# THE ROUTLEDGE COMPANION TO SOUND STUDIES

Unedited Page Proofs

*Edited by Michael Bull*



Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2019
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN
and by Routledge
711 Third Avenue, New York, NY 10017

*Routledge is an imprint of the Taylor & Francis Group, an informa business*



*British Library Cataloguing-in-Publication Data*
A catalogue record for this book is available from the British Library

*Library of Congress Cataloging-in-Publication Data*
[CIP data]

ISBN: 978-1-138-85425-3 (hbk)
ISBN: 978-1-315-72219-1 (ebk)

Typeset in Bembo
by Sunrise Setting Ltd, Brixham, UK

# CONTENTS

# 21
# SONIC ARCHAEOLOGIES

*Shannon Mattern*

Materiality has been among the most widely resounding conceptual refrains in media and cultural studies over the past two decades. While our digital lives and media landscapes ostensibly became more virtual, placeless, and weightless, we – media and cultural scholars, artists, and designers – turned our attention to our gadgets' guts; to the chemistry, physics, and even geology behind their construction, operation, and disposal; and to the heavy infrastructures undergirding our supposedly ethereal existences. Media archaeology, in particular, by emphasizing the materiality of media – the stuff, the institutions, the infrastructures, the labor practices, the code, the algorithms – has given rise to new, non-teleological modes of historiography that aim to trace media's peripheral routes and forgotten paths (see Huhtamo and Parikka 2011; Parikka 2012). Caleb Kelly (2009), Mara Mills (2011), Jentery Sayers (2013), Jacob Smith (2015), Jonathan Sterne (2003), and Siegfried Zielinski (2006) have re-sounded such historical audio artifacts as musical automata and songbirds, hearing tubes, stethoscopes, phonautographs, shellac discs, magnetic recording devices, hearing aids, and audio-cassette tapes.



Recognizing the myriad forces and entangled temporalities shaping the historical terrain from which such devices emerged, media archaeologists have come to question the "old"/"new" media divide – to recognize that "old" media were once "new," too – and to regard material engagement with their research subjects as a vital means of critical investigation, or what Wolfgang Ernst calls "epistemological reverse engineering" (Ernst 2011: 239; see also Marvin 1988). Archaeological research thus takes place not only in libraries and archives, but also in labs and studios, where screwdrivers and emulators, magnifying glasses and contact microphones, soldering irons and audio-editing software serve as integral research tools.

In this chapter we'll examine several such sonic-archaeological media researchers, designers, and artists who listen to media – to their internal machinery, their code, their pipes – in order to give voice to their mechanisms of operation. But we'll also examine another terrain of sonic-archaeological investigation: the field site, the archaeological dig. Taking media archaeology *literally*, we'll examine how archaeologists of the trowel-wielding variety have long adopted media technologies, including audio recorders and editing software, to better understand how archaeological sites might have functioned as sonic spaces.[1] We'll explore how archaeoacoustics – which melds techniques and sensibilities from archaeology, audio production, and sensory history – allows us to hear echoes from sites of the distant past.

## Listening as diagnostic, epistemic, and historical method

Sound serves as a useful diagnostic tool. We can often hear malfunctions – a clanging pipe, a stuttering hard-drive, an irregular heartbeat, a coughing engine – we might not be able to detect or diagnose otherwise. In February 2016 Loughborough University posted a PhD "studentship" focused on "listening to infrastructure" in order to "provide early warning of deterioration and facilitate targeted maintenance and renewal" of the UK's "aging geotechnical assets": its rail lines, petroleum and potable water pipelines, offshore wind turbines, bridges, earth-retaining structures, and foundations. Researchers would listen for Acoustic Emissions, stress waves generated when such structures move and deform. This applied research extends a tradition among sound artists who have sonified various infrastructural elements, particularly bridges. In 1983, for the 100th anniversary of the Brooklyn Bridge, which at the time had a steel grid roadway (it has since been paved over), Bill Fontana (1983) mounted eight microphones under the bridge and broadcast the sounds to the plaza of the World Trade Center, via speakers embedded within the façade of the One World Trade Center. More recently, sound artist and filmmaker Kevin T. Allen (2012), one of my own former thesis students, produced a haunting small-gauge film mixing the sounds of three of New York's major bridges – the Brooklyn, Manhattan, and Williamsburg – which he collected via contact microphones that pick up vibrations. Such works make sensible the micro-rhythms and macro-scale physical stresses that our infrastructures withstand and amplify the distinct mechanics of their different materials and construction techniques.

