright condemning, his work as a kind of technical and aesthetic failure. Yet I want to stress that Harbisson's work is nevertheless productive insofar as his cyborgism functions like an instrument: it has a built-in excess that resonates between material and metaphorical registers, and it does epistemological work even, indeed precisely, without knowing it. Harbisson's body-as-instrument transduces (for me, as critical listener) the historicity of the cyborg and crystallizes a particular identity politics around technological body modification in the contemporary moment. His work also conceives of the body as a technical interface with the environment, thus implicating bodies, instruments and interfaces in the same mediating circuit that, in the context of my own work, conducts and transduces earthly energies and affects. That Harbisson's work can bear such a critical weight in the context of geosonics, and do so *unwittingly*—that is, without himself reflecting critically and explicitly on the cultural and technical infrastructures that he arguably embodies—reinforces the non-conscious epistemological and experiential dimension of instruments (and bodies and interfaces). In this chapter I turn to the nonconscious dimension of bodies and listening, using transductive listening to attend to the infrastructure "beneath" conventional phenomenology, as I attempted to listen "beneath" the soundscape in the preceding chapters.

I argue that the experience of being in a body is inextricable from being on a planet, positing sleep as a crucial interface between embodiment and enearthment. I theorize sleep as a kind of geosonics in which planetary cycles of light and dark interact with the human brain, crystallizing sleep as the by-product or processing artefact of

informational and neurochemical processes. Sleep, thus defined, recasts the brain not as a centre of rational cognition and consciousness, but rather as a relay of nonconscious and noncognitive embodied processes. Sleep is nevertheless part of our lived, daily/nightly experience, and as such also represents a liminal or paradoxical nonexperience: in sleeping, we live out an obscure, but immanent connection between body and planet though the affectivity of shared rhythms and periodicities. Privileging the sonic as the material and metaphorical means of articulating the embodiment and enearthment of sleep, I borrow from theories of affective listening to explore the affective planetarity that enfolds and permeates our bodies (i.e. enearthment) in ways analogous to the vibratory affectivity of sound. I conclude with some critical remarks on the neoliberal biopoliticization of sleep though the analysis of Max Richter's *Sleep* (2015), an 8-hour piece of music composed for a small chamber ensemble, meant to be performed before—and listened to by—a live, sleeping audience.

Part I: Sleep on the Brain

"There exists a lived brain, but [. . .] this lived brain is not necessarily conscious."
Catherine Malabou, *What Should We Do With Our Brain?*

The modern scientific definition of sleep rests on a palimpsest of three historically distinct, cerebro-centric models.[59] The first is mechanistic and homeostatic: neurochemicals accumulate in the brain after too little sleep and gradually exert a force of so-called "sleep pressure" that increases over time. Sleep itself acts as a kind of release valve for this accumulated pressure, allowing the machinery of the post-sleep brain to work again at an optimum level. A second model is cybernetic, envisioning sleep as a complex biofeedback process, which links environmental cycles of day and night to a

brain center that governs the physiological and neurological processes linked to sleep. A third model, derived from the metaphor of the brain as computer, approaches sleep as a kind of informational process in which the brain organizes and stores data acquired in the course of the day for future retrieval and use. In any case, the sleepy or sleeping brain is figured variously as a steam engine, thermostat and computer, each corresponding to key technoscientific paradigms of the 20th century. Undergirding all of this is the ultimate metric of sleep, electroencephalography (EEG), which uses electrodes placed on the scalp to record electrical differences associated with brain activity and which has given rise to the modern definition of sleep as a phased alteration of brain waves distinct from that of the conscious or waking brain. So decisive was the introduction of EEG to the sleep laboratory that one historian has remarked that "the ability to visualize sleep in terms of recorded graphical data was absolutely pivotal to the status of sleep as an object of modern scientific research and biomedical practice" (Kroker 2007). Sleep, in other words, only came into being through the real-time coupling of a scientific instrument with the brain.

In this sense, long before the development of more sophisticated techniques for monitoring and modeling brain activity in real time—like the cutting-edge functional magnetic resonance imaging (fMRI) of today—sleep had quietly inaugurated a paradigm in the neurosciences I call "brainism"—a predominant tendency to isolate and monitor specific areas of brain activity, usually in highly artificial and highly technologized laboratory environments, and then to ascribe complex mental events like consciousness, memory, volition (etc.) to those "legible" areas. Brainism implies the downplaying of language, culture, environment and daily life in the scientific study of the brain, yet

insists at the same time that its minute, laboratory-specific observations can serve as the explanatory ground for cerebral and mental events that necessarily occur out there in the world. Sleep, in a sense, paved the way for this general bracketing or reduction of the embodied and environmental dimensions of the (study of the) brain: by conjoining a specific technical procedure (EEG) to specific brains in a real-time laboratory environment, sleep first produced the brainist epistemological conditions by which scientists could claim to know and describe complex mental and embodied processes primarily by measuring and visualizing brain activity. Sleep in neuroscience is analogous to the eardrum in audio technology (as outlined by Jonathan Sterne in *The Audible Past*) insofar as the physiology of an isolated organ grounds an epistemological paradigm for treating a host of technical and ontological questions. In short, brainism is like tympanism. Despite critiques from a range of philosophical, technical and neuroscientific perspectives, a certain brainism still predominates in contemporary imaging and visualization of the functional brain, in which hi-tech imaging offers an ontological short-cut to age-old debates around minds, brains and the complexity of human thought (Rose 2016).

If there is such a thing as a lived, embodied brain—that is, a brain that cannot be technically reduced to cerebral monitoring and isolated from the body to which it is attached, not to mention from the social and geographical environment in which it is immersed—then perhaps one way to approach it is to rethink sleep. In order to do this, first I turn to Catherine Malabou's concept of neural plasticity (2008). From a critical and philosophical perspective, Catherine Malabou has argued effectively against both literary metaphors and scientific models that cast the brain in the role of an autonomous control

centre, that is, against the brainist tendency to regard the brain as a discrete, biologically determined and technically visualizable entity that serves as the ultimate biological and metaphysical ground of consciousness and mental life. In contrast to the perceived brainism of the cognitive and neurosciences, Malabou's concept of the brain's plasticity (which explicitly replaces a century's worth of mechanistic, homeostatic, and informational models) stresses how the brain is shaped both internally (by biological factors and neurological processes) and externally (by environment and culture). Plasticity reflects the neuronal interaction of the brain's determinate and indeterminate development, and, philosophically, the contradiction between a closed, biological form and the openness of a mind. That openness is, at the same time, dialectically grounded in the neurophysiology of brain function: in synapses (the *literal* openings that connect neurons), and in the aleatory (re)formation of neural pathways across synapses over time. For Malabou, the brain is neither a metaphor, nor an identity: it is a field of action constituted by plasticity and as such, it resists not only biological determinism, but also determinism's equivalent in socioeconomic terms: neoliberal globalism (to which I return in Part II).

Against the brainist discourses of neuro- and cognitive sciences, I would suggest that Malabou conceives of the brain like a body. Taking the above epigraph one step further: that which is lived, but not necessarily conscious is precisely the body, and the embodied brain along with it. Sleep, then, would be a privileged means of glimpsing or sounding out the lived brain because sleep bypasses consciousness altogether and reveals the embodiedness of the brain as such. Yet how can we locate and measure the sleep of the body in the absence of a privileged technological device like the EEG? The answer

requires a shift in scale via the cybernetic model of sleep I mention above. If sleep is a kind of planetary networking, then the sleeping body can only be found on the rotating body of the earth, and these two bodies, from the perspective of sleep, mutually determine each other. The interdisciplinary field of body studies already grapples with the fundamental problem of how to define and even locate the body in terms of its inside and outside; its lived, subjective dimensions; its cultural and social enmeshment; its technological coupling; and its environmental embeddedness.[60] Studying the body means inquiring into the boundaries of what constitutes the body (in relation to medicine, media, technology and social life), even as those boundaries are constantly being reimagined and renegotiated. The *sleeping* body extends that shifting borderline to include the light-dark cycles of planetary rotation and forces us to conceptualize the body's interaction with and embeddedness in not only social and cultural life, technological assemblages and physical environments, but also in the rotational motion of the earth and the rhythms it imposes, in short to rethink embodiment as enearthment.

