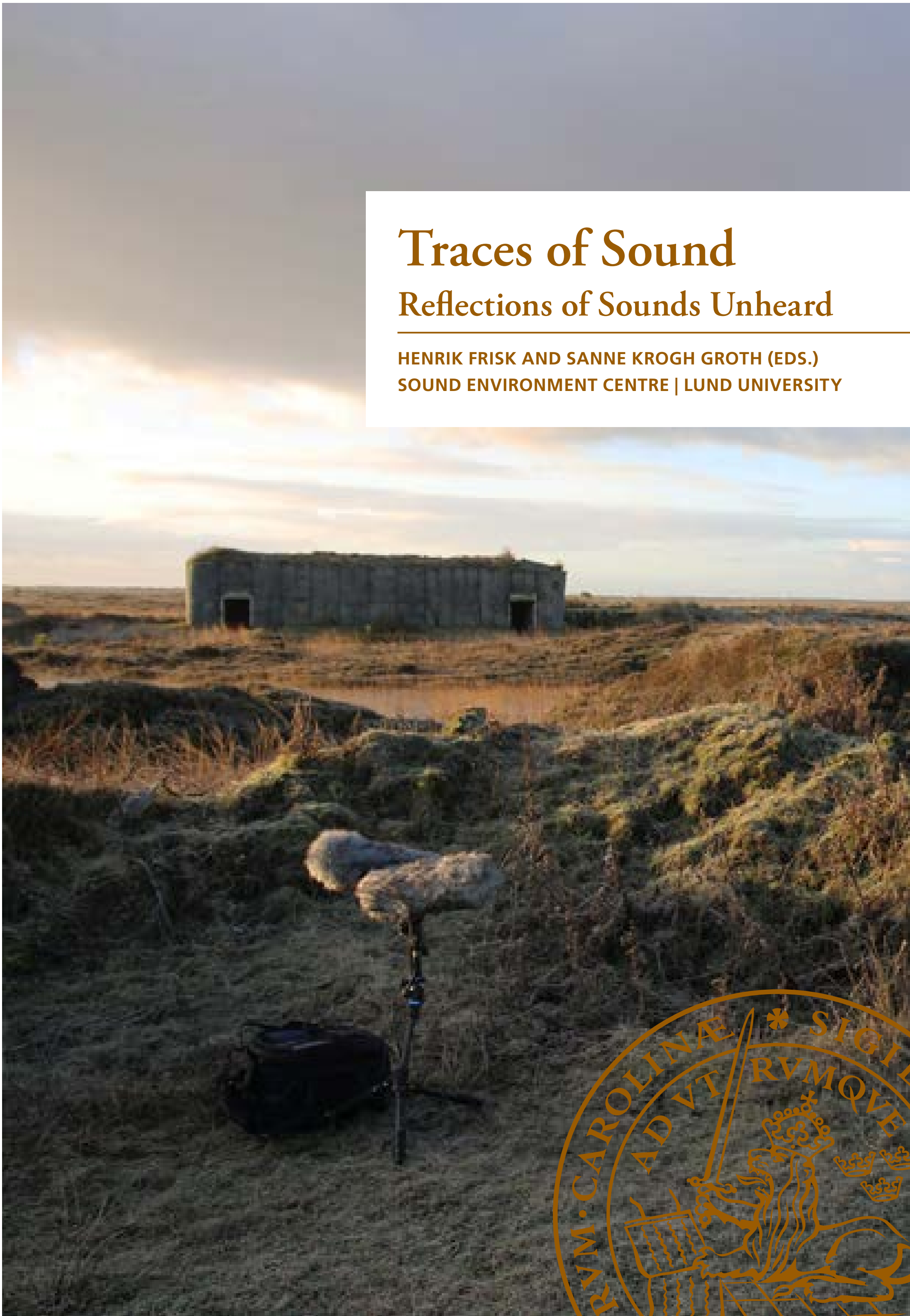
Traces of Sound

Reflections of Sounds Unheard

HENRIK FRISK AND SANNE KROGH GROTH (EDS.)
SOUND ENVIRONMENT CENTRE | LUND UNIVERSITY



What is sound when it is not heard? How does this unheard sound affect us? What might such sound reveal to us and how would we know? How do we recall sounds when their sources are no longer accessible? *Traces of Sound. Reflections of Sounds Unheard* invites scholars of music archaeology, German literature, media technology, sound art, human perception and theoretical physics to reflect upon these questions from their various positions within the broad field of sound studies. The contributors' answers, empirical material and methods are highly diverse, but they share interests in sounds that are not necessarily heard, how these sounds can be traced, and what stories they might tell. The book is an outcome of the symposium *Spår av Ljud* (Traces of Sound), organized on the occasion of The Swedish Royal Academy of Music's 250th anniversary in 2021.

Printed by Media-Tryck, Lund 2024 NORDIC SWAN ECOLABEL 3041 0903

LUND UNIVERSITY

Publications from the
Sound Environment Centre
at Lund University
No. 20
ISBN 978-91-89874-19-0
ISSN 1653-9354

TRACES OF SOUND

Traces of Sound

Reflections of Sounds Unheard

Henrik Frisk and Sanne Krogh Groth (eds.)

Lund University

PUBLICATIONS FROM THE
SOUND ENVIRONMENT CENTRE
AT LUND UNIVERSITY REPORT NO. 20

This publication can be ordered through Lund University at:
https://www.ht.lu.se/serie/ljud. Email: skriftserier@ht.lu.se

Cover photo by Jacob Kirkegaard from a field recording
for his work Crossfire (2022).

Publications from the Sound Environment Centre
at Lund University No. 20
ISBN 978-91-89874-19-0 (tryck)
978-91-89874-20-6 (digital)
DOI https://doi.org/10.37852/oblu.255
ISSN 1653-9354

Typesetting by Gunilla Albertén, Media-Tryck, Lund University
Printed in Sweden by Media-Tryck, Lund University, Lund 2024

Nordic Swan Ecolabel 3041 0903

Contents

Biographies

Henrik Frisk is an active performer and composer of improvised and contemporary music and a professor at the Royal College of Music in Stockholm. Henrik has performed in many countries in Europe, North America, and Asia, and as a composer he has received commissions from many institutions and appears on numerous recordings available on American, Canadian, Swedish and Danish record labels.

Sanne Krogh Groth is associate professor of Musicology and office director of the Sound Environment Centre, Lund University, Sweden. She is editor-in-chief of Seismograf Peer. She has an educational background in musicology and theatre studies from the University of Copenhagen, Denmark. Her current research is field based and concerns noise and experimental music in Java, Indonesia.

Markus Huss is associate professor of German at the Department of Slavic and Baltic languages, Finnish, Dutch and German at Stockholm University. He has published on literary multilingualism, intermediality and multimodality, the relationship between historiography and literature, German and Swedish postwar literature and exile literature.

Jacob Kirkegaard is a Danish artist sound with an MA from the Academy of Media Arts in Cologne. The core element and method of Jacob Kirkegaard's work derive from the use of sound recordings of the tangible aspects from its intangible themes. His work is presented throughout the world, including MoMA (New York), Louisiana Museum of Modern Art and ARoS (DK) and at the Rothko Chapel (Houston).

Cajsa S. Lund is considered one of the pioneers, also internationally, in the interdisciplinary field of Music Archeology with a particular focus on Nordic prehistory. She is currently affiliated with Linnaeus University. Cajsa S. Lund is recognized and awarded for her ability to bring her research results to life for the public, both for children and adults.

Thomas Lund has authored papers on human perception, spatialisation, loudness, sound exposure and true-peak level. He is researcher at Genelec OY, and convenor of a working group under the European Comission. Out of a medical background, Thomas previously served in healthcare and as CTO at TC Electronic, where he first studied the sensation of space and auditory envelopment.

Leif Lönnblad is a professor of Theoretical Physics at Lund University. His research is mainly focused on understanding high energy particle collisions, such as those studied experimentally at the Large Hadron Collider at CERN in Geneva. His speciality is the detailed modelling and simulation of particle collisions at current and future experiments.

Sandra Pauletto is associate professor of Media Technology at KTH Royal Institute of Technology, Sweden. Her research encompasses sound and music computing, media production and sound design. Currently she leads three research projects: Sound for Energy (Swedish Energy Agency), Personalizing Sonic Interactions (Swedish Research Council), and she is the Swedish lead for the Lullabyte EU Project.