Other artists have proposed that there's much to be learned by listening to technical and media infrastructures: WiFi networks, cell phone connections, GPS, and other systems dependent on electromagnetic waves (see Mattern 2011). In 2004 German composer/sound artist Christina Kubisch began hosting her "Electrical Walks," in which participants use specially designed headphones that translate electromagnetic signals within the environment into sounds, thus disclosing the myriad waves and particles that not only make possible their ATM transactions and signal their surveillance by ubiquitous CCTV, but that also perpetually envelop and penetrate their bodies.[2] Her work resonates with growing public concerns about the potential health effects of ubiquitous and invasive electromagnetic signals – ever present in the universe, but now harnessed and targeted by devices we regularly carry in our pockets or near our brains. On a similar wavelength, Shintaro Miyazaki (2013) and Martin Howse also use logarithmic detectors, amplifiers, and wave-filter circuits to transform electromagnetism into sound, and thereby reveal the "rhythms, signals, fluctuations, oscillations and other effects of hidden agencies within the invisible networks of the 'technical unconscious.'" Howse (2014) frames such experiments as "forensic" epistemological investigations, which question what we can know, through transduction, about a seemingly imperceptible wireless world.

Myriad artists have used sound to index media's rhythms – both their mechanical movements and signal-processing operations. Consider, for instance, the audible physical rhythm of a Vandercook press or a 3D printer, a 16mm film projector or a high-speed book scanner. Sound artist and scholar Matt Parker (2015a, 2015b), as part of his "Imitation Archive" project, recorded the groans, hums, and crunches of historic calculating and computing machines at The National Museum of Computing at Bletchley Park, UK. Parker then mixed his 116 individual recordings into ten compositions, which are intended to give voice to the successive "movements" of computing history: "the 'always on' durational nature of many of the machines," "the clunking masses of early relay-based machines," the "whirring monoliths of the 1980's mainframe era," and "the high frequency whir of modern day server units." We learn about the evolving processes of computation by listening to the internal mechanisms of these machines. Howse and Miyazaki's Detektors project (2010–12) applied similar methods to contemporary electronic devices,

including mobile phones, cameras, and hard drives, and artist-scholar Jamie Allen has examined the epistemologies given voice in lie detectors and the Church of Scientology's E-meter (Allen n.d.; Detektors n.d.; Institute of Experimental Design and Media Cultures 2016). These skills of diagnostic and forensic listening are of critical importance to archivists – particularly audio-visual archivists – because their work to preserve cultural heritage typically requires preserving archival media's recording and playback devices, too.

Even the seemingly abstract algorithms driving media-machines' operations are rhythmic and lend themselves to listening. Howse and Miyazaki's method of "algorhythmics," they claim, allows us to "hear that our digital culture is not immaterial, but consists of lively, rhythmical, performative, tactile and physical … machinic assemblages" (Detektors; see also Parikka 2012: 151–2). Miyazaki's and Michael Chinen's AlgorhythmicSorting program, for instance, sonifies the "rhythmic and pattern generating behavior" of different sorting algorithms: bubble sort, merge sort, heap sort, and so forth (Studio Algorhythmics; see also Ernst 2013). Yet algorithmic sonification isn't merely a clever means of making computational processes intelligible to non-specialists. Listening has long been an essential skill in computer engineering and programming. As Miyazaki (2012) reports, some early mainframes like the UNIVAC I and the Philips PASCAL computer featured an auditory interface, which transformed signals into sound via a speaker. Louis D. Wilson, one of the chief engineers for the BINAC, recounts that, in testing the computer, he and his colleagues discovered that they could recognize the machine's patterns via static on the lab's radio. Other early computer engineers noted that their machines and programs had a "characteristic sound."

The modes of listening, or what Jonathan Sterne would call "audile techniques," of these seasoned engineers were shaped by their professional training and their historical and cultural contexts. Engineering – and *listening* – during and after the War, amidst computing's incunabula, were quite different practices than they are today. While there is much debate within sensory history about the epistemology of historical "reenactment," Wolfgang Ernst, who practices an engineering-oriented version of media archaeology, proposes that "reenact[ing] the sound-generating setting" can shed light on "auditory perception in the past" (2013: 175).[3] In creating his archive at Bletchley Park, Parker (2015c) sought to reflect the architectures and environments within which the computers operated; after all, these contexts were integral to the way Alan Turing and his colleagues would have listened and responded to their machines. While Parker had no presumptions of "re-creating" the acoustics of the labs in which these machines operated, he did acknowledge their architectural "habitats" through sonic allusion, by weaving the rooms' signature acoustics (that is, their impulse responses) into his compositions.