The cybernetic model of sleep is an entrainment of internal bodily processes with planetary motion, whereby minute quantities of neurochemicals and hormones ebb and flow in sync with the rotation of the earth. The body's circadian rhythm requires constant feedback and recalibration from external light sources (above all, the light of day and the dark of night) in order to function in proper alignment with the homeostatic and informational needs for sleep. Here it is important to note the literal meaning of "circadian," namely "about a day." The in-built rhythm of numerous cellular and metabolic processes cycles only *roughly* every 24 hours, but the mechanism requires regular environmental cues to synchronize the dual processes of the sleep-wake cycle.[61]

Without the input of external lighting cues, a deviation of even a few minutes +/- 24 hours on the internal homeostat can produce chronic sleep disturbances in individuals. Lockley and Foster write, "The 24-hour light-dark cycle is the most important environmental time signal, and this light information is captured exclusively by the eyes in mammals" (2012, 20). They go on to point out that the human eye contains within it a small percentage of cells—photoreceptive retinal ganglion cells or pRGCs—whose sole function is to transmit light directly to brains areas responsible for the regulation of circadian rhythms (21). In other words, about 1-3% of the human eye has nothing to do with vision at all, but is devoted exclusively to "illuminating" the interior of the brain with daylight.

Night is also registered by a different part of the brain, the pineal gland, which further contributes to the synchronization of the sleep-wake cycle by secreting the hormone melatonin: "Pineal melatonin is the major biochemical correlate of darkness and provides an internal representation of the environmental night-length. As night-length changes with the seasons in non-equatorial latitudes, melatonin not only encodes the daily night-length, but also the time of year (season)" (23). Although the exact role that melatonin plays in the onset and maintenance of sleep remains to be specified, its secretion has become the major "phase-marker" of the circadian clock in human sleep studies (24). The eye and brain are thus hardwired to respond to the rotation of the earth as it manifests itself in light *and* dark, and not just in the course of a single day, but over entire seasons and years. The sleeping brain is a kind of global positioning system for itself, constantly establishing and calibrating its location on the surface of the earth. Sleep, then, is our user interface between our body and planetary motion. In this sense, it

is impossible to draw an absolute distinction between a (human) body at rest and a planet in constant motion as the former simply would not exist without the latter. Even if the brain is at the centre of sleep, it is the earth that is at the centre of the (sleeping) brain.

The concept of interface is inherently multiple: interfaces imply touch, control, access and communication between ostensibly passive or inert devices or instruments, and active, usually human users. But if we take sleep as a kind of user interface, we have to ask who is using whom? Do humans use or instrumentalize the earth when they sleep? Or is the earth itself pushing our buttons and eliciting an anticipated response from us, that is, using or instrumentalizing us? What kind of agency or instrumentality emerges when we think about the nonconscious experience of sleep as a human/earth interface? Here I want to turn to Jean-Luc Nancy's meditation on sleep, *The Fall of Sleep* (2009), where Nancy sets himself the paradoxical task of a phenomenology of sleep, that is phenomenology of a state in which the two crucial, mutually constitutive elements of that philosophical practice—self and world—are suspended. The absence of self and world, for Nancy, amounts to a kind of paradoxical instantiation of embodiment and enearthment.

For Nancy, sleep is a mode of indistinction, a state in which the conscious self does not so much disappear altogether as merge or coincide with the body and the world. He writes that, in sleep:

> I become indistinct [. . .] I no longer properly distinguish myself from the world or from others, from my own body or from my mind, either. For I can no longer hold anything as an object, as a perception or a thought without this very thing making itself felt as being *at the same time* myself and something other than myself. A simultaneity of what is one's own and not one's own occurs as this distinction falls away. (7)

Sleep is thus, on the one hand, a phenomenological void, an evacuation from the self of all the perceptions, objects and, indeed, the world in which it embeds itself, a state in which there are no phenomena to be phenomenalized. Nancy even writes explicitly that "[t]here is no phenomenology of sleep" (24). Yet on the other hand, for Nancy the sleeping body is the very (non-)manifestation of that thing at the root of all phenomena, a real instance of the Kantian thing-in-itself. He calls the sleeping body, "The thing isolated from all manifestation, from all phenomenality, the sleeping thing at rest, sheltered from knowledge, techniques and arts of all kinds, exempt from judgments and prospects. The thing not measured, not measurable, thing concentrated in its indeterminate and non-appearing thingness" (14). The sleeping body thus somehow appears precisely in its non-appearance, *does* something precisely because it *manifests* nothing, and unfolds itself into and across the world precisely because it only burrows into itself, into its thingness.

But the sleeping body, even if it is a kind of thing-in-itself, is not isolated or cut off from other things. Sleep joins bodies in a kind of indistinct distinction and validates them according to a principle of general equivalence, of equality. Nancy writes: "Sleep itself knows only equality, the measure common to all, which allows no differences or disparities" (17). So the disappearance of the self in sleep reveals the equality of all bodies and—or with—the world, or the world's non-phenomenological counterpart, the earth. Here Nancy writes: "For it is in effect the great equal sleep of the whole Earth that those who sleep together share. In their 'together' is refracted the entirety of all sleepers: animals, plants, rivers, seas, sands, stars, set in their crystalline spheres of ether, and ether itself, which has fallen asleep" (20). Nancy's book contains many protracted, enumerative passages like this one that attempt to span the indistinction or equivalence of

sleep across minute, inorganic particles; terrestrial life; and celestial phenomena on a cosmic scale. Unwieldy as they are to cite, let alone conceptualize, such passages at least suggest how sleep opens up an immense continuum, a kind of thingly togetherness or concrescence that comprises animal, vegetal and celestial bodies, both organic and inorganic.[62] This equality of sleep is not experienced, but it is shared; it is not sensed, but it is fulfilled. And it posits, in an obscure and silent way, some kind of possibility of expanded being in or on a phenomenological nowhere called the earth.

There is much to critique in Nancy's phenomenological lullaby. After all, sleep requires time, money and shelter, and thus serves to amplify, rather than equalize the impact of socioeconomic factors on our embodied experience (Williams 2011). There is moreover no single, evolutionary ur-sleep, but rather only the overlaying of internal and external rhythms that vary across organisms, seasons and environments and depend on the availability of resources, shelter, etc. (Reiss 2017). In short, sleep's "indistinction" is political through and through, and re-inscribes on our bodies all the differences, inequalities and contingencies that it may suspend from our consciousness. Yet what I want to emphasize in Nancy's account is that sleep's embodiment is also a kind of enearthment. As much as sleep suspends concepts of self, place and world, it also embeds them on the earth, simultaneously dispersing and burrowing the self into the body and into the earth, which is itself but another body among countless, equivalent others. Yet if we tone down the metaphorical and speculative register of Nancy's writing and transduce the infrastructure beneath its immersive rhetoric, we find that we are not too far afield from the cybernetic model of sleep, which diagrams sleep as a network linking bodies, brains and the planet. If Nancy seems to suggest that when we sleep, we all hold a body

and the earth in common, then the cybernetics of sleep suggests, along similar lines, that we sleep because we all carry a piece of the planet in our very own brains. A further affinity between these two theories of sleep is rhythm: the circadian rhythm that entrains body, brain and planet could be regarded as a technical explanation of the rhythm that Nancy identifies in the "rocking" of the body during sleep. He writes that "sleep is also a rhythm, a rocking back and forth, the body rocked to the rhythm of its heart and lungs," and he continues in another rhetorically and conceptually expansive passage:

> Rocking is a matter of high and low and of right and left, of the great symmetries, asymmetries, and alternations that govern crystals, tides, seasons, the cycles of planets and their satellites, exchanges of oxygen and carbon dioxide, captures and releases, assimilations and evacuations, nervous systems, attractions and repulsions between metals, between flora and fauna, between sexes, between stellar masses, black holes, quarks, and infinitesimal jets of dust. . . It is a matter, to conclude or rather to begin, of the initial beat between something and nothing, between the world and the void, which also means between the world and itself. (30-1)

Rhythm is a kind of constitutive gap for Nancy that enables the oscillation between our sense of subjective, waking distinction and our nonsense of earthly indistinction. Our brain may not allow us to experience this rhythm, but it does nevertheless facilitate it. But "brain" here cannot be reduced to the brainist encephalon of the sleep sciences. Rather, brain is part of a geosonic ensemble of chemicals and cosmos, rhythmically implicated in the enearthment and embodiment of sleep.

Part II: Nonconscious Listening

"How can one study something to which one does not pay attention?"
Annahid Kassabian, *Ubiquitous Listening: Affect, Attention and Distributed Subjectivity* (142)

If the cybernetics and nonphenomenality of sleep constitute an affective rhythm, we can think of sleeping as akin to listening and can explore an analogy or affinity between the nonconscious experiences of sleeping and the nonconscious, *affective* experiences of listening. There are currently two related, but distinct approaches to affect and listening: one that links affect and the materiality of sound to the aesthetics and politics of the (in)audible;[63] and a second that thinks through affect, sound and space within a framework of urban geography.[64] What both approaches have in common is the reconceptualization of listening as distinct from conscious attention, yet nevertheless constitutive of how we (make) sense (of) sound, bodies and the world around us. Steve Goodman writes, "Before the activation of causal or semantic, that is, cognitive listening, the sonic is a phenomenon of contact and displays, though an array of autonomic responses, a whole spectrum of affective powers" (2010, 10). On a similar note, Annahid Kassabian writes that "all listening is importantly physiological, and […] many kinds of listening take place over a wide range of degrees or kinds of consciousness and attention" (2013a, *xxi-xxii*). Indeed, for Kassabian the attentive listening subject need not be especially attentive, nor even a subject in the first place: for Kassabian (explicitly, and implicitly for much work on sound and affect), the listening subject is not prior to the act of listening, but is rather a reside left behind by the flow of affect (qua sound or vibration) through a body.[65] Affect thus entails transduction within, but, more importantly, beyond and beneath the culturally and discursively constructed notions of subjectivity or self. When we listen, we also listen along with the affective, bodily substrate that both constitutes and constrains our conscious, attentive listening. In other words, we listen to consciously heard sound *and* to our nonconscious selves listening to

sound at the same time.[66] Or as I phrase it in the Introduction, we listen always again to the material and metaphorical, to physics-and-physiology-becoming-culture and vice versa.

Not only is it possible to listen to sounds within a feedback loop of nonconscious "attention" to them, it is possible to listen to sounds that do not even exist. In a subsequent piece explicitly on the theme of "Music for Sleeping" (2013b) Kassabian discusses the use of binaural beats as a sleep aid, that is, how certain sonic sleep aids propose to "tune" the brain to sleep through beat frequencies. She cites a classic audiological study by Gerald Oster, in which listeners hear sounds of minutely varying frequencies in each ear of a set of binaural headphones. Listeners would then "hear" the interference between the two signals as infra-sonic "beats," even if one signal were beneath the audible threshold, or masked in background noise. As Oster puts it, "Evidently the brain is able to detect and process the signals even though one of them is too weak to impinge on consciousness" (1973, 96) Kassabian calls such beats "a processing artefact of the brain, not an actual sound" because the brain (and not the ears) hears a beat of, say, 10Hz when exposed to one 440Hz tone in one ear, and one 430Hz one in the other (2013b). There is no sound with a frequency of 10Hz emanating from any of the audio equipment in the scenario, yet the brain essentially provides that vibration, or presupposes it, and thus "hears" it. The seeming paradox that the brain hears sounds that are not there, or that a listener can listen to the neurophysiological by-products of the very process of listening is, in a way, a kind of proof of the affectivity of listening: we are affected by sounds (as vibrations) that we do not, indeed *cannot* hear, just as much as we can listen to sounds that do not exist. Sound constantly converts itself

from the material to the imaginary (even hallucinatory) at the frontier between conscious and nonconscious listening.

In any case, both Goodman and Kassabian attend to the ways in which pre- and nonconscious listening (including listening to infra- and ultra-sonic frequencies) nevertheless affect listeners' bodies and become part of the overall material and cultural networks in which sounds are manufactured and circulated. Conscious, attentive listening would then be based in the nonconscious affective body of the listener, a body that registers and resonates with vibrations whether or not they are consciously perceived and meaningfully articulated. The materiality of affect thus merges with a certain materiality of sound insofar as both can be rooted in an ontology of vibration, and analyzed in and through the vibrational assemblages of bodies. This expanded notion of a body (which would include any material that can conduct vibrations) would make it theoretically possible "to hear how sound circulates through any and every kind of body: from plants, animals, machines, objects and architectures, through to environments, atmospheres and the earth itself" (Gallagher 44). Sound, as Michael Gallagher describes it here, sounds very much like sleep as I describe it above. Listening to sound affectively has little to do with hearing actual sounds, that is, with the thresholds of human audibility and the conscious perception of sound waves. Rather it is an imaginative listening that recognizes (if it is possible recognize without cognition) or opens itself up to material and environmental scales well beyond the human experience, yet within which the human is inevitably caught up—and trying to catch up.

Affect, like sound, moves faster than the speed of thought, and consciousness and self are always lagging behind the complex work of affect. A similar temporal gap is of

increasing interest in recent work on cognition that explores the interactions between conscious thought and what N. Katherine Hayles calls the cognitive unconscious (2017). The human cognitive unconscious refers to all the information processing carried out by the nervous system "to keep consciousness, with its slow uptake and limited processing ability, from being overwhelmed with the floods of interior and exterior information streaming into the brain every millisecond" (10). Hayles examines how cognition is distributed across a range of conscious and nonconscious processes in the human nervous systems, as well as other biological and technical systems. Hayles' turn away from the privileged domain of consciousness offers a significant anti-brainist take on neuro- and cognitive sciences, insofar as cognition is attributed not only to an extended or distributed human nervous system, but also to plants, microbes and machines. Such de-centering of the human and de-braining of cognition would seem to resonate not only with the affect theory mentioned above (among other new materialisms[67]), but also with Malabou's notion of the plasticity of the brain. For Malabou, as I have suggested, the plastic brain is constantly de-territorializing itself, both literally (through neuronal plasticity) and metaphorically through its slippage between the models and metaphors that try to fix and define it. Here Malabou makes a rigid distinction between the transformative potential of plasticity and neoliberal flexibility, which, for her, means a neuro-biologistic model of adaptation, acceleration and resilience that equally describes brain cells and the neoliberal workforce.[68] What is at stake in Malabou's book is the perniciousness of metaphors in locking us in to patterns of thought that traverse politics and economy and grey matter in our skulls. The consciousness of the brain's plasticity is an important philosophical and political step in challenging and reimagining what, for Malabou, would be an

emancipatory politics in political and economic terms. But does the cognitive nonconscious (and, by extension, listening and sleeping) have the same emancipatory politics?