Introduction to Traces of Sound: Reflections of Sounds Unheard

Sanne Krogh Groth & Henrik Frisk

> What is sound when it is not heard?
> How does sound affect us?
> What can sound tell us?
> What may sound reveal?
> How would we know?
> And how do we recall the sound when its source is no longer accessible?

Even unheard sounds can be perceived and not only the ear hears sound, so does the body. The thing that constitutes sound, changes in air pressure, happens obviously also when we cannot hear it, and even if we listen, we may not hear it. From a physical point of view there is little difference between the frequencies that fall outside the audible range and those that fall within it; both are functions of changes in air pressure. Sounds that have not yet been heard, those that are imagined, and those that have long been silenced are all part of our listening, and perceptually are as real as physical sound.

Drawing a line between heard and unheard sound is difficult, and debates within the fields of sound art and music have also moved away from it. Sound is simply more than merely its audible properties. Sound can be a potentiality or a method. Sound can be significant of something past or something not yet realized. It can be an embodied

https://doi.org/10.37852/oblu.255.c608

experience, physical beyond the meaning of the physicality of the sound waves, and it can be a reaction of the autonomic nervous system.

The questions that open this essay were put to the contributors to the book, and we asked them to reflect on them in their essays. The authors come from a wide range of different academic disciplines, but they all have in common that they work with sounds that are not immediately audible to humans. Thus this is a book about music archaeology's interest in ancient music-making and its investigation of the silent traces it has left. About laboratory work and auditory envelopment—how the human brain experiences reverb. About theoretical physics' use of sound as a measurement of the universe's smallest and largest units. About imagining the sounds that could appear from the cracks of a human skull. About how manipulated sounds can conjure up the past, as if it were present in the sounds being played. And about how the art of unheard sounds in specific places can invite new reflections.

With this in mind, we are interested in how different notions of sound depend on epistemological and even ontological perspectives; how these perspectives are presented and what effect sound has on us; and what stories and information are derived from or added to the material, and what the methods in doing so are.

All the essays were first presented at the online symposium *Spår av Ljud (Traces of Sound)* in 2021, held in Lund in Sweden. The symposium papers and sounds were recorded, edited, and uploaded to the Lund University Sound Environment Centre's official YouTube channel, and much revised versions are published in this book. This virtual online, yet highly situated, symposium was a more elaborate version of the many online symposiums we organized and attended during the pandemic, when the demands of distance, isolation, and limited numbers gave extra weight to video and streaming technologies, substitutions for the shared spaces we once took for granted. What came with it were mediatised settings and high-quality recordings, carefully documenting what was said and performed, leaving the traces of what evolved into the volume *Traces of Sound*.

The idea for the symposium came from Fredrik Wetterqvist, the permanent secretary at the Royal Swedish Academy of Music (KMA), who contacted us and asked if we would join the celebrations of the Academy's 250th anniversary by looking at the work of Cajsa S. Lund. Lund in 2019 had received the KMA's medal for her work on music archaeology, which the KMA itself had supported in its early years. The KMA has not only played a role in media archaeology, but was also an important partner in the 1990s debate about sound environments, eventually helping establish the Lund University Sound Environment Centre in 2005. The first time Lund presented her research at the centre was shortly after it opened at a symposium in 2007 (Mossberg 2008).

The book opens with Lund's survey of her 50 years of work with sound archaeology and prehistoric musical instruments. She revisits her engagement with prehistoric instruments and provides insight to today's imaginations of prehistoric listening to auditory landscapes and surroundings. Cajsa S. Lund is an institution, having pioneered the field and inspired both researchers and artists. At an art exhibition at Charlottenborg in Copenhagen in 2012, the Scottish artist Ruth Ewan's installation *The People's Instruments*, which included a piano being sacrificed in a pond, Lund's voice was quite literally present, as she appeared as interviewee in a poetic video installation. Though long retired, Lund is still active researcher. She is one of the research leaders of the European Music Archaeology Project, which is an offshoot of the Study Group on Music Archaeology of the ICTMD, a UNESCO body.

Building on Lund's fascinating work, we the editors have cast our net wide to include researchers and artists working in related areas. How do other fields trace sounds that cannot be heard? Markus Huss is an associate professor of German literature at Stockholm University. In his essay, he speculates on the traces of sound that could be caused by a needle 'playing' a skull's coronal suture. He concentrates on a contemporary piece of music, 'Primal Sound', based on data sonification of the skull of an unknown Victorian woman. The title is a direct reference to the German poet Rainer Maria Rilke's essay Ur-*Geräusch* of 1919. Rilke reflected on his schooldays, when he was introduced to the phonograph and sound recordings with a needle on a wax cylinder. Rilke speculated what the sound would be if a phonograph needle instead played the cracks in a skull. 'What would happen?' he asked. 'A sound would necessarily result, a series of sounds, music'. Huss meditates on what such peculiar sounds could tell us—and what would be missing—as Rilke's reflections found their way into media archaeological and archaeoacoustical contexts.

Sandra Pauletto is an associate professor of media technology at the Royal Institute of Technology in Stockholm. 'Sound is a trace, a ghost, a signifier of feeling' she writes. 'It tells us about the past, the present, and the future; it is contingent and transient; it lives inside and outside our bodies'. With this, Pauletto sums up a debate that has kept musicologists and sound theorists busy for half a century, ever since Pierre Schaeffer coined the concept of the sound object. With a close analysis of the production and use of sound in films and documentaries, the article argues that objectifying sound is highly questionable, as the nature of sound in these settings is too ambiguous to capture as an unambiguous unity.

Jacob Kirkegaard is an artist who has dedicated his career to making the inaudible audible. In works such as *Testimonium*, inspired by the sound of rubbish burning or decomposing in huge waste plants in Ethiopia and other places, and *Melt*, inspired by the sound of ice melting, he creates sound worlds from things we as listeners did not even know existed. Even if we knew that ice melting made a sound, his special technique of putting sensors on key objects creates a particular sound world where sounds pop out of their environment and create a world of their own. In an interview, he considers his role in this process. Since works such as *Aion*, recorded in Ukraine before the war, may seem to have a political undertone, this was a topic of discussion.

Thomas Lund, a researcher associated with the Finnish loudspeaker manufacturer Genelec, enlarges on the subject of auditory envelopment, something of great interest in the field of acoustical engineering. The brain, through efferent nerve fibres, communicates with and changes the auditory system for reception, which plays a role in all kinds of listening, but also in the ways in which we feel satisfaction because of certain stimuli. Auditory envelopment can be described as a positive response to a particular listening activity, specifically indoors. When the sound is reflected from the walls, ceiling, and floor of a hall, the reverb effect created promotes a sense of envelopment in the listener. The practice of performing music in indoor spaces that can create this envelopment is thousands of years old and is observed in musical practices in caves, churches, and every kind of manmade space. The text includes the results of a survey of both trained listeners and children, studying an emerging sense of envelopment.

The final contribution is an abridgement of the paper by Leif Lönnblad, a professor of theoretical physics at Lund University, given at the seminar in Lund, in which he explains in layman's terms how the universe was created, what quantum field theory is, the Large Hadron Collider at CERN and its part in the history of the Higgs particle. He explains the nature of sound in space and how we can listen to the universe, concentrating on the process of two enormous black holes collapsing in on each other to generate unimaginable amounts of energy as gravitational waves. Such waves were detected in 2015 and their waveform was actually in the audible range. It is possible for us to hear collapsing black holes.

Sound is more than what we hear, and everything we hear is not what we ordinarily think of as sound. The interrelation between the sound source, our listening and our perception of it has long been our focus. From the metaphysics of the early Enlightenment, when perception was everything, to the phenomenologically inspired theories of reduced listening by Pierre Schaeffer in the 1950s, when what mattered was the sound object, sound is far more than what we might first think. Sound exists far away in the universe and isolated inside our minds where it is disconnected in both space and time. It can tell us something about what happened, how, and where, but one of the most powerful sound producers may still be our minds. We can imagine the sound of a found archaeological object by sensing its shape and material, or a sound that is the reflection of a needle on a skull. Sandra Pauletto tells us that sound can be something too ambiguous to be understood as an object, too volatile to be captured. We may also imagine an object from an unknown sound, such as in Jacob Kirkegaard's works, or imagine a safe place through the sensation of envelopment. Finally, we may experience physical processes that are almost unimaginable in size and impact through a tiny sound recorded billions of light years after the event.