The site of sounding and listening is also of critical importance to the work of Lawrence Abu Hamdan and Susan Schuppli, both of whom employ variations on sonic archaeology in their "Forensic Architecture" research. In his Earshot project, Hamdan (n.d.) worked with Defense for Children International, a human rights organization, to conduct an "audio-ballistic analysis" of a May 2014 incident in the occupied West Bank. Hamdan's forensic methods – which involved creating spectrograms of gunshots and 3-D models of the urban crime scene – provided critical evidence in establishing that Israeli soldiers shot and killed two teenagers with live ammunition, rather than rubber bullets, as they claimed. His modeling techniques have attracted attention from international media and governments. Schuppli, meanwhile, has investigated the sonic nuisance of drone surveillance in northern Pakistan. Not only are the drones' round-the-clock, high-frequency buzz and occasional deafening missile-strikes the source of much "psychological grief" – from anxiety and depression to post-traumatic stress disorder – but, as Schuppli (2014) proposes, their sonic effects might also be sufficiently harmful to constitute a violation of humanitarian law (see also Bishop 2011; Goodman 2010). Schuppli's, Hamdan's, and Parker's archaeological work requires attention to the particular acoustic properties of their

research sites. They must attend not only to the sound, but also to its resonance chamber; to both the signal and all the ambient noise through which it must pass.

## Listening to ancient places

Archaeologists and acousticians working in the field of *archaeoacoustics* have applied similar sensibilities in examining the sonic architectures of ancient sites, from Stonehenge to Peruvian temples to American petroglyph sites (see, for instance, Blesser & Salter 2007; Sample 2012; Watson & Keating 1999). Archaeologists have a long history of employing a wide repertoire of media techniques and technologies – field notes, drawings, maps, photographs, films, satellite imagery and GIS, material artifacts, etc. – for "making manifest the past (or, crucially … allow[ing] the past to manifest itself)" (Olsen, Shanks, Webmoor & Witmore 2012: 93). Archaeacousticians, or sonic archaeologists, also make use of such tools as omnidirectional or "bouquet" microphone and speaker arrays, binaural mics, amplifiers, field recorders, and sophisticated modeling software. They measure their research sites' impulse responses, standing waves, and reverberation times, and conduct on-site sonic tests by playing instruments and singing as their ancient subjects might have done.[4] Of course there's much conjecture involved in piecing together ancient multisensory experiences and ancient builders' intentionality, and the speculative nature of such archaeoacoustics research has generated debate (see Drake 2012; Scarre & Lawson 2006).[5] Archaeoacousticians certainly don't intend to "re-enact" ancient sounding or listening experiences, as Ernst proposes, or to be able to approximate "auditory perception in the past." Still, opening the ears during archaeological investigation allows for a recognition that human experience is, and always has been, multisensory, and that ancient spaces have long functioned, either by accident or by intention, as resonance chambers and transmission media for sonic activity – for public address, interpersonal communication, ritual or musical performance, and so on.



Mathematician and archaeologist Iegor Reznikoff (2012), who has studied Paleolithic art in caves throughout Europe, has identified a correlation between a site's resonance and its concentration of markings; he suggests that densely decorated sites were likely the location of rituals using instruments and chant.[6] At Chichen Itza, the Mayans built a pyramid along the narrow end of their Great Ball Court, which was surrounded by vertical stone walls. "By adding reflections and resonances," researchers have discovered, the Ball Court could "augment the perceived mass and size of the leader's voice, raising his stature and perceived power" (Blesser & Salter 2007: 85–6; see also Lubman 2006). And in a network of tunnels beneath the city of Chavìn, Peru, archaeologists found a set of marine-shell trumpets, *pututus*, corroborating their theory that, somewhere between 1500 and 400 BCE, the tunnels functioned as a series of resonance and sound transmission tubes. "Tones in the same frequency range as both human voices and the shell trumpets produced consistent resonances in the alcoves" (Smith 2011). Archaeologists have also examined sound-amplifying wall niches, including one curved, carved projection known as the "Oracular Chamber," in the Hal Saflieni Hypogeum, an underground cemetery used in Malta from 4000 to 2500 BCE (Stroud 2014). They've surmised that it was no accident that, somewhere between the eighth and sixth century BCE, the Elamites situated their Kūl-e Farah open sanctuary near the opening of a gorge in present-day southwestern Iran; the site was geologically predisposed to function as a "giant sound box" (Henkelman & Khaksar 2014). And informed by Vedic Hinduism, which places great importance on acoustics – particularly speech and music – archaeologists have been exploring the sonic properties of stone in ancient Indian architecture.