I have argued above that the nonconscious experience of sleep is akin to a kind of nonconscious affective listening, that is, to an opening-up of the body and mind to the sensation and imagination of nonconscious affects; material and planetary scales; and to an embodied and enearthed experience that conjoins all (listening and sleeping) bodies in a shared rhythm or vibration. This would mean that sleep, like listening, is a kind of cognition (albeit a nonconscious one), in which the brain is engaged in informational and cybernetic work that does not require, or is in fact hindered by, the deliberation of consciousness. Sleep's nonconscious cognition would include the processing of sleep signals from internal sleep mechanisms—as well as from the environmental cycles of light and dark—signals whose transmission is constant. As a form of cognition and information processing, human sleep would thus be constantly catching up and recalibrating itself according to the internal and external information that, in principle, exceeds it, streaming across our nervous systems 24/7, and leaving us with only 8 hours a day (optimistically) to keep up. From this perspective, sleep would cease to be a slowing down of body and mind, a rhythmical pause or caesura of conscious and cognitive life; instead sleep would be an acceleration, a bodily speed-up to adjust and adapt to a 24/7 flow of biological and planetary information. Sleep would likewise be enfolded into the anti-rhythm of the 24/7 information economy, with its imperative of constant connectivity and its promise of an asymptotically receding up-to-date-ness (Crary 2013). It is with this dichotomy—sleep as a rhythm traversing body/earth, sound/affect,

matter/imagination on the one hand; sleep as perpetual deficit that reinforces the accelerated self-management of the neoliberal individual on the other—that I turn to Max Richter's *Sleep*.

Part III. The Politics of *Sleep*

"The sleepless are on call at any hour, unresistingly ready for anything, alert and unconscious at once"

Theodor Adorno, *Minima Moralia: Reflections from Damaged Life*

I borrow the phrase "politics of sleep" from Simon J. Williams's recent book, with the addition of italics to signal my interest in thinking about the politics of sleep via the politics of *Sleep*, a piece of music (and an immersive, durational listening experience) composed by Max Richter (2015). In Williams' sociological account of contemporary sleep, sleep is an ideological prism that reflects two main aspects of neoliberalism: on the one hand, sleep is a "powerful and potentially troublesome or problematic reminder of the limits of rational modernity, which in turn, paradoxically, further fuels or redoubles attempt to 'discipline,' 'contain,' 'control' or 'rationalize' it (*xiii*)". This connects sleep to already existing discourses on (the management of) worker fatigue, weariness and depression.[69] At the same time, contemporary sleep has become "a personal and public matter of concern, [. . .] if not something to be colonised, commercialised or capitalised upon through a burgeoning sleep industry which now includes everything from sleep clinics to mattresses, bedding and soporific CDs for that 'perfect night's sleep'" (*xiv*). Sleep finds itself in double bind insofar as it is both devalued *and* monetized, an on-going public crisis from which we simultaneously suffer and profit. Any simple exhortation to sleep (even if it comes in the form of an 8-hour music performance) would have to

negotiate the two sides of the ideological, instrumentalizing trap, which both disciplines and regulates sleep, while cashing in on it under the guise of promoting it. In what follows, I argue that Richter engages this ideology of sleep obliquely, displacing the politics of sleep itself onto a problem of listening and background music.

Sleep is a fully notated musical composition for piano/keyboards, string quintet and voice. It is sold as an 8-disc recording, as well as an hour-long extract called *From* Sleep, and is, of course, available for streaming and download online. The entire piece has been performed live a number of times since its 2015 release, with shows in London, Paris, Sydney, New York City and, in the summer of 2018, two outdoor performances at a park in Los Angeles. Instead of seats, cots and bedding are provided for each audience member. The work is a set of variations in 31 movements, cycling around a handful of themes, stretching, elongating, and echoing the same musical ideas over the hours. It is a quiet and slow piece, as one would expect, with the keyboard (played by Richter himself) plodding out austere, minimalist chord cycles that have a kind of intensity if only through their sheer slowness and repetition. The strings play long bows, avoiding high registers, creating a dim, gauzy texture around the central pulse of the keys. The solo soprano, when it does appear, hums a kind of counter-theme to the opening progression, and, at the end of the piece, vocalizes a single repeated note for minutes on end. The variations are loosely based on Richter's understanding of the neuroscience of sleep (he even consulted a famous neuroscientist, David Eagleman, as he worked on the composition) so that the timbral and rhythmic variations of the music follow the EEG-based stages of sleep. There is thus a deep narrative structure at work in the piece, even if it isn't exactly available in isolated moments of close listening.

Stylistically, there is a kind of minimalist nod to the Baroque (and one cannot help but think of the obvious link to Bach's *Goldberg Variations*) and to early modern polyphonic singing, as well as elements of contemporary ambient and drone music (Richter, liner notes 2015). In hearing the opening bars of the piece, one cannot escape the sense that there is something happening, something to listen to. And yet, the non-development of the music (at least on the minute-to-minute scale) thwarts our ability to concentrate on musical content for too long. *Sleep* asks us to pay close attention to it—and its European classical styling, concert-hall trappings and *Deutsche Grammophon* branding all chime in to legitimize that attention. Yet the music also tells us to get distracted, to daydream, or just dream, period—because it also seems to suggest that the music is going nowhere in no great hurry, and the listener should follow suit.

It is tempting to hear, in *Sleep*, a kind of hymn to precisely the kind of earthly co-sleeping that I've attributed to Nancy above. Richter, in his liner notes, calls the piece a "personal lullaby for a frenetic world—a manifesto for a slower pace of existence." In a promotional video on YouTube, he says he wrote the piece out of a conviction that the "night can offer us some creative refuge" from "the fast-paced digital world" (2018). Richter, like Nancy, seems genuinely concerned with sleep as something we all hold in common, as perhaps the last dimension of the human experience under capitalism where private and property dissolve in a shared experience of radical equality, sociality and even ecology. Yet this radical ecology/equality of sleep seems incompatible with the neoliberal ideology of sleep outlined above. If even the affirmation of sleep participates in an ideological matrix that seeks to control it and sell it, then how can think through

what Richter might be (however unwittingly, and with doubtlessly good intentions, both artistically and humanly) selling us?

In composing for the background, in composing to make an environment more conducive to a particular human activity (even if that activity is sleeping), Richter's piece admits an affinity to so-called background music, easy-listening, mood music—what can be summed in a single, if now defunct, corporate word: Muzak. Muzak is the crystallization of the military-industrial complex in musical form, instrumental music in the most pernicious sense of the term.[70] In workplaces, Muzak's famed "stimulus progression" programming was designed to use ascending patterns in rhythm and tempo to counter, minute-for-minute, the "Industrial Efficiency Curve," that is, the psychology and physiology of worker fatigue.[71] Its off-work programming (which went 24/7 as of January 1942) was designed to relax and soothe in domestic environments (and was even proven effective in slaughterhouses), as well as to create upbeat commercial spaces for boosted sales.[72]

Goodman goes further to identify a decisive change in Muzak's compositional or design strategy. In the 1980s, Muzak shifted from the "stimulus progression" model to what he calls "quantum modulation," that is, apparent changes in tempo, rhythm and musical "colour" that in fact conceal a plateau of affective intensity. Muzak, in other words, sought to manipulate workers/consumers directly at the level of affect, to manufacture a mood, rather than discipline a body. The way to overcome the bodily and mental limits of worker/consumer inertia was to bypass them altogether and directly target the more pervasive and profound level of affect. For Goodman, this amounts to a shift from a disciplinary society to a neoliberal society of control, and it manifests itself

in sonic terms by the deployment of strategies of sonic branding (viral audio, hooks, and earworms) that are meant to operate below the threshold of conscious listening. Such branding is not meant to sell particular products (as "jingles" did in the past), or even to facilitate acts of consumption (as Muzak in shopping malls sought to do). Rather it seeks to "catalyze the [very] motivation to consume," to create sonic and affective associations between virtual consumers and a brands that will coalesce in the not-too-distant capitalist future (145).