Taking the essays in this book to their logical conclusion, we would argue we all need traces of sound if we are to understand the world. Sound is omnipresent and easy to take for granted, but however cursorily we listen to it there is so much more to be heard and understood. The epistemological capacity of listening has been discussed in several disciplines (Kvicalova et al. 2019, Gautier 2015, Bijsterveld 2019) and several contributors to this book point to the connection between sound, listening, and knowledge. To listen is to know and to know is to hear.

Traces of sounds are everywhere, and objects revealed through sound are repeatedly created and recreated. We are constantly affected by sound, and it carries continual information about our environment, close by and far away. Life is all about sound. Even if we do not hear it.

References

Bijsterveld, K. (2019), *Sonic skills: Listening for knowledge in science, medicine and engineering (1920s–present)* (London: Palgrave Macmillan).

Gautier, A. (2015), *Aurality: Listening and knowledge in nineteenth-century Colombia* (Durham, NC: Duke University Press).

Kvicalova, A. (2019), *Listening and knowledge in Reformation Europe: Hearing, speaking and remembering in Calvin's Geneva* (Cham: Springer).

Mossberg, F. (2008) (ed.), *Sounds of history* (Lund: Sound Environment Centre, Lund University).

The Sound of Archaeology: In Honour of the Royal Swedish Academy of Music

Cajsa S. Lund

An inaudible prologue

The year is 2007. A unique music-archaeological band, Heimdalls Borduner, was invited to perform in Malmö at Sweden's major international festival of contemporary music, Sound Around.[1] Heimdalls Borduner combine art and knowledge, improvising timeless sound events with prehistoric sound tools, but also with raw materials such as branches, sticks, logs, stones, bones, nutshells, and animal skins. The message is provocative: that we really do not know anything about the music created in prehistory. The inspiration comes from composers such as Edgar Varèse (1883–1965), Luigi Russolo (1885–1947), John Cage (1912–1992) and R. Murray Schafer (1933–2021).

The performance in Malmö ended with a solo on a fox fur, the performer slowly pulling his hand along the fur several times. It was inaudible. It was quiet in the hall when the performer stopped playing the fox fur. There was no applause. Then suddenly a composer present in the hall stood up and whispered to the audience, 'Silent music. Inaudible. You hear what you want to hear.'

1 The person in charge of the festival was Peter Wilgotsson, today the CEO of the Swedish regional music foundation Östgötamusiken.

https://doi.org/10.37852/oblu.255.c609

The sounds of Nordic prehistory

As a music archaeologist, I am interested in societies with little or no written language, meaning prehistory. Nordic prehistory comprises about 13,000 years or some 390 generations. This is a short prehistory in a pan-European perspective and a drop in the ocean in a global perspective, which is measured in millions of years and billions of people, or at least human-like creatures. Nordic prehistory is customarily divided according to the three-period system: the Stone Age (12,000–1700 BC), the Bronze Age (1700–500 BC), and the Iron Age (500 BC–AD 1100). The final phase of Nordic prehistory, from AD 750–1100, is called the Viking Age. The boundary between prehistoric times and the Middle Ages is naturally flexible. Archaeological practice places it today at AD 1100 for southern Scandinavia, but it occurs later the further north we are. The continental Middle Ages, meanwhile, are usually considered to begin with the fall of the Western Roman Empire in AD 476.

There are several constituent fields of music-archaeological research in the Nordic countries (Fig. 1). How did prehistoric humans relate to the sounds made by other living organisms, that is, the rest of the animal kingdom and vegetation? How did they listen? Listening habits of course depend on the availability of sounds in the environment, but the meanings we attribute to them determine how we hear. It was important in prehistoric times—sometimes perhaps a matter of life or death—to recognize different animal sounds, to hear where the hunting pray was and from where predators threatened. Equally important were the sounds of the weather such as wind, rain, and thunder.[2]

What sounds did people themselves create, intentionally and unintentionally (Fig. 1)? In the latter category were the sounds of human activities, such as the rasp of scraping tools against animal hides, flint

2 Compare soundscape ecology, the study of the relationships between the sources of sound comprising a soundscape. As coined by Bernie Krause 2002, sounds generated by non-human living organisms are referred to as the biophony; those from non-biological natural categories are the geophony; and those produced by humans are the anthropophony. See also Kolltveit 2014, 73–84.

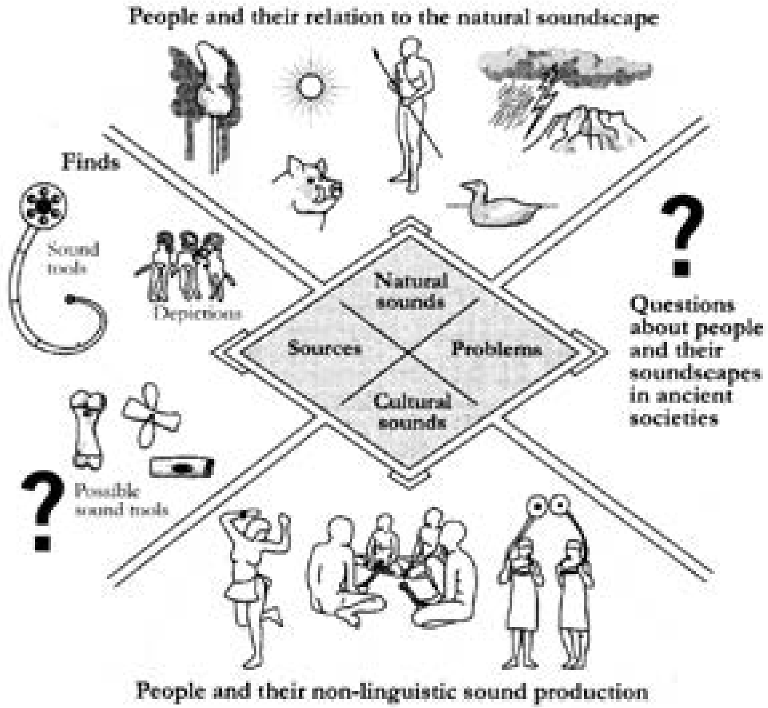


FIGURE 1. Music–archaeological research in the Nordic countries. Model by Cajsa S. Lund

knapping, shooting arrows, axe blows, a blacksmith working iron, or scythes cutting grass and corn. I think it safe to assume that, like us, unintentional sounds were mostly part of a background of natural, ordinary sounds for our prehistoric ancestors. However, some unintentional sounds may at times have been deliberately used, reinforced, and structured. Thus, the thump of stone axes, hoes, and horn hammers may have been synchronized in regular patterns that regulated a working rhythm and kept the work going. Work sounds of this kind were probably also further enhanced with rhythmic shouts and songs to help with heavy, time-consuming work such as rowing or prying loose heavy boulders. Take a custom known from late peasant society in southern Sweden, Denmark, and Ireland: horse skulls were buried in barns under the threshing floors for acoustic reasons, to amplify the sound so the threshers could coordinate what was usually collective threshing work (Egardt 1950, 149–60) in something reminiscent of sound pots in medieval churches (for example, Valière et al. 2013, 70–81; Brycki 2018).

The key question in the field addresses an all-embracing issue (Fig. 1): how to arrive at an understanding of the nature of the soundscapes and their changes, uses, and functions in prehistoric societies? It may seem almost utopian to try to answer questions of this sort. But music archaeology has a responsibility to see to it that such questions are posed and must also be responsible for tackling them. The central concept, soundscape, was coined in 1977 by the composer and academic R. Murray Schafer. Soundscapes, according to Schafer, refer to the entire acoustic environment, including natural sounds such as animals or wind and rain, as well as humans. His concept includes not only environments, however, but also perception: how people hear, perceive, process, and interpret sounds.

If we are to achieve any useful research results about intentional soundscapes and our human ancestors' music, whether Early Stone Age hunters, fishermen, and gatherers or the inhabitants of the Viking Age villages, we must go beyond the musical concepts and terms of our own time and culture. I, for example, prefer to use the term sound tool or sound instrument for the objects people used in prehistoric times to produce sound. True, there are no clear dividing lines between sound production and music, or indeed sound tool and musical instrument; however, there is always a place for pragmatism, so there will be times I call a lyre a musical instrument and not a sound tool, if only to be able to communicate with other archaeologists and the general public.