The ancient Greeks' appreciation of acoustics was also informed by spiritual and metaphysical beliefs: they made use of oracular sites, where the gods could speak to mortals; their Archeron

Necromacy employed acoustic effects befitting the "gates to Hades"; and Pythagoras's "harmony of the spheres" proposed the existence of a harmonious natural order (see Blesser & Salter 2007: 77–89). "Given their strong interest in all forms of aural activities, including music, oration, rhetoric, and religion," Barry Blesser and Linda-Ruth Salter write, "the ancient Greeks were likely to have been aware of how these activities were influenced by spatial acoustics" (Blesser & Salter 2007: 94). The diversity of activities in the open *agora*, for instance, invited walking and casual conversation, and generated a cacophony of all citizens' voices (those voices, of course, didn't include women's, slaves', or many foreigners'). In the amphitheater, meanwhile, the stepped seats of rough-hewn limestone acted – whether by design or by accident – as an acoustic filter, suppressing low-frequency background noise and isolating the higher-frequency performer's voices (Ball 2007). The theaters' location, often among rolling hills, also provided favorable acoustic conditions.

While renowned for its theatrical innovations, ancient Greece is also the quintessential example – among archaeologists, classicists, philosophers, rhetoricians, political scientists, architectural historians, etc. – of a civilization founded upon a particular structural form of rational communication: the linking of meeting places, debate, and democracy. Architectural historian Anthony Vidler (2005) argues that Plato's ideal city – of which we find six versions throughout his oeuvre – is primarily "a city of discourse," which "exists first and foremost for the dialogues themselves." Aristotle, too, prescribed a city that would contain no more people than could hear a herald's voice.[7]

Classicist Christopher Lyle Johnstone, noting in 1997 that "physical setting [had] been virtually ignored" in rhetorical scholarship, draws on archaeological research to explore how the architecture of Athens' *agora*, where most civic functions were carried out until the early sixth century, and the architecture of its civic buildings – including the law courts, stoa, and various auditoria – shaped both an orator's delivery and his audience's engagement, and even limited the size of the audience (juries usually numbered at least 200, and more typically close to 500) (Johnstone 1997: 99; see also Johnstone 2001). He, like those archaeologists practicing archaeoacoustics, acknowledges the speculative and conjectural nature of his work. Yet he proposes that the stoa – long, narrow structures with walls (typically made of stone) along both short ends and one long side, and an open colonnade along the other long end – had a "pronounced reverberation effect," which had the potential to distort speakers' voices (2001: 137–8). Experienced speakers, however, "might have selected [their] cadences so as to take advantage of the building's acoustical properties"; if they found the structure's acoustic "sweet spot," the rhetorical effect could be "mesmerizing and engrossing" (Johnstone 1997: 103; Johnstone 2001: 138). Meanwhile, in the *Bouleutêrion*, the square or rectangular council house, tiered seating, high ceilings, and internal columns allowed speakers and auditors to see one another, cultivating a sense of intimacy, and permitted some degree of acoustic subtlety; "thus could a speaker employ an ordinary speaking voice in addressing a fairly large audience, and thus could he make the sorts of asides and sotto voce comments that would be ineffective in a less intimate setting" (Johnstone 1997: 106; see also Sennett 1994: 56–7).



In the fifth century BCE, the political assembly moved to the Pnyx Hill. A short walk from the agora, it was also far removed from the agora's mobility and cacophony. The Pnyx's formal design "emphasized the seriousness of attending to words," Richard Sennett argues; it "made political use of … sitting, spectator bodies" (Sennett 1994: 60, 66). Yet its physical setting also had affective power; the scenery cultivated pathos and ethos. From this site,

> one could look toward the Acropolis and see the Nike Temple nestled neatly inside the larger Parthenon behind it, as though the arrangement of these two temples was

> deliberately designed for the speaker (from among an all-male assembly) with this orientation in mind: winged victory nested within the temple of the city's patron goddess, declaring hegemony held by her citizens…. The ancients understood the importance of the view offered by the assembly place. (Fredal 2006: 4)

The broader topography was also part of the scene. Blesser and Salter argue that the rolling hills and mild climate of many ancient Greek cities – the fact that the *demos* could meet out-of-doors, or in open buildings, and appreciate the surrounding scenery – "contributed to the success not only of the amphitheaters but also of Greek democracy, which might not have flourished without the frequent, publicly shared experiences" that these meeting places made possible (Blesser & Salter 2007: 95).