What is crucial here for my purposes is that this turn signifies the beginning of the 24/7 working/listening/sleeping day. Goodman writes, "The submerged affective sensorium in which ubiquitous listening is now a subset compels the transformation of outmoded frameworks of sonic thought [e.g., conventional sonic branding and Muzak]. In an attempt to perform the necessary upgrade, an audio virology starts from the premise of a mode of audition that is 'always on'" (145). Indeed, as we have seen, affective listening is always on, even when consciousness is not, just as the sleeper is always "on" in non-cognitive terms, informationally catching up to the non-stop spiralling of the planet. It is perhaps no coincidence that Goodman's chapter on "The Earworm" begins with a literary epigraph about a sleeper awoken by a sound he heard literally *in* his sleep. The earworm is heard in and by the sleeping brain not only when conscious listening is suspended, but in the absence of any actual sonic stimuli. Unlike some nocturnal ambient sound that makes its way into the texture of a dream, the earworm heard by the "always on" sleeper/listener is a processing artefact of a brain played like an instrument, or instrumentalized, by predatory sonic branders. The actual production of "music for sleeping" and other sonic sleep aids in the early 21st century would merely be the

formalization of a colonization of sleeping that already occurred as a colonization of listening in the background music and sonic virality of the late 20th century.

The ambitious conceit of Richter's music, its formidable compositional architecture, its daunting performance time (for both musicians and audience) are not easy to dismiss; yet it is all rather uneasily congruent with a musical aesthetics and infrastructure aimed at manipulating workers and consumers, unconsciously, indeed of creating unconscious workers and consumers (as prefigured in my epigraph from Adorno). Richter's *Sleep* may well represent a strange dialectal twist in which art music fully embraces the status of background music that, in many ways, it has already attained unwittingly.[73] And the performance of *Sleep* would amount to the simulation of an experience whose conditions of possibility have been ideologically and practically abolished. It is entirely conceivable that *Sleep*/sleep could be marketed as a way to leverage contemporary neurocapital, or that Silicon Valley managers would urge their teams to attend (a performance of/to their) *Sleep*/sleep, only report back to the office the next morning, ready to deliver and innovate, etc. From the side of the listener, it would seem that *Sleep* would resonate in imaginative and affective spaces that have already been sounded out by capitalism, with the embodied/enearthed experience of sleep echoing, rather than resisting the 24/7 world.

Endnotes

[1] "Sonic Pavilion," Doug Aitken Workshop, accessed April 26, 2020, https://vimeo.com/152320997.
[2] John Cage, "The Future of Music: Credo" (2011, 25).
[3] Cage in a 1965 interview, cited in Douglas Kahn (1999, 194).
[4] Kahn (1999, 196).
[5] Mixing the metaphor even further, the call of the earth (of the painting) is structured not unlike a phone call: even though Heidegger uses the term *Zuruf* (an acclamation), not *Anruf* (calling someone up on the phone), the interpretation of the painting is framed within a distinctly modern (i.e. not ancient Greek) telephonic paradigm that recalls Avital Ronell's *The Telephone Book: Technology, Schizophrenia, Electric Speech* (1989). I thank Sumanth Gopinath for the Heidegger/Ronell connection. It seems unlikely that Heidegger would have known of a device used by German trench forces in World War I called an *Erdsprechgerät*, or earth speech device, a kind of wireless field telephone that worked by conducting voice signals through the earth. For more on such earth circuit systems in the history of telegraphy and radio, see Kahn *Earth Sound, Earth Signal: Energies and Earth Magnitude in the Arts* (2013, 69-78).
[6] See David Novak and Matt Sakakeeny on sound's "feedback loop of materiality and metaphor" (2015, 1); George Revill on the "'thingness' of sound as co-produced by the act or process of making, the materials which carry and transmit, and the means of receiving, sensing and making sense" (2016, 252-3); Frances Dyson on the fluctuations "between the sonic and the metaphoric, between sound as substance and sound as imagination" (2014, 54); David Cecchetto on sound "as a particular object that has no substance, as a kind of ideal object that nonetheless has real material effects (i.e., literal sounds) (2013, 2); Mack Hagood on "account[ing] for sound in its remembered, imagined, phantom and linguistic forms" (2019, 27); and Robin James for a critique of how "sound embodies material immediacy and the metaphysics of a probabilistic universe" in neoliberal biopolitics (2019, 3-4).
[7] See Bennett (52-61).
[8] For example, Alain Corbin's authoritative campanarian history of 19th century France avoids references to soundscape or sonic environment, preferring instead the notion of an "auditory landscape" (1998 [1994]). For him, the sonic is always to be contextualized within a sociocultural sphere, and the materiality of sound only matters insofar as it aids the reconstruction of a cultural history.
[9] Kahn has discussed Oliveros' debt to occult, Theosophical traditions and her affinities to New Age and transhumanist ideas of technological enhancement (what Kahn calls a "spiritual technofuturism." See Kahn (2013, 174-86). The vexed points where the physics of music blurs into the metaphysics of some dubious spirituality is a theme Kahn follows from Pythagoras to John Cage (Kahn 1999 189-9; Kahn 2004).
[10] This is the basis of Helmreich's "transductive ethnography" that has also been of use of to sound scholars like Mack Hagood (2019), who uses transductive ethnography to understand how physiology, audiology, neoliberal subjectivity and changing ideas about

sound, space and agency coalescence around the auditory phenomena like tinnitus, noise and their technocultural remediations.

[11] *Schnitt* means cut, but also implies combination. The word is tied to notions of shaping, arranging and editing.

[12] See Oxford English Dictionary on "nick" and "to nick." Dictionaries are geosonic instruments insofar as they transduce layers of (tangential and even contradictory) meaning that accrue around a particular material entity: a sound, and its textual form as a written word.

[13] Key texts on Deleuzian aesthetics and philosophy of the earth "as such" include: Elisabeth Grosz (2008); Ben Woodard (2013) and Kathryn Yussof (2015)..

[14] Stephen Jay Gould includes the following epigraph (from 19th century British geologist George P. Scrope) to his history of modern geology: "The leading idea which is present in all our researches, and which accompanies every fresh observation, the *sound to which the ear of the student of Nature seems continually echoed* from every part of her works, is—Time! Time! Time!" Gould also notes that "[t]his quote has become a virtual cliché by overuse in modern textbook epigraphs" (1987 *xi*, emphasis added).

[15] See Florian Dombois, "Auditory Seismology" (2011). There are some anecdotal exceptions. See Kathryn Miles (2017, 26-33). See also Kahn (2013, 133-7).

[16] Scott Hessels' "Celestial Mechanics" (2005) is a complex data visualization piece adapted for viewing in planetariums. It doesn't display stars or planets, but rather documents flight paths, satellites and non-pathed objects flights (like helicopters and weather balloons) using data gathered from NASA. See also Jussi Parikka's discussion of satellite debris via Trevor Paglen's *The Last Pictures* project in *Geology of Media* (125-31).

[17] Side A of the record is a presentation of earthquake sounds, Side B of ionospheric "whistlers." Douglas Kahn discusses the latter at length in connection to the work of composer Alvin Lucier (Kahn 2013, 107-14), and mentions Side A in his chapter "Sound of the Underground" in connection both to the Cold War seismology of Speeth and the seismographic experimental compositions of Gordon Mumma, which I discuss later in this chapter. See Kahn, 133-61.