Potsherds, plow furrows, flint axes, and other traces of prehistoric work processes are all silent traces of lost soundscapes (Fig. 1). The main sources for Nordic music archaeology, though, are intact or fragmentary finds of musical instruments and other sound tools or their images—the material traces of presumed sounds. A specific and enigmatic type of instrument that has been found in large numbers in southern Scandinavia since the first find in 1797 is the bronze lur (Fig. 2).

FIGURE 2 Bronze lurs found in the Brudevaelte Mose bog in Denmark. Late Bronze Age (700 BC), length c.220 cm. Photo National Museum, Copenhagen.

First steps in music archaeology

The first music archaeology was done in Sweden in the 1970s and worked on the hypothesis that the archaeological collections and magazines held traces of prehistoric sounds in the form of sound tools that had been overlooked, uninterpreted, or misinterpreted. The belief was that traces of sound lay hidden in objects used for various socially beneficial sound productions, for example, signalling, decoy hunting, in rites, magic, and children's games (Lund 2019, 6). The primary method was to track the use and function of traditional sound tools in the Nordic countries as far back as possible.

This ethno-music-archaeological approach promised new interpretations of archaeological finds. On the initiative of what is now the Swedish Museum of Performing Arts in Stockholm, inventories of archaeological collections across Sweden were carried out, funded by Riksbankens Jubileumsfond between 1975 and 1980 and sporadically thereafter. They were supplemented by surveys of collections in other Nordic countries (see Reimers 1977, 67–8; Lund 2010, 186–7). Music archaeology in Sweden, which like the rest of Europe was then in its infancy, thus had the unique opportunity, albeit with a time limit, to

FIGURE 3 Green instruments. Photo Annemies Tamboer.

systematically collect data from archaeological collections. Music archaeologists were—and are—digging into already excavated material to register all kinds of potential sound tools. To date, roughly 1,000 confirmed or possible sound tools from Nordic prehistory have been documented. Compared to the amount of other types of archaeological finds, the surviving sound tools are few in number. Qualitatively, however, Nordic music archaeology has access to an outstanding source material, namely two homogeneous groups of specific sound instruments: 250 *rangler* (Norwegian Viking Age iron rattles) (Lund 2019, 91–128) and 60 bronze lurs (South Scandinavian Bronze-Age S-shaped horns) (Lund 1986) (see Fig. 2).

Many sound tools remain hidden in the ground, of course. From time to time there are reports from field archaeologists that a sound instrument has been found. Future excavations will doubtless result in even more finds. Due to the composition of the soil, some bone and wooden sound instruments will have been destroyed over time, but

FIGURE 4 Hollow tube with beveled ends made from a bird bone, found in a cave on the island of Gotland, Sweden. How it was used is unknown, but it can easily be blown as a whistle (Lund 1984/1991, track 9). Late Stone Age (2500 BC), length 8 cm. Photo S. Hallgren.

above all it is likely that most prehistoric sound tools were lost at the time they were manufactured and used, namely those made of plant parts and other perishable materials such as flutes and pipes of sallow, reed, or bark, or blowing on dandelion stalks, leaves, and straws of grass and other types of spontaneous instruments made for the day—what I call green music (Fig. 3) or the sounding herbarium (Lund 2018, 47–9).

On the other hand, maybe our prehistoric ancestors did not use many specially designed sound instruments. Instead, several objects may have had double functions. The metal shield was struck for the sake of sound, a hunting bow could be used as a stringed instrument, and a bone tube (Fig. 4) may primarily have been, for example, a bead, an amulet, a shaft or a needle case, but was perhaps sometimes also used as a whistle. It should not be forgotten, however, that tool-based sound production and music-like activities may have mattered little to prehistoric Nordic people: their voices may have been the dominant means by which they created their non-lingual or language-enhancing sound worlds.

Prehistoric voices are forever lost to us. Although perhaps not, given that researchers have recently succeeded in recreating how a mummified priest in Egypt, Nesyamun, who died 3000 years ago, may have sounded (Fig. 5). His throat and vocal organs were fairly intact, and measured with a CT scan were used to construct a 3D-printed version of the mummy's vocal organs (Fig. 6), which was connected to an artificial larynx and a special loudspeaker. The resultant six-second sound

FIGURE 5 The mummified Egyptian priest Nesyamun. 1000 BC.
FIGURE 6 The parts of the throat of the mummy were measured with computed tomography and then a 3D-printed version of the mummy's vocal organs was created. https://www.bbc.com/news/world-middle-east-51223828. Accessed August 20, 2021.

is said to imitate a vowel as uttered by the priest three millennia ago (BBC 2020). However, the synthetic sound is far from a natural voice, and the researchers admit the accuracy is not perfect because the mummy's tongue has lost much of its volume.

There is also a fascinating hypothesis presented by Paul Åström (1929–2008), a classicist and professor of archaeology at the University of Gothenburg, known for his achievements in the prehistoric archaeology of Cyprus. He suggested that sounds from ancient pottery workshops could have been stored in the clay when turning pots, and that these sounds could be played back in a modern laboratory. This has not proved successful thus far, though in collaboration with an acoustics expert he did complete a scoping study (Kleiner & Åström 1993).

Probability groupings

I would categorize music-archaeological finds in the Nordic countries into five groups according to the probability they were used for sound production, whether primarily or secondarily—the probability groupings. Group 1 includes objects which were clearly sound tools, such as cow horns with finger holes, bells, and lyres. Others are possible sound tools, on a diminishing scale, so that Group 5 has objects with the smallest probability of being sound tools. The majority of the objects fall into Groups 2–5 (Lund 1981a, 247). At the same time, there is a problem with this approach: how best to substantiate, or at any rate corroborate, the assumption that a particular archaeological artefact, or a whole group of similar artefacts with unknown or unclear functions, was used for sound production, either primarily or secondarily? When verifying or rectifying the preliminary assignment of an object to one of the five groups—or wholly excluding it—I have drawn on a combination of theoretical and practical investigative methods, using all the archaeological data, analogy analyses, laboratory examinations, and practical experiments. The experiments include making substitutes or reproductions of the objects in question in order to test their possible methods of playing, tonal qualities, sounding ranges, and possible social uses.

From sound tool to multitool

The worked humerus of a swan was found in 1913 among the remnants of a fishing net near the town of Antrea in what was then Finnish Karelia (Fig. 7). Dated to 8500 BC, the hunter–gatherer Stone Age, it is an example of an object in Group 5, which after the results of an extensive, international research project was excluded as a possible sound tool following a detailed laboratory analysis (Fig. 8–9). One of the subprojects was to make substitutes or reproduction models of the swan bone as a possible instrument, in this case a tongue-and-lip duct flute—a recorder, but with the tongue or lip used as a block instead of an artificially made block (Fig. 10–11)—which was a relatively unknown type of flute, found mainly in Arctic areas (Lund 1981b, 106–109). The swan bone was also reconstructed as a reed instrument (the clarinet family) with a reed of birch bark (Fig. 12).

Various experiments with the models showed the wind instrument hypothesis could be abandoned, it being neither a flute nor a reed instrument, and the swan bone was probably not a sound instrument at all. It was more probably a multipurpose tool, perhaps used by people going fishing. According to extensive experiments, it may have been

FIGURE 7 The Antrea find, a worked swan bone. Stone Age (8500 BC). Photo K. Mannermaa.

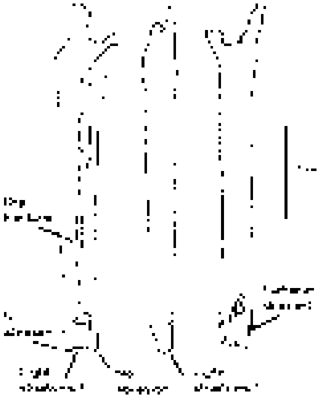


FIGURE 8 Notes on the laboratory analyses of the swan bone by the osteologist K. Mannermaa. Drawing K. Mannermaa.