For the Romans, too, cities were predicated on rhetoric: "Never in my opinion," Quintilian (95C.E.) writes, "would the founders of cities have induced their unsettled multitudes to form communities had they not moved them by the magic of their eloquence" (see also McEwen 1993). The Roman architect Vitruvius tells of ancient builders who sought to cultivate acoustics that maximized the "clearness and sweetness" of orators' voices (1914: 139). One of their techniques – inspired by the principles of harmonics, and inventive though ineffectual – involved placing bronze vessels beneath the seats of an auditorium, which would supposedly resonate with and amplify the voice.

In 1872 archaeologists found in the Roman Forum a marble relief representing an emperor, either Trajan or Hadrian, standing on the Forum's Rostra Augusti (speaker's platform), delivering a public address or adlocutio (an address to the army). In Julio-Claudian times, the emperor often delivered speeches from across the forum, on a platform at the Temple of Divus Iulius, while his heir occupied the Rostra Augusti. Inspired by such finds, architectural historian Diane Favro and classicist Christopher Johanson are creating digital models of the Forum to understand how the space accommodated funeral processions, multisensorial affairs choreographed to appeal to multiple audiences. With further research, they're attempting to model and understand, in part, how the Forum functioned *acoustically* as a space for speech and pageantry: "How did accompanying sounds reinforce the activities? ... Where did spectators stand? ... What route to the forum was taken by participants?" (Favro & Johanson 2010: 15). They want to understand how the material urban landscape functioned as an "infrastructure" for the sights and sounds of these public events – how various architectures "dictated the choreography" and "created a formal tableau" that assigned status to particular sensory experiences (Favro & Johanson 2010: 31).[8] Johanson again articulated the challenges of modeling the sounds of ancient sites: With so many variables – the dimensions and materials of the buildings surrounding the plazas, each of which is a "tightly controlled sonic environment," and the myriad waterworks throughout Roman cities – it's hard to piece together a recreation of what they would've sounded like, how they functioned as infrastructures for mediation.[9]

Archaeoacousticians and sonically minded architectural and urban historians have also examined the sonic properties of 17th-century New England meeting houses and 19th-century public auditoria and mechanics halls; the booming commercial streets of early-modern London; and the battlefields of the Civil War and the underground bunkers of 20th-century warfare; the pealing bells that defined village boundaries and structured village life from the 7th through the 19th century throughout Western Europe and in colonial Latin America; the *muezzins* that have broadcast the call to prayer in cities across the Islamic world for over a millennium; the carefully considered acoustics of Byzantine churches and 16th-century mosques.[10] These sounding spaces, in containing, transmitting and reverberating the sound waves projected into them, function as media themselves. Archaeoacousticians, like their media-archaeologist counterparts,

have to understand architectures' and cities' materials and mechanisms of acoustic operation. We might thus regard archaeoacoustics as a symphonic-scale version of sonically attuned media archaeology – one in which ancient media, including voices and musical instruments, resound within ancient architectural instruments.

## Notes

1 For more on the *literal* archaeology of media archaeology, see Mattern 2013a and Mattern 2015.
2 See also Mattern 2013b for more on multisensory means of experiencing and comprehending infrastructure.
3 See also Smith 2007 for a discussion of reenactment's methodological and epistemological concerns.
4 See Kolar 2013 for more on archaeoacoustic methods.
5 Sensory history has addressed similar epistemological and methodological concerns; see Smith 2007.
6 Much of this final section of the chapter is drawn from Mattern 2013a and the "Speaking Stones: Voicing the City" chapter in my *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media*, forthcoming from University of Minnesota Press in Fall 2017.
7 "For who can be the general of such a vast multitude, or who the herald, unless he have the voice of a Stentor?" Aristotle 1998: 1326b5-7.
8 Favro identifies several other studies examining how rituals and processions shaped the form of ancient Rome, focusing in particular on "the close connections among events, meaning, and the physical locale." A continuing blind spot, or silence, in such work, Favro argues, is the perspective of non-elite participants (Favro 1999: 369).
9 Christopher Johanson, interview with the author, February 26, 2013. For more on modeling sensory history, see the work of Richard Beacham at Kings College London, who aims to model ancient theaters; and the work of the LCSE-MSI Visualization Laboratory at the University of Minnesota (in collaboration with Christopher Johnstone, whom we encountered earlier), which aims to model the acoustics of ancient Greek theaters and auditoriums particularly "how variables of architecture design affected the sound, sight lines, and behaviors of speakers and listeners" ("Ancient Greek Rhetoric" n.d.; Beacham, n.d.).
10 Most of these cases are addressed in the "Speaking Stones: Voicing the City" chapter in my *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media*.