[18] See the YouTube upload, "Earthquake Recording from Emory Cook Labs—WHEN AUDIOPHILES WERE INSANE!" Uploaded by Mikegoat March 11, 2014. https://www.youtube.com/watch?v=D9pLEmdbK5A&feature=emb_logo
Although much of Benioff's presentation hinges on the design and operation of the turntable itself (not to mention high-output home audio equipment), I am grateful that this rare recording was made available on YouTube (and that my headphones did not explode).

[19] Kahn discusses Benioff's interest in music, specifically his development of an electric cello and violin for which he built pick-ups using the same electronics as his industry-standard seismograph. According to Kahn, Benioff's instrument making grew out of what the geophysicist understood to be deep analogy between the stress and strain of bowing a stringed instrument, and the seismic stress systems of earthquakes. The "seismographic fiddle" thus possessed "earth-scale acoustics" (Kahn 2013, 147-9).

[20] Far be it from me to correct a pre-eminent geophysicist of the 20th century, but the term "earth's acoustics," while rhetorically effective, is at best a mixed metaphor. The earth would be better said to have elastics, not acoustics.
[21] Another three minutes and three seconds would bring this "silent" recording to a length of 4'33." It is not clear if Benioff was familiar with John Cage's debut of *4'33"* in 1952, the year before *Out of this World* was released. It is also not clear if Cage knew a geophysicist had made a recording of inaudible, indeterminate, aleatory sounds within a year of the publication of his famous "silent" piece.
[22] "'Earthquake for Home Use. It is understood as a condition of sale that Cook Laboratories, Inc., will in no way be responsible for damage this phonograph record may cause to equipment directly or indirectly. For users with wide-range woofers this disclaimer shall be construed to include neighbors as well, dishware and pottery'" (cited in Kahn 2013, 146).
[23] Astonishingly, if somewhat morbidly, the poet imagines what kind of "primal sound" would emerge from tracing the coronal suture of the human skull. For Kittler, that "primal sound" would be the "real," the inhuman materiality that underlies the operation of all media, and that renders human subjectivity, and really all human social life, a kind of hallucinatory side-effect of media technologies. This is not the place to go into Kittler's provocative and problematic media materialism, but it is necessary to remark that the sound that grounds a whole media ontology and history of audio technology is not exactly sound at all, but a transductive fiction: an imagined sound that nobody ever actually heard reconstructed as a figure within a speculative literary text.
[24] Kittler almost certainly has in mind Florian Dombois' audifications of the 1995 earthquake in Kobe, Japan (on the album *Earthquake Sounds* [1999]) when he makes the following remarks in the lecture "Light and Series—Event and Thunder": Take an earthquake like the one in Kobe [Japan] with thousands of casualties, seismographically record its inaudible slow vibrations, replay the signals of the entire horrific day in 10 seconds—and a sound will emerge. In the case of earthquakes that, like those in the Pacific, result from the clash of two tectonic plates, the sound will resemble a high-pitched slap, in the case of those that, like those in the Atlantic, are the result of the drifting apart of two continental plates, it will, conversely, sound like a soft sigh. Thus, the spectrum, that is, a frequency composition, gives the violent events timbre or quality: America becomes Asia. A short time ago I was privileged to hear the timbre of such quakes and I will not forget it for the rest of my life. (2006, 69)
[25] Frantti and Leverault's paper is titled "Auditory Discrimination of Seismic Signals from Earthquakes and Explosions" (1965). Kahn maps out these connections (2013 155-6).
[26] To my ear as a bass player, in any case, though it should be noted that pitch discrimination, like quake/bomb discrimination, is not the forte of a bassist. Speeth initially wanted to train bass players specifically as test subjects in his research, "but he found that their pitch discrimination was not as keen as cellists'" and was ""pleased and somewhat amused to give employment to a bunch of cello players for a short period of time"" (Lauren and Christopher Speeth in correspondence with Douglas Kahn [151]).
[27] Mumma's *Mographs* are a pre-cursor to another ambitious piano playback installation, namely Gordon Monahan's "A Piano Listening To Itself – Chopin Chord" (2010), an

outdoor installation in Warsaw, Poland in which a 24-hour loop of digitized Chopin recordings is mechanically fed into piano wires stretched from the tower of the Royal Castle to the soundboard of a piano in the square below. The music becomes audible as it vibrates the piano's soundboard, transforming the musical instrument into something that, in a sense, it already is: a transducer and a playback device. The lengthy piano wires also periodically transmit Aeolian vibrations when the wind conditions allow it, lending an aleatory, site-specific atmosphere to the otherwise closed playback circuit. See gordonmonahan.com; and also https://www.youtube.com/watch?v=YUi8MNRhXT8. The conceit of a 24-hour cycling sound installation that (potentially) opens itself onto a geosonic time-scale is a problem I discuss in Chapter 2.

[28] The *Large Size Mograph* recording time does not derive from Mumma's four-hands collaboration with Tudor in the 1960s, but from *Gordon Mumma: Music for Solo Piano 1960-2001*, performed by Daan Vandewalle, New World Records, 2008.

[29] See Kahn 115-21. See also the 2008 DVD with documentary footage, interviews and a audio track of one of the performances.

[30] See also my discussion of Doug Aitken's "Sonic Pavilion" from the Introduction.

[31] *Inner Earth, A Seismosonic Symphony* (1999) by Wolfgang Loos and Frank Scherbaum (a composer and seismologist respectively) uses digital techniques to create a five-movement ambient work out of seismographic data, which the back cover of the CD describes as "new musical territory beyond chill-out music and Musique Concrète." Mark Bain's "Live Room: Transducing Resonant Architecture" (1998) uses seismographs to playback mechanically induced "seismicity" in built environments, a project that was initially realized in a former cold-war instrument research facility at MIT. The "Seismodome," a project tied to the Columbia University's geology department, retrofits a cutting edge data aggregation tool called "Instaseis" (a kind of Instagram for earthquakes) for audio-visual simulations of earthquakes in immersive-surround presentation in planetariums.

[32] User comments on YouTube cast doubt on the viability of such a small sensor/implant to contain a Bluetooth, a power source and to convey the complex seismographic data with any nuance or texture. I myself lack the technical or engineering know-how to weigh in with any authority, but it does seem unlikely that the complex information played back by audio seismograms could be meaningfully transferred to a buzzing or pinching sensation felt by the elbow.

[33]Although Douglas Kahn (1997), among others, is critical of the extent of Cage's departure from the privileged aesthetics of the concert hall. See also my remarks on Cage and microphones from the Introduction.

[34] Not to mention under the auspices of microphony. The score of *0'00"* specifies that performers should "perform any disciplined action" that is part of their everyday life on surfaces fitted with contact microphones. At the debut, Cage conducted the business of his personal correspondence, opening, reading and responding to letters while seated at a desk (with microphones) on stage (Kahn 1999). The redirection of aesthetic attention (from musical "objects" to daily processes") is facilitated by microphones, but the aesthetics of the piece insist on the inherent musicality of processes that only become so when transduced microphonically.