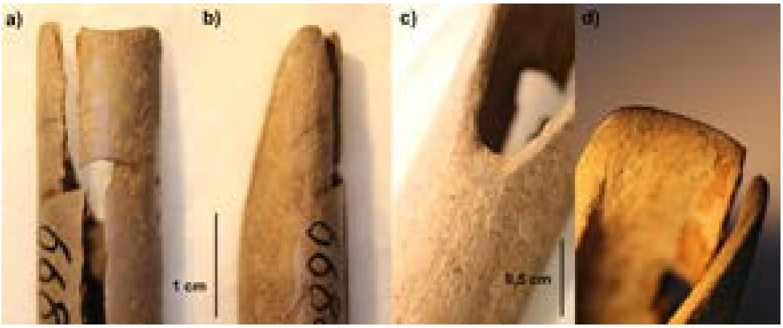


FIGURE 9 Detail of the swan bone. Photo K. Mannermaa.

FIGURE 10 The swan bone reconstructed as a tongue duct flute. Photo A. Lund Lavoipierre.

FIGURE 11 The reconstructed swan bone played as a tongue duct flute. Photo A. Lund Lavoipierre.

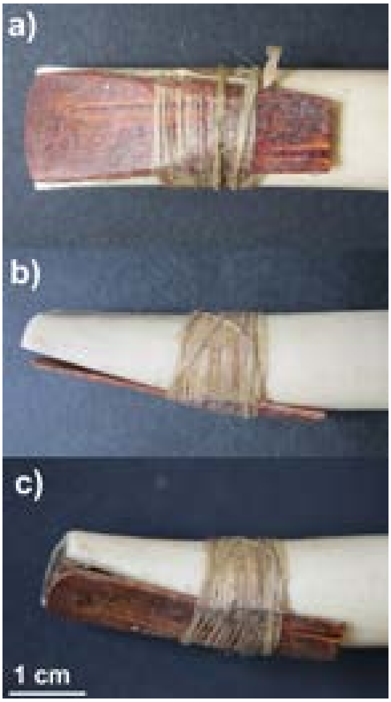


FIGURE 12 The swan bone reconstructed as a reed instrument with a birch bark reed. Photo R. Rainio.

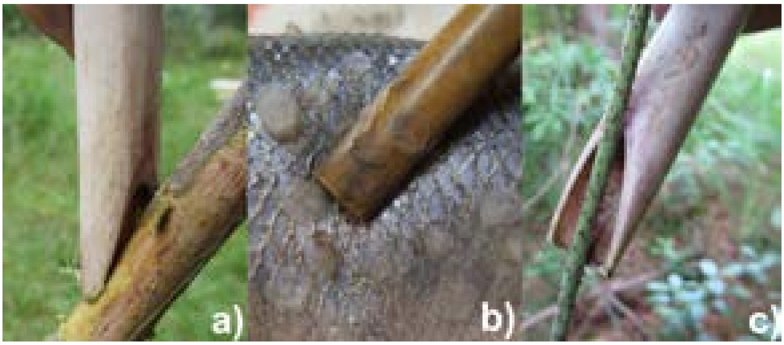


FIGURE 13 The swan bone reconstructed as a multitool for (a) peeling bark, (b) scaling fish, and (c) removing thorns. Photo R. Rainio.

used to peel bark, scale fish, remove thorns from raspberry bushes, or make and repair fishing nets (Fig. 13a–c). The thinning and sharpening of the edge of the original—seen on the models after the scaling and peeling experiments—indicate those kinds of functions (Lund et al. 2015, 6–23).

A 7000-year-old soundscape

Archaeology today is a complex multidisciplinary science, which in addition to its own special research techniques also uses methods and findings from many other sciences, especially the natural sciences. The results of interdisciplinary investigations of the 7000-year-old hunter–gatherer Stone Age settlement of Skateholm on the Swedish south coast illustrate this. In a scientific analysis of charred plant remains and meal residues in the form of animal bones and the like, traces of 89 different animals have been found. House remains, hearths, objects made of flint, stone, bone, and horn and remnants from flint knapping shed light on which tools were manufactured there and the contexts where they were used. A probable fragment of a drumstick has been found, and several possible rattling sound tools in the form of pierced animal teeth. A large number of skeleton graves are an indication of their notions of death (Larsson 1984, 5–38).

In one of the skeleton graves, a woman was buried in a seated position with a baby on her hip, probably in a baby sling (it does not survive, but there are traces of red ochre) to which some 30 pierced animal teeth visible by her hip seem to have been attached (Fig. 14). The baby was perhaps newborn or stillborn—the woman may have died in childbirth. The baby sling, which was probably made of leather and coloured with red ochre, has been reconstructed in an extensive interdisciplinary project (Fig. 15), with one of the project researchers demonstrating how the woman in the grave was placed (Rainio & Tamboer 2018). The many pendants on the sling may have been purely decorative or intended to act as a rattle, whose subtle sound might have calmed the child. At the same time, the rattling sound may have served as a magical defence against evil forces.

FIGURE 14 Skeleton grave of a woman and baby at Skateholm in southern Sweden. Some 30 pierced animal teeth are visible at her hip, thought to have been attached to a baby sling. Stone Age (5000 BC). Photo L. Larsson.

FIGURE 15 Reconstruction of the Skateholm skeleton grave showing the baby sling. Photo R. Rainio.

It is possible to put together a detailed picture of how that coastal Stone Age society in southern Scandinavia about 7000 years ago functioned socio-economically, how everyday life was lived, how death and burials were handled, how flora and fauna were shaped. And this picture gives clues as to how it may have sounded there, because the acoustic dimension, a possible soundscape, is within our hearing, evident in the artefacts and natural surroundings. R. Murray Schafer (1977) has given us the 'keynote sound', a sound that is more or less continual and forms a background that other sounds are heard against, and a tool for analysing and recreating all soundscapes, past and present. The sound of the sea in a coastal community is a prime example.

Pitfalls

There are pitfalls in any attempt to identify traces of sound and recreate an ancient soundscape. They were discussed in detail by me and music archaeologists when in the 1980s I was commissioned by the Musica Sveciae project, under the auspices of the Royal Swedish Academy of Music, to make a gramophone record with music and sounds from Swedish prehistory—a real challenge. I chose to create short probable sound milieus, scientifically based as far as possible, where I placed one or more reproductions of sound instruments. For example, an Iron Age cow bell was hung around the neck of a grazing cow in a pasture with other cows and was duly recorded (Lund 1984/1991, track 28).

A problem I raised with the palaeozoological experts was the breed of cows which we had the opportunity to record were not the same as the skeletal remains found in the same context as the bell. What did prehistoric cows really sound like?

Sound archaeology

The relevance of the term music archaeology, originally launched in Sweden, is nowadays debated. International colleagues (especially Rupert Till at Huddersfield University) advocate sound archaeology as the umbrella term, with music archaeology as one of several sub-disciplines. Other sub-disciplines include auditory archaeology, acoustic archaeology, archaeomusicology, palaeo-organology, and archaeo-organology (Till 2020, 31–53).[3] 'All music is sound, but not all sound is music,' says Till (40). What then is music? There is no unambiguous answer to that. Music, in the words of the Swedish musicologist Jan Ling (1983, 2), has become an almost unmanageable universal concept for various sound phenomena in time and space. Similarly, the relevance of the term for Nordic music archaeology has rightly been questioned by Sweden's musicologists and archaeologists. One reason is that I and others have been concerned with the why and what of the sounds prehistoric people may have deliberately organized, as well as the actual and potential objects they used to generate such sounds. Further, it was only in the sixteenth century that the word 'music' entered the Swedish language, taken from the Greek *mousiké*; there was no uniform concept nor delimiting term for 'music' in the oldest Nordic texts such as Snorri's Edda or the Icelandic Sagas (Nilsson 1994, 39). Music archaeology is still regarded by most researchers, and not least by the general public—both children and adults—as an exciting and appealing term, which also clearly states what the subject is.

An inaudible epilogue

Finally, some reflections from an ethno-music-archaeological perspective that pick up where the 'Inaudible prologue' left off. First, a rattle made of clay, found in a children's grave in Denmark and dated to the Early Iron Age, AD 200–400 (Fig. 16). As a confirmed sound tool it belongs in Group 1. There are several finds of prehistoric clay rattles in Europe, and in other continents, too (Eriksson 1960, 80–3; Sachs 1975,

3 Auditory archaeology seeks to identify and reconstruct the significance of hearing and mundane sounds (Mills 2001; 2005). Acoustic archaeology is the study of the acoustic properties of caves, chambers, churches, and other manmade or natural structures (Lawson et al. 1998; Devereux 2002; Scarre & Lawson 2006). Archaeomusicology is synonymous with music archaeology (see, for example, Lund 1981a). Palaeo-organology or archaeo-organology is the science of prehistoric musical instruments, organology being the science of musical instruments and their classification. See also Kolltveit 2014.