## References

Allen, J. (n.d.) "The Lie Machine," *Jamie Allen*, accessed December 22, 2016, at www.jamieallen.com/the-lie-machine/.

Allen, J. (n.d.) "Recomposing the E-Meter," *Jamie Allen*, accessed December 22, 2016, at www.jamieallen.com/recomposing-the-e-meter/.

Allen, K. T. (2012) "Bridge," Filmography, accessed December 22, 2016, at www.phonoscopy.com/works.html#filmography.

"Ancient Greek Rhetoric in Immersive Virtual Reality" (n.d.) Minnesota Supercomputing Institute, accessed December 22, 2016, at www.msi.umn.edu/content/ancient-greek-rhetoric-immersive-virtual-reality.

Aristotle, (1998) "Politics," in J. Barnes (ed.) *Complete Works of Aristotle*, Revised Oxford Translation, New York, NY: Princeton University Press.

Ball, P. (2007) "Why the Greeks Could Hear Plays from the Back Row," *Nature*, March, accessed December 22, 2016, at www.nature.com/news/2007/070319/full/news070319-16.html.

Beacham, R. (n.d.) "THEATRON – Theatre History in Europe: Architectural and Textual Resources Online," *Didaskalia* 6(2), accessed December 22, 2016, at www.didaskalia.net/issues/vol6no2/beacham.htm.

Bishop, R. (2011) "Project 'Transparent Earth' and the Autoscopy of Aerial Targeting: The Visual Geopolics of the Underground," *Theory, Culture & Society*, 28(7–8), pp. 270–86.

Blesser B. & Salter, L-R. (2007) *Spaces Speak, Are You Listening?: Experiencing Aural Architecture*, Cambridge, MA: MIT Press, pp. 67–97.

"Detektors" (n.d.) Shintaro Myazaki, accessed December 22, 2016, at http://shintaro-miyazaki.com/?work=detektors.

Drake, N. (2012) "Archaeoacoustics: Tantalizing, but Fantastical," *Science News*, February 17, accessed December 22, 2016, at www.sciencenews.org/view/generic/id/338543/description/Archaeoacoustics_Tantalizing_but_fantastical.

Ernst, W. (2011) "Media Archaeography – Method & Machine versus History & Narrative of Media," in Huhtamo and Parikka (eds) *Media Archaeology: Approaches, Applications, and Implication*, Berkeley, CA: University of California Press, pp. 239–55.

Ernst, W. (2013) "Toward a Media Archaeology of Sonic Articulations," in J. Parikka (ed.) *Digital Memory and the Archive*, Minneapolis, MN: University of Minnesota Press, pp. 172–83.

Favro, D. (1999) "Meaning and Experience: Urban History from Antiquity to the Early Modern Period," *Journal of the Society of Architectural Historians* 58(3), pp. 364–73.

Favro, D. & Johanson, C. (2010) "Death in Motion: Funeral Processions in the Roman Forum," *Journal of the Society of Architectural Historians* 69(1), pp. 12–37.

Fontana, B. "The Brooklyn Bridge Sound Sculpture at One World Trade Center, New York, 1983," *Resoundings*, accessed December 22, 2016, at http://resoundings.org/Pages/Oscillating.html.

Fredal, J. (2006) *Rhetorical Action in Ancient Athens: Persuasive Artistry from Solon to Demosthenes*, Carbondale, IL: Southern Illinois University Press.

Goodman, S. (2010) *Sonic Warfare: Sound, Affect, and the Ecology of Fear*, Cambridge, MA: MIT Press.

Hamdan, L.A. (n.d.) "Earshot," accessed December 22, 2016, at http://lawrenceabuhamdan.com/new-page-1/.

Henkelman, W. F. M. & Khaksar, S. (2014) "Elam's Dormant Sound: Landscape, Music and the Divine in Ancient Iran," in L. C. Einix (ed.) *Archaeoacoustics: The Archaeology of Sound*, Proceedings of the Archaeoacoustics Conference, Malta, 2014, Myakka City, FLOTS Foundation, pp. 211–31.