[35] Evens' opening chapter is a tour de force that links psychoacoustics, musical performance and recording technology to an all-encompassing sonic materialism enacted through the contraction of hearing.
[36] In this sense, *9 Beet Stretch* is not dissimilar from Douglas Gordon's *24 Hour Psycho* (1993)—another work premised on 24 hour remediation of a canonical work—in that the defamiliarization of the altered playback speed is matched frame by frame, grain by grain, with the formal refamiliarization of a Hitchcock's masterpiece. Never having attended a screening of the *24 Hour Psycho* myself, I have been unable to ascertain how (if at all) Gordon incorporates sound into the installation.
[37] It is worth noting that Beethoven himself experimented with compositional conventions to show how musical form itself can be "stretched." For example, the second movements of op. 57 and op. 111 (piano sonatas no. 23 "Appassionata" and 32 respectively) as well as the third movement of the String Quartet in A minor (op. 132) play with duration, variation and modulation in ways that anticipate the effects of audio stretching. I am grateful to an anonymous reviewer of an earlier version of this chapter (published in *Aesthetics & Culture*) for these references.
[38] For a lucid critique of Hansen's positing of the primordiality of the body with respect to technology and language, see David Cecchetto (2011).
[39] In a separate chapter, Hansen does discuss Gordon's *24 Hour Psycho*, but his focus is the work's foregrounding of viewer anticipation in the slowness of its playback. He mentions in passing that the screening of the film would have to be limited "to the opening hours of a museum or gallery" and that "no perception of the whole film is possible" (244). In the digital light years of cultural time that have elapsed since the 2004 publication of Hansen's book, 24-hour works like Christian Marclay's *The Clock* (2010) regularly play in full duration at major galleries and venues, not to mention the *9 Beet Stretch* itself in its "live" installation and portable formats. A more recent 24-hour music video, Pharrell Williams' *24 Hours of Happy* (directed by Yoann Lemonie and We Are From LA) has been reviewed, in its full duration by a number of bloggers. Both Marclay's and Williams' pieces (the latter via its continuous playback on its website) are synced to the actual clock time, whereas the online incarnations of Inge's piece are synched to the original start time of the debut of Beethoven's symphony in Vienna at 7pm (on May 7th, 1824). In any case, further on in the chapter I address the gap between Hansen's putative impossibility of a 24-hour duration circa 2004 and the seeming plausibility of devoting 24 hours (continuously, or in digitally separated chunks) just over a decade later.
[40] For an insightful review of Crary's book that both appreciates its critical gesture, but also draws attention to some of the overgeneralizations that such a broad argument (arguably) employs, see Parry-Davies (2016).
[41] Harbisson shares biographical and personal anecdotal material in a number of print interviews with journalists as well as promotional talks and videos (usually with corporate sponsors like Samsung, Vodaphone, Google etc.) available online. His 2012 TED Talk "I Listen to Colour" and his 2016 talk at Google "What's It Like to be a Cyborg?" (co-presented with Moon Ribas) are his most concise and extensive (respectively) self-presentations. Unless otherwise indicated, all the information I offer on Harbisson's life, art and implant is drawn from these two sources.

[42] The cyborg history I trace here begins around 1920, a good forty years before the neologism was first used in print (Clines and Kline 1960). Other scholars trace the cyborg problem back to European Romanticism (Coekelbergh 2017), to the Enlightenment (Muri 2007, even the Middle Ages (Jones and Sofia, 2002).

[43]Such interpretations tend toward the sensationalistic: an internet search of "transpecies" might yield, besides Harbisson's own website, links to tabloid stories of people who identify as cats, dragons or elves and spend thousands of dollars on surgery, implants, tattooing and piercing to modify their bodies accordingly.

[44] Mark O'Connell's *To Be a Machine: Adventures Among Cyborgs, Utopians, Hackers and the Futurists Solving the Modest Problem of Death* (New York: Anchor, 2017) is a lucid and critical survey of the major figures, factions and paradoxes in contemporary transhumanism. In terms of the scope of the movement, O'Connell shows that both Oxford and MIT have transhumanist research institutes; robotics and AI research overlap with transhumanism in a number of professional and institutional contexts; Silicon Valley is open for transhumanist business, symbolized most prominently in Ray Kurzweil (popularizer of "technological singularity") as director of engineering for Google; DARPA and military R&D can be linked to transhumanism as much as DIY "grinders" who make their own experimental body modifications in basement lab spaces across North America; and there are even Mormon transhumanists, and other more ecumenical, explicitly religious variants of transhumanism. In O'Connell's book, the movement emerges as a strange fusion of speculative theology, self help, American "manifest destiny," risk theory and technocapitalism. Another useful introductory text (though without O'Connell's outsider scepticism) is the *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future*, eds. Max More and Natasha Vita-More (Malden, MA: Wiley-Blackwell, 2013), which uses an academic format to present a range of promotional and programmatic transhumanist texts.

[45] The editorial introduction to a recent volume on *The Matter of Disability* offers an unambiguous critique of the transhumanist take on disability: "Transhumanism effectively extends the most dangerous inclinations within humanism in that the proponents invest in the capacity of a human-directed escape from disability and other late eugenical dreams of an exceptionally capacitated humanity beyond our current one" (Mitchell, Antebi and Snyder, 4).

[46] The coining of the term cyborg is of course linked to space exploration. Clynes and Kline (1960) introduced the term to describe the external cybernetic systems that would need to be incorporated into the human body to enable extraterrestrial existence.

[47] Such tokenization approaches the notion of "narrative prosthesis," namely, the ways that figures of disability have both a grounding and mystifying role in literary texts (Mitchell and Snyder 2001). What Mitchell and Snyder develop as a narrative and literary-historical concept can be, arguably, applied to political rhetoric as well.

[48] Armstrong's position on the body is at times Kittlerian, except that, for, Armstrong the materiality of the body—as part of a discursive network of inscribing technologies—is not simultaneously an ontology (105). The technologized body for Armstrong, in contrast to Kittler, is explicitly a product of industrial capitalism, a system which first produces an alienated, fragmented body, then dialectically generates the techno-scientific discourses

that would analyze and treat the body, as well as the commodities that would render it whole again.

[49] Ernst Haeckel in biology, Gottfried Benn in aesthetics, Hugo von Hofmannsthal in literature, in addition to Freud (psychoanalysis) and Georg Simmel (sociology) discussed above. There is a kind of primitivism in imagining the human as a single-cell creature in a primordial sea that emerges precisely as a response to the increasing speed and complexity of modern social life.

[50] Bernadette Wegenstein's reading of Freud also emphasizes the imaginary projections that constitute the body as an image, fundamentally, and secondarily as the physical, organic entity. For psychoanalysis, the body is as much imaginary as it is physical, or rather, embodiment refers to a dynamic network of imaginary and physical relations that are necessarily in and beyond the body "itself." All bodies are, essentially and constitutively, cyborg bodies. See Wegenstein, *Getting Under the Skin: The Body and Media Theory* (2006).

[51] Tobin Siebers's *Disability Aesthetics* also argues for the centrality of disability to 20th century aesthetics, though industrial capitalism is not as central to his argument as it is for Foster and Armstrong (Siebers 2010).

[52] See, among many discussions, three edited volumes: Mike Featherstone, ed., *Body Modification* (London: Sage Publications, 2000); and Joanna Zylinska, ed., *The Cyborg Experiments: The Extensions of the Body in the Media Age* (London: Continuum, 2002); and Arthur Kroker and Marilouise Kroker, eds., *Critical Digital Studies: A Reader* (Toronto: University of Toronto Press, 2008), 442-512.