FIGURE 16 Clay rattle found in a child's grave in the Vendsyssel region, Denmark. Early Iron Age (AD 200–400), length 8 cm. Photo A. Lund Lavoipierre.

146; Both 2018, 42–3). On the basis of ethnomusicological and ethnographic knowledge, the general hypothesis is that rattles in ancient children's graves were not placed there as toys in the first instance, but instead they primarily had a magical function, protecting the children from evil forces (much like the baby sling found at Skateholm). Rattling sound tools in most parts of the world are used for apotropaic purposes in natural folk contexts, for example by shamans and medicine men (Eriksson 1960, 72–83). Particularly interesting was the information given to me in the 1970s that for generations small children in western Skåne, Sweden's southernmost county, had a clay rattle placed in their cradle or under their mattress to keep away evil—but the rattle would not make a sound and had to be inaudible for the children (Lund 1985, 23).[4] As recently as the early twentieth century, a couple of silver bells hung in the window frame of the nursery in the academic home in Lund where the professor of archaeology Carl-Axel Moberg (1915–1987) grew up. They too were there to protect the Moberg children from evil forces, but not by rattling. On the contrary, the rattles were meant to be silent. Just the fact that there were

4 Cf. Eriksson 1960, 77–8 for the use and function of traditional children's rattles in Sweden.

FIGURE 17 Hollow clay bird with a large hole in the forehead found in a grave at Bjerkreim, near Sandnes in Norway. Early Iron Age (AD 400), width c.18 cm. Photo Museum Stavanger.

rattling sound tools in the room, although inaudible, was enough to protect the children.[5]

A hollow, bird-shaped figure with a large hole in its forehead made of clay was found in a grave near Sandnes on the south-west coast of Norway (Fig. 17). It dates to the Early Iron Age, around AD 400. In the 1970s I studied this object at Museum Stavanger, where it was catalogued as a bird-shaped goblet or a vase (which if nothing else raised questions about the shape of Norwegian vases). Yet it can easily be blown as a flute, like blowing a glass bottle, which evidently no archaeologist in Norway had thought to do. The object was documented by me as a possible sound tool, in Group 5—a distant possibility (Lund 2019, 157–73). Since the Middle Ages, Norway's production of clay cuckoos was located in Sandnes, not far from Stavanger, because of the access to the right sort of clay. Even the Norwegian name for the clay cuckoos is *Sandnesgauk*. Could the Iron Age bird figure be its forerunner? I spent a long time in Sandnes and studied the clay

5 Personal information by C.-A. Moberg to the author in 1980.

cuckoo tradition there. It emerged there was a local tradition stretching back generations that the oldest woman in certain families wore a small Sandnesgauk on a necklace or kept one in a purse or pocket to ward off evil. It was not to be blown, not used, it just existed—it was about sound, but it would not be heard. When the woman died, she took her clay bird with her to the grave and the next oldest woman in the family received her magical *Sandnesgauk* (Lund 2019, 164–5).

Most people are familiar with buzzers of various kinds, for example in the form of a button threaded on a string. In 1980, I met an 80-year-old woman, born and raised in the fishing village Råå in Skåne, who told me she made buzzers out of oyster shells as a child (Fig. 18). She also told me her grandmother had taught her, who had learnt it from her great-grandmother. We are then almost in the eighteenth century. And it was on the women's side the tradition was practised and passed down. What the women told their grandchildren and great-grandchildren was to use an oyster-shell buzzer at the sea's edge, alone, and not

FIGURE 18 Traditional oyster shell buzzer from Råå in southern Sweden. Photo A. Lund Lavoipierre.

as a sound toy nor to hear the sound, which is almost inaudible. It would be heard only by a sea monster such as a mermaid; such creatures could hear and understand even inaudible sounds. A buzzer was an auspicious mode of communication with a dangerous mermaid (Lund 1985, 23).

'A mermaid hears what she wants to hear',
as the old woman said to me.

References

BBC (2020), 'Mummy returns: Voice of 3,000-year-old Egyptian priest brought to life', *BBC News*, 24 Jan. www.bbc.com/news/world-middle-east–51223828.

Both, A. (2018), 'Sounding Clay: Horns, Rattles, Flutes and Drums in the Neolithic', in De Angeli et al. 2018.

Brycki, M. (2018), 'Efterklangstid och ljudkrukor i Dalby kyrka' (MA diss., Linnaeus University, Växjö, Sweden).

De Angeli, S., et al. (2018) (eds), *Music and Sounds in Ancient Europe: Contributions from the European Music Archaeological Project* (Rome: Regione Lazio).

Devereux, P. (2002), *Stone Age Soundtracks. The Acoustic Archaeology of Ancient Sites* (London: Vega).

Egardt, B. (1950), 'Problem kring hästskallar', *RIG Kulturhistorisk Tidskrift* 33/4, 140–60.

Eriksson, G. (1960), 'Skallror', in *Kulturen: En Årsbok* (Lund: Kulturhistoriska Föreningen).

Kleiner, M. & P. Åström. (1993), 'The Brittle Sound of Ceramics: Can Vases Speak?', *Archaeology & Natural Science* 1, 66–72.

Kolltveit, G. (2014), 'Classification of Sound, Sound Tools, and Soundscapes', in A.-K. Salmi, T. Äikäs & J. Ikäheimo (eds.) *Sounds Like Theory* (Monographs 2; Helsinki: Archaeological Society of Finland).

Krause, B. (2002), *Wild Soundscapes: Discovering the Voice of the Natural World* (Berkeley: Wilderness).

Larsson, L. (1984), 'The Skateholm Project: A Late Mesolithic Settlement and Cemetery Complex at a Southern Swedish Bay', *Meddelanden från Lunds Universitets Historiska Museum* 5, 5–38.

Lawson, G., C. Scarre, I. Cross & C. Hills. (1998), 'Mounds, Megaliths, Music and Mind: Some Thoughts on the Acoustical Properties and Purposes of Archaeological Spaces', *Archaeological Review from Cambridge* 15(1), 111–34.

Ling, J. (1983), *Europas musikhistoria*: 1730 (Uppsala: Esselte Studium).

Lund, C. S. (1981a), 'The archaeomusicology of Scandinavia', *World Archaeology* 12(3), 246–65.

Lund, C. S. (1981b), 'A Medieval Tongue- (Lip-) and-Duct Flute', *Galpin Society Journal* 34, 106–109.

Lund, C. S. (1984/1991), *Fornnordiska klanger/The Sounds of Prehistoric Scandinavia* (Musica Sveciae MS101; Stockholm: Swedish EMI) [LP booklet]. (Reissued in 1991 on CD as MSCD101.)

Lund, C. S. (1985), 'Kinderklanggeräte und Musikarchäologie', *Studia Instrumentorum Musicae Popularis* 10, 18–23.

Lund, C. S. (1986), 'The Phenomenal Bronze Lurs', in ead. (ed.), *The Bronze Lurs* (Stockholm: Royal Swedish Academy of Music).

Lund, C. S. (2010), 'Music Archaeology in Scandinavia, 1800–1990', in Sam Mirelman (ed.), *The Historiography of Music in Global Perspective* (Piscataway, NJ: Gorgias Press).

Lund, C. S., K. Mannermaa, R. Rainio, J.-L. Ringot & A. Tamboer (2015), 'Sound Tool or a Fisherman's Tool? An Experimental Approach to the Mesolithic Bird Bone Artefact from the "Antrea Net Find"', *Finskt Museum*, 2013–2015 120, 6–23.

Lund, C. S. (2018), 'Green Instruments. The Sounding Herbarium', in De Angeli et al. 2018.

Lund, C. S. (2019), *Music Archaeology in a Nordic Perspective* (rev edn, Lund: Lund University Media-Tryck).

Mills, S. (2001), 'The significance of sound in fifth millennium BC Southern Romania: Auditory archaeology in the Teleorman river valley' (PhD thesis, University of Wales, Cardiff).

Mills, S. (2005), 'Sensing the Place: Sounds and Landscape Archaeology', in Douglass W. Bailey (ed.), *(Un)settling the Neolithic* (Oxford: Oxbow).