Howse, M. (2014) "Sonic Archaeology," Harvestworks Workshop, April 5–6, accessed December 22, 2016, at www.harvestworks.org/apr-56-sonic-archaeology-workshop/.

Huhtamo, E. & Jussi Parikka (eds) (2011) *Media Archaeology: Approaches, Applications, and Implication*, Berkeley, CA: University of California Press.

Institute of Experimental Design and Media Cultures (2016) "U.S. Media Archaeology Lab Hosts Apocryphal Technologies, March, accessed December 22, 2016, at www.ixdm.ch/u-s-media-archeology-lab-hosts-apocryphal-technologies/.

Johnstone, C. L. (1997) "Greek Oratorical Settings and the Problem of the Pnyx," in C. Johnstone (ed.) *Theory, Text, Context: Issues in Greek Rhetoric and Oratory*, Albany, NY: State University of New York Press, pp. 97–128.

Johnstone, C. L. (2001) "Communicating in Classical Contexts: The Centrality of Delivery," *Quarterly Journal of Speech* 87(2), pp. 121–43.

Kelly, C. (2009) *Cracked Media: The Sound of Malfunction*, Cambridge, MA: MIT Press.

Kolar, M. (2013) "Tuned to the Senses: An Archaeoacoustic Perspective on Ancient Chavín," *The Appendix*, July 22, accessed December 22, 2016, at http://theappendix.net/issues/2013/7/tuned-to-the-senses-an-archaeoacoustic-perspective-on-ancient-chavin.

Kubisch, C. (2004) "Electrical Walks: Electromagnetic Investigations in the City," Christina Kubisch, accessed December 22, 2016, at www.christinakubisch.de/en/works/electrical_walks.

Loughborough University, "Listening to Infrastructure: Acoustic Emission Sensing of Geotechnical Infrastructure to Improve Resilience," Loughborough University, accessed February 5, 2016, at www.lboro.ac.uk/study/finance/research/studentships/studentships/listening-to-infrastructure-acoustic-emission-sensing-.html.

Lubman, D. (2006) "Acoustics of the Great Ball Court at Chichen Itza, Mexico," *Journal of the Acoustical Society of America* 120, accessed December 22, 2016, at http://asa.scitation.org/doi/abs/10.1121/1.4777330.

Marvin, C. (1988) *When Old Technologies Were New: Thinking About Electric Communication in the Late Nineteenth Century*, New York, NY: Oxford University Press.

Mattern S. (2011) "SoundMatter," "No Thing Unto itself: Object-Oriented Politics," CUNY Graduate Center, October 20, accessed December 22, 2016, at www.veralistcenter.org/engage/event/241/no-thing-unto-itself-objectoriented-politics/.

Mattern, S. (2013a) "Ear to the Wire: Listening to Historic Urban Infrastructures," *Amodern* 2, accessed December 22, 2016, at http://amodern.net/article/ear-to-the-wire/.

Mattern, S. (2013b) "Infrastructural Tourism," *Places Journal*, accessed December 22, 2016, at https://placesjournal.org/article/infrastructural-tourism/.

Mattern, S. (2015) *Deep Mapping the Media City*, Minneapolis: University of Minnesota Press.

McEwen, I. K. (1993) "Hadrian's Rhetoric I: The Parthenon," *RES: Anthropology and Aesthetics* 24, pp. 55–66.

Mills, M. (2011) "Hearing Aids and the History of Electronics Miniaturization," *IEEE Annals of the History of Computing*, 33(2), pp. 24–45. Reprinted in J. Sterne, (ed.) (2012) *The Sound Studies Reader*, New York, NY: Routledge.

Miyazaki, S. (2012) "Algorhythmics: Understanding Micro-Temporality in Computational Cultures," *Computational Culture*, accessed December 22, 2016, at http://computationalculture.net/article/algorhythmics-understanding-micro-temporality-in-computational-cultures.

Miyazaki, S. (2013) "Urban Sounds Unheard-of: A Media Archaeology of Ubiquitous Infospheres," *Continuum: Journal of Media & Cultural Studies*, 27(4), pp. 514–22.

Olsen, B., Shanks, M., Webmoor T., & Witmore, C. (2012) *Archaeology: The Discipline of Things*, Berkeley, CA: University of California Press.

Parikka, P. (2012) *What Is Media Archaeology?* Malden, MA: Polity.