[53] One leading narrative of the posthuman is traced by Katherine Hayles in *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature and Informatics* (1999), describing how the history of cybernetics and information theory are implicated in a redefinition of the human body as a "posthuman" cyborg, that is, a technically mediated ensemble of embodiment and virtuality. Similar ground, with an emphasis on the future of distributed cognition rather than its historical evolution, is covered with a more sanguine touch by Andy Clark *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (2003). A philosophically robust theory of originary technics (and by extension, a kind of originary cyborgness of the human) has been developed out of Heidegger's work on technology and Derrida's notions of supplementarity and prosthesis by thinkers such as Bernhard Stiegler and Mark Hansen. Judith Butler (1993) and David Wills (1995) offer similar accounts of the body's incomplete origins, emphasizing language and discourse, rather than technology, as the body's originary and continual supplement. Preceding, and in many ways, presiding over most of these postmodern, posthuman cyborg discourses is Donna Haraway's "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century" (1990), which frames the problem of the cyborg in explicitly political terms. For Haraway, the cyborg embodies the pure instrumentality of militarism and the machinations of infocapitalism, while at the same time holding out some kind of subversive, uncontainable lived and social energy that escapes and threatens the grid of control imposed by capitalism and technoscience. Haraway's text is well aware of the ambivalence of the cyborg politically, yet sees a kind of potential precisely in the non-identitarian, amalgamated and discontinuous nature of the cyborg body which rewrites

the binaries that structure mythical and cultural thinking, perhaps even rewriting the ultimate binary system that effects "the translation of the world into a problem of coding." (164)

[54] In his Google talk, Harbisson refers to the long history in western science of studying sound and colour together, mentioning in passing the work of Isaac Newton on the subject. Newton was convinced that light had a cyclicality analogous to the musical octave, and devised a colour scale accordingly. Proceeding from "deepest scarlet" to its supposed octave "deepest violet," Newton plotted the remaining colours along mathematical intervals that matched the Dorian mode. Yet as Peter Pesic has shown, these intervals were not born out by experiment nor theoretical calculation, and Newton was forced either to omit colours to match the scale, or to recalculate the intervals of the wavelengths of the visible spectrum, essentially pretending that the ratio of red to indigo (400nm:700nm) was actually an octave (1:2). See Peter Pesic, *Music and the Making of Modern Science* (MIT Press, 2014), 121-31.

[55] In a presentation of an earlier version of this chapter at the Tuning Speculation V conference (2017), many participants (with serious backgrounds in electronic and digital sound production) expressed doubt that such a prosthetic could actually work in the way that Harbisson describes. Of course, whether the prosthesis actually "works" or is just a mere rhetorical performance is all the same from the perspective of a transductive listening analysis.

[56] Hansen, *Bodies in Code: Interfaces with Digital Media* (New York: Routledge, 2006).

[57] This problem (in ancient to modern philosophy and music) is treated by Daniel Heller-Roazen, *The Fifth Hammer: Pythagoras and the Disharmony of the World* (2011).

[58] "The ultimate private acoustic space is produced with headphone listening, for messages received on earphones are always private property" (Schafer 118). As a visible marker of an audio secret, the antenna functions like a Walkman in the classic essay "The Walkman Effect" by Shuhei Hosokawa, where theatricality and spectacle supplant the matter and technique of listening (2012).

[59] In this paragraph I paraphrase freely from Steven W. Lockley's and Russell G. Foster's *Sleep: A Very Short Introduction* (Oxford University Press, 2012), which deftly synthesizes much of the current science on sleep, along with the history of its interdisciplinary study in medicine, neuroscience and sociology.

[60] Decades of social constructionist approaches have effectively done away with stable, self-evident and essentialist notions of the body. For an overview, see Bryan S. Turner (2012) and Lisa Blackman (2008).

[61] Decisive experiments on the gap between internal and externally determined circadian rhythms involved researchers and subjects descending into perpetually dark caves (such as Nathaniel Kleitman in Mammoth Cave, Kentucky in the 1930s) or designing sealed, windowless bunkers where subjects could only use artificial light sources (as in Jürgen Aschoff's and Rütger Wever's pioneering experiments in chronobiology in the 1960s). See Benjamin Reiss (2017).

[62] John Durham Peters makes a different, but not unrelated point about lists in *The Marvelous Clouds*, where lists "repeatedly point to how the world escapes our concepts" and constitute a "crisis of uncontainable relevance" for media theory" (9). In the age of Google, lists represent for Peters the sometimes exhilarating, sometimes exhausting

trade-off between stable forms of knowledge and endlessly proliferating knowability. For Nancy, the potential exhaustion of the list appears as the juxtaposition of bodies and the sliding of scales in the (in)distinction of sleep.

[63] Steve Goodman's *Sonic Warfare: Sound, Affect and the Ecology of Fear* (Cambridge, MA: MIT Press, 2010) focuses on the (counter-)weaponization of sound in a Deleuzian politics of the war machine. Annahid Kassabian's *Ubiquitous Listening: Affect, Attention and Distributed Subjectivity* (Berkeley: University of California Press, 2013) explores how the circulation of affect in music demands a rethinking of subjectivity and attention in listening. And the recent volume edited by Marie Thompson and Ian Biddle, *Sound, Music, Affect: Theorizing Sonic Experience* (London: Bloomsbury, 2013) listens for the ways that music in particular facilitates and distributes affect within sonic cultures.

[64] See, for example, George Revill, "How is space made in sound? Spatial mediation, critical phenomenology and the political agency of sound." *Progress in Human Geography* 40.2 (2015): 240-56; and Michael Gallagher, "Sound as affect: Difference, power and spatiality." *Emotion, Space & Society* 20 (2016): 42-8.

[65] "Identity is a position left behind by the work of affect and while it has been perceived as positional—that is, as static—it now looks like a constant process. [. . .] Affect both conditions and enacts identities and identifications, and it does so not within bodies, but across them." (*xxix*).

[66] Some musicians even find this kind of nonconscious listening crucial for creation and improvisation. John Corbett's excellent book, *A Listener's Guide to Free Improvisation* (2016) recounts the following anecdote: "[B]assist Barry Guy once told me he believed in hearing through his bones. Because sound travels as much as four times as fast in liquids and non-porous solids than in air, he insisted that he could sense the music immediately, long before it made its way through the convoluted path of the outer ear, drum, stirrups, cochlea, basilar membrane, organ of Corti, sensory hairs, auditory nerve, to the brain" (110). Such a hearing is perhaps materially possible, though it is practically or experientially only imaginary, which does nothing to undermine its status as listening.

[67] See Hayles' chapter 3, "The Cognitive Nonconscious and the New Materialisms," pp. 65-85.

[68] For Malabou, any study or theory of the brain implies necessarily a theory of power, control or governance on some level: "There is today an exact correlation between descriptions of brain functioning and the political understanding of commanding" (32).

[69] Such discourse have been addressed in a critical-historical context by: Anson Rabinbach, *The Human Motor: Energy, Fatigue and the Origins of Modernity* (Berkeley: University of California Press, 1990); Alain Ehrenberg, *The Weariness of the Self: Diagnosing the History of Depression in the Contemporary Age* (Montreal: McGill-Queen's University Press.

[70] See Joseph Lanza's ironically laudatory account in *Elevator Music: A Surreal History of Muzak®, Easy-Listening, and Other Moodsong®* (Ann Arbor: University of Michigan Press, 2004). Goodman's take on Muzak is more cautionary, see *Sonic Warfare*, pp. 141-8.

[71] It is worth noting that Rabinbach's exhaustive (no pun intended) cultural history of fatigue in the 19th and early 20th century concludes with his assertion that after World War II the technoscientific paradigm of the productivist human body (including

techniques to enhance productivity and minimize fatigue) came to an end. It is likely that the science of sleep (just gaining legitimacy in the post-war era) as well as the work-enhancing powers of Muzak stepped in to fill the void left by the long 19th century's materialist, positivist conception of the body at work.

[72] On 24/7 programming, see Lanza, p. 45. On the use of Muzak in agribusiness, Lanza cites a 1973 *Rolling Stone* article: "'There was a situation when the National Stockyards in Illinois had too many 'dark cutters,' which happens when the release of adrenalin makes the blood congeal and the meat turn. They put the Muzak in and it calmed the cattle as they went to the hereafter'" (152).

[73] Speaking specifically of Western "classical" music, Kassabian has pointed out that, in the spaces of ubiquitous listening, much of what used to be considered "foreground" has been relegated to the background.

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