Nilsson, A.-M. (1994), 'Bakgrunden till medeltidens musik', in Leif Jonsson, A.-M. Nilsson & G. Andersson (eds), *Musiken i Sverige*, i: *Från forntid till stormaktstidens slut* (Stockholm: Fischer).

Rainio, R. & A. Tamboer (2018), 'Animal Teeth in a Late Mesolithic Woman's Grave, Reconstructed as a Rattling Ornament on a Baby Pouch', *EXARC Journal* 1. exarc.net/ark:/88735/10333

Reimers, C. (1977), 'Riksinventeringen och musikarkeologin', *Artes: Tidskrift för Litteratur, Konst & Musik* 2, 67–8.

Sachs, C. (1975), *Geist und Werden der Musikinstrumente* (Buren: Frits Knuf) (first pub. Berlin 1929).

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

Schafer, R. M. (1977), *The Tuning of the World* (New York: Alfred A. Knopf).

Till, R. (2020), 'Sound Archaeology and the Soundscape', in G. Kolltveit & R. Rainio (eds), *The Archaeology of Sounds, Acoustics and Music: Studies in Honour of Cajsa S. Lund* (Berlin: EKHO).

Valière, J-C., B. Palazzo-Bertholon, J-D. Polack & P. Carvalho (2013), 'Acoustic Pots in Ancient and Medieval Buildings: Literary Analysis of Ancient Texts and Comparison with Recent Observations in French Churches', *Acta Acustica & Acustica* 99, 70–81.

Wikipedia contributors (2021), *Soundscape ecology*, in Wikipedia, The Free Encyclopedia, 18 Aug., accessed 20 Aug. 2021. w.wiki/8wHR

Unforgotten Grooves: Reading and Listening to Rainer Maria Rilke's 'Primal Sound'

Markus Huss

> What the coronal suture yields upon replay is a primal sound without a name, a music without notation, a sound even more strange than any incantation for the dead for which the skull could have been used. (Kittler 1999, 44–45)

The first track of the 2011 album *Hidden Music: Sonic translations of the biological world* by the composer and scholar Milton Mermikides is called 'Primal Sound'. In his description of this compositional project in 'data sonification', Mermikides said the track was 'inspired by Rilke's 1919 Ur-Geräusch', referring to a short essay published 92 years earlier in the literary magazine *Das Inselschiff* by the Austrian poet Rainer Maria Rilke (1919). The track puts an experimental suggestion by Rilke into artistic practice, converting 'the contour of the coronal suture into musical data' (Mermikides 2011).[1] In a key passage of the essay, quoted by Mermikides, Rilke speculated on what would happen if a phonographic needle were placed in a 'naturally' occurring groove:

> What if one changed the needle and directed it on its return journey along a tracing which was not derived from the graphic translation of

1 A coronal suture is 'an arching line that separates the frontal bone from the two parietal bones, on the sides of the cranium' (Britannica 2020). See Fig. 1.

https://doi.org/10.37852/oblu.255.c610

> sound but existed of itself naturally—well, to put it plainly, along the coronal suture, for example. What would happen? A sound would necessarily result, a series of sounds, music. (Rilke 1919, quoted in Kittler 1999, 40–41)

Hidden Music is available online along with brief descriptions of the compositional method behind each track. According to the notes for 'Primal Sound', its 'source material' is 'The coronal suture of the skull of an unknown Victorian woman', which has been 'translated directly using MAX/MSP and Jitter (a visual programming language) into amplitude, frequency, harmony, timbre, musical event and spatialization'; this 'audio-visual translation', as Mermikides (2011) calls it, was then recorded. The result is almost 15 minutes of atmospheric, varied, and immersive sound experience.

Mermikides' composition raises a host of thought-provoking questions of importance for a volume engaging with traces of sound, most notably how to conceptualize and theorize the process of the sonification–audification of 'naturally occurring' traces. If we accept 'audio-visual translation' as a description of what Mermikides is doing, what is it, then, that is actually being translated? How are we to understand the concept of translation from the vantage point of Rilke's thinking and Mermikides' composition, in light of historical and contemporary sonification–audification practices? To shed some light on these questions, I will revisit Rilke's 'Ur-Geräusch' essay and its historical context, along with the literature about the history of audification and the relationship between translation and sonification, the better to understand Mermikides' project in the light of Rilke's essay.

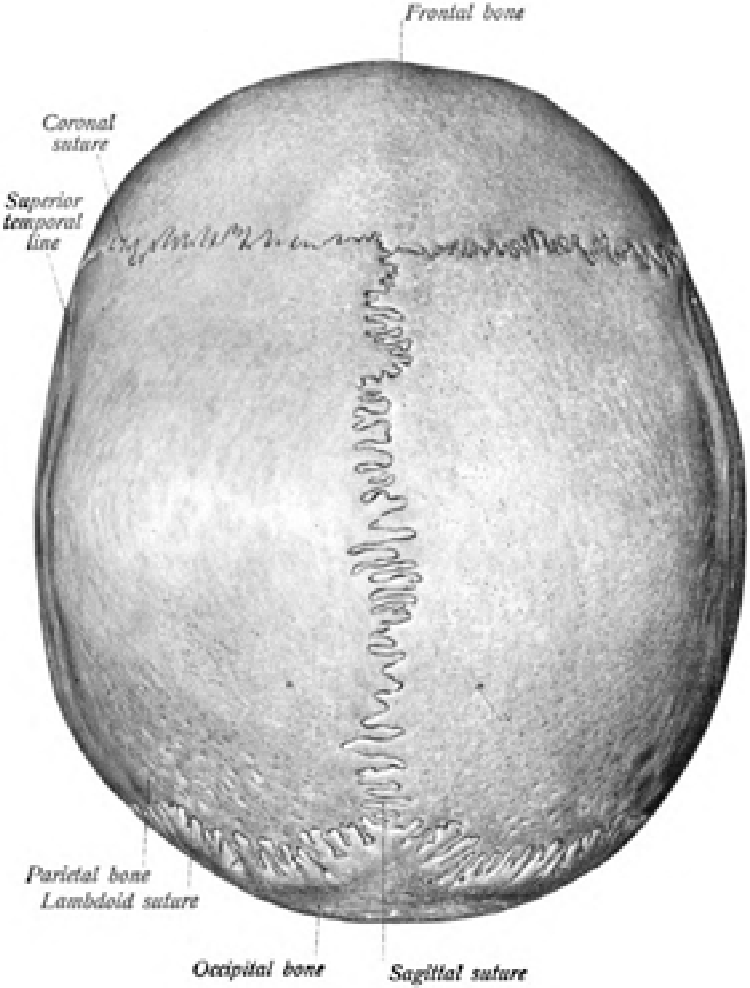


FIGURE 1 Illustration of coronal suture from Sobotta's *Atlas and Text-book of Human Anatomy* (1909). (Wikimedia Commons/Public domain)

'Primal Sound' 1919

The essay 'Ur-Geräusch' (Primal sound) opens with an account of a deeply ingrained memory from Rilke's school years. On the instructions of their enthusiastic physics teacher, schoolchildren constructed a rudimentary phonograph out of cardboard, a piece of paper, a bristle from a brush, and a cylinder coated with candle wax. The recent invention of the phonograph, Rilke wrote, was 'a chief object of public wonder', which extended to the physics teacher and his pupils (Rilke 1919, quoted in Kittler 1999, 38). Together they are able to produce a rudimentary recording by speaking into the funnel, thereby causing the tiny needle to move and leave a trace on the cylinder covered in soft wax: 'when the moving needle was made to retrace its path … the sound which had been ours came back to us tremblingly, haltingly from the paper funnel, uncertain, infinitely soft and hesitating and fading out altogether in places' (39).