Parker, M. (2015a) "The Imitation Archive," *Earth Kept Warm*, accessed December 22, 2016, at www.earthkeptwarm.com/the-imitation-archive/.

Parker, M. (2015b) "The Imitation Archive Part 1: Recording the Sounds of the World's First Computers," *British Library Sound and Vision Blog*, May 15, accessed December 22, 2016, at http://britishlibrary.typepad.co.uk/sound-and-vision/2015/05/the-imitation-archive-part-1-recording-the-sounds-of-bletchley-parks-historic-computers-.html.

Parker, M. (2015c) "The Imitation Archive Part 2: Making Music from the Sounds of the World's First Computers," *British Library Sound and Vision Blog*, May 26, accessed December 22, 2016, at http://britishlibrary.typepad.co.uk/sound-and-vision/2015/05/the-imitation-archive-part-2-.html.

Quintilian, *Institutio Oratoria* (ca. 95CE), 2.16.9, accessed December 22, 2016, at http://perseus.uchicago.edu/perseus-cgi/citequery3.pl?dbname=LatinAugust2012&getid=1&query=Quint.%202.16.15.

Reznikoff, I. (2012) "On the Sound Related to Painted Caves and Rocks," In J. Ikäheimo, A. Salmi & T. Äikäs (eds.) *Sounds Like Theory* XII, Nordic Theoretical Archaeology Group Meeting, Oulu, April 25–28, Monographs of the Archaeological Society of Finland 2, pp. 191–109, www.sarks.fi/masf/masf_2/SLT_07_Reznikoff.pdf.

Sample, I. (2012) "Stonehenge was Based on a 'Magical' Auditory Illusion, Says Scientist," *The Guardian*, February 16, accessed December 22, 2016, at www.guardian.co.uk/science/2012/feb/16/stonehenge-based-magical-auditory-illusion?newsfeed=true.

Sayers, J. (2013) "Making the Perfect Record," *American Literature*, 85(4), pp. 817–18.

Scarre C. & Graeme Lawson, G. (eds.) (2006) *Archaeoacoustics*, Cambridge, UK: McDonald Institute for Archaeological Research.

Schuppli, S. (2014) "Uneasy Listening." In Forensic Architecture (ed.) *Forensis: The Architecture of Public Truth*, Berlin: Sternberg Press, pp. 381–92.

Sennett, R. (1994) *Flesh and Stone: The Body and the City in Western Civilization*, New York, NY: W. W. Norton.

Smith, J. (2011) "Listening to the Gods of Ancient Peru," *Archaeology Magazine* 64(4), accessed December 22, 2016, at http://archive.archaeology.org/1107/trenches/chavin_de_huantar_caves_acoustics.html.

Smith, J. (2015) *Eco-Sonic Media*, Berkeley, CA: University of California Press.

Smith, M. M. (2007) *"Producing Sense, Consuming Sense*, Making Sense: Perils and Prospects for Sensory History," *Journal of Social History* 40(4), pp. 841–858.

Sterne, J. (2003) *The Audible Past: Cultural Origins of Sound Reproduction*, Durham, NC: Duke University Press.

Stroud, K. (2014) "Hal Saflieni Hypogeum – Acoustic Myths and Science," in L. C. Einix (ed.) *Archaeoacoustics: The Archaeology of Sound*, Proceedings of the Archaeoacoustics Conference, Malta, Myakka City, 2014, FLOTS Foundation, pp. 37–43.

Studio Algorhythmics, (n.d.) "Algorhythms of Sorting," accessed December 22, 2016, at http://algorhythmics.ixdm.ch/?p=152.

Vidler, A. (2005) *"How to Invent Utopia: The Fortunes and Misfortunes of Plato's Polis," Mellon Lecture, Canadian Centre for Architecture, Montreal*, Canada, May 17.

Vitruvius (1914) *The Ten Books on Architecture*, Cambridge, MA: Harvard University Press.

Watson A. & Keating, D. (1999) "Architecture and Sound: An Acoustic Analysis of Megalithic Monuments in Prehistoric Britain," *Antiquity* 73(280), pp. 325–36.

Zielinski, S. (2006) *Deep Time of the Media: Toward an Archaeology of Hearing and Seeing by Technical Means*, Cambridge, MA: MIT Press.

Portions of this chapter are modified, with permission, from "Ear to the Wire: Listening to Historic Urban Infrastructures," *Amodern* 2, (2013), and my *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media*, forthcoming from University of Minnesota Press in Fall 2017.