Rather than the uncanny experience of listening to the reproduction of their voices, it was something else that would stay with the young Rilke: 'what impressed itself on my memory most deeply was not the sound from the funnel but the markings traced on the cylinder; these made a most definite impression' (Kittler 1999, 38). Some 15 years after the phonographic experiments at school, Rilke found himself attending 'anatomy lectures in the École des Beaux-Arts' in Paris (38). The human skeleton, particularly the skull—that 'most solid protection for the most daring feature of all, for something which, though itself narrowly confined, had a field of activity which was boundless' (40)—fascinated him to such a degree that he obtained a human skull to study by candlelight in his digs. At one point, glancing at the by then familiar object, he suddenly realized the similarity between the skull's coronal suture and the etched pattern on the wax cylinder from his experiment at school: 'I knew at once what it reminded me of: one of those unforgotten grooves, which had been scratched in a little wax cylinder by the point of a bristle!' (40). Ever since this sensation, the poet continued, he had repeatedly felt the urge to make 'this perceived similarity the starting point for a whole series of unheard-of experiments', despite 'the most unrelenting mistrust' (40) on his own part and a lack of proof for his speculation. He continued, almost apprehensively, to present his bold idea:

> What if one changed the needle and directed it on its return journey along a tracing which was not derived from the graphic translation of sound but existed of itself naturally—well, to put it plainly, along the coronal suture, for example. What would happen? A sound would necessarily result, a series of sounds, music. (Kittler 1999, 40–41)

He hesitated to suggest a name for such a 'primal sound', but continued to ponder the possibility of other naturally occurring objects to play, or, in his words, to 'put under the needle and try out'. 'Is there any contour that one could not, in a sense, complete in this way and then experience it, as it makes itself felt, thus transformed, in another field of sense?' (41).

In a media archaeological reading of Rilke's essay, Jan Thoben (2014, 174–5) has demonstrated the extent to which Rilke was inspired by the musical aesthetics of composer Ferruccio Busoni and his thoughts on 'silent primal music', a topic which Thoben contextualizes against the backdrop of early theories of audification and the experiments by Rilke's contemporaries. Rilke, however, seemed unaware of previous experiments closely resembling his theoretical speculations, Thoben continues, mentioning the acoustician Rudolph Koenig's 'wave siren' (see Pantalony 2009, 152–7), which decades earlier had made random airwaves audible (Thoben 2014, 184).

Rilke's speculations would later be put to the test by Richard Woodbridge (1969, 1465), a pioneer of archaeo-acoustics, who gave an account of his 'experiments establishing the principles of recalling ancient sounds from antiquity': '(1) the recording of sound on wheel-thrown clay pots, and (2) the recording of sound in paint strokes applied to canvas'. The experiments suggested that actual sounds and human voices from the past, unintentionally 'recorded' in pottery and the like, could as it were be replayed with the aid of modern technology. In a similar vein, Mendel Kleiner and Paul Åström (1993) claimed to have been able to record sounds on a self-made clay cylinder.

The possibility of placing a gramophone needle onto such grooves from the past, accidentally produced by vibrations carved into soft surfaces, recording long-gone human voices or whole soundscapes, continues to be a thrilling thought. Yet there is an important difference between Rilke's notion of placing the phonographic needle in a groove 'occurring naturally' and the archaeo-acoustic experiments of the 1960s and 1990s. The latter presupposed the existence of a source material that was not entirely arbitrary, but instead followed a certain pattern emanating from a specific source—traces of human voices captured in clay objects. These patterns would be *replayed*; according to this logic, we would be able to experience the source material *again*, to relive a past soundscape in the present.[2] In contrast, and despite 'Primal sound' being the title of Rilke's essay, the sound produced by letting the needle trace the coronal suture's path would not be a *reproduction* of something primitive, original or earliest—the ur- in *Ur-Geräusch*—but a production of something hitherto unheard.[3] Rather than experiencing the past anew, Rilke envisaged us entering a new 'field of experience' (1919, quoted in Kittler 1999, 41).

Friedrich Kittler underscores the radicalness of Rilke's musings in 'Primal Sound' by putting his thinking into perspective against the background of scientific development of his day, arguing that his conclusions were 'more radical than all scientific boldness. Before him, nobody had ever suggested to decode a trace that nobody had encoded and that encoded nothing' (Kittler 1999, 44). Rilke's speculations, prompted by the sight of the coronal suture, testified to a historical shift in how writing was conceptualized: 'Ever since the invention of the phonograph, there has been writing without a subject. It is no longer necessary to assign an author to every trace, not even God' (45).

2 In Huss 2016 I discuss sonification in terms of 'replaying' a planetary past.

3 Pasewalck 2013, 12, n. 22 suggests the title of Rilke's essay was chosen by the publisher Katharina Kippenberg, though Rilke was concerned and would have preferred 'Experiment' instead.

The possibility of using a machine to transform the contour—or to 'complete' it 'in another field of sense' (Rilke 1919, quoted in Kittler 1999, 41)—was at the heart of Rilke's fascination. Such a form of 'intermedial translation' (Schober 2010, 164) would still have to be understood as something rather different from what we usually regard as a translation. Rilke's primary source for his experimental transformation—the coronal suture—in fact negated any designation as 'text' when understood as a system of conventional signs; on the contrary, this manoeuvre would have to be described as an intermedial creation rather than a translation (I shall return to this with reference to Mermikides' composition). The *fons et origo* of such a creation, as imagined by Rilke the poet, would be neither poet nor divine entity ('not even God'), but a machine.

With reference to Kittler's reading of Rilke, Thoben (2014, 173) picks up on the paradox of an author who celebrated the creation of white noise that no writing would be able to store, for Rilke was fascinated by the visual qualities of the coronal suture, resembling writing, but which would potentially—if 'replayed'—produce something entirely different to a sequence of encoded sounds. Rather than echoing the late Romantic trope where sounds and noises were ascribed meaning in terms of a 'voice of nature', Rilke was concerned with a sensory expansion by means of technology, a sensory dimension unattainable by means of language (174–5). For Kittler (1999, 46) 'Replaying the skull's coronary suture yields nothing but noise. And there is no need to add some hallucinated body when listening to signs that are not the result of the graphic translation of a note but rather random anatomical lines. Bodies themselves generate noise. And the impossible real transpires.'[4]

In the literature as in Rilke's train of thought, the 'unforgotten grooves' radically differ from a piece of poetry on an ontological level: whereas the poetry *signifies*, the grooves simply *are*. Thoben (2014, 184–5) argues the sound produced by the phonograph is an 'objet

4 Like Thoben drawing on Kittler's reading of Rilke, for Christoph Haffter 2015, 13 the sound which would be produced by the needle placed on the coronal suture is 'a technically transmitted Real' (Haffter).

trouvé sonore', a readymade sound, to be aesthetically experienced, and that Rilke insisted on the difference between the poem's 'sublime reality' and 'a new and infinitely delicate point in the texture of reality' produced by the makeshift phonograph.

Poetry meets sound machine

Despite Rilke's insistence on the difference between the two spheres, the rest of his essay is dedicated to a poetological reflection informed by precisely this difference: a meditation on the possibilities and limits of the human senses in poetry in light of modern technology. The essay came at a critical juncture in his *oeuvre*, usually regarded as marking the beginning of his late works which would include the *Duino Elegies* (1923) and *Sonnets to Orpheus* (1923). According to Hanna Milena Klima (2018, 227), Rilke's 'Ur-Geräusch' essay formed an important part of his poetological reflections, in turn influencing his own lyrical practice. Indeed, the second part of the essay opens with a comparison of European and Arabic poetry, in which Rilke criticized the dominance of sight in the former at the expense other senses, not least hearing; not so in Arabic poems, 'which seem to owe their existence to the simultaneous and equal contributions from all five senses' (Rilke 1919, quoted in Kittler 1999, 41). What he called 'the perfect poem', however, 'can only materialize on condition that this world, acted upon by all five levers simultaneously, is seen, under a definite aspect, on the supernatural plane, which is, in fact, the plane of the poem' (41).

Thoben (2014, 175) includes a reproduction of a pencil sketch Rilke is supposed to have used as visual aid to explain his essay when visiting Thankmar von Münchhausen in 1920. For Thoben, the sketch was a 'poetical parallelization' (179) between the coronal suture and a circle representing 'the world's whole field of experience' (Rilke 1919, quoted in Kittler 1999, 41). Along with a rudimentary phonograph, a skull, a coronal suture, and other details, the sketch shows a circle divided into five separate sections representing the five senses. These sections are in turn separated by larger, grey areas, representing those sections of reality unattainable for the five human senses. Citing a similar 'diagram' in the essay, Rilke had earlier described how the five human senses were only able to grasp limited sections of reality, between which were larger, grey areas unattainable for the human senses. 'The question arises here', Rilke continued, 'as to whether the extent of these sectors on the plane assumed by us can be enlarged to any vital degree by the work of research' (42). His answer, having mentioned 'the microscope' and 'the telescope' as examples of new scientific devices, tended towards a 'no', since 'the increase thus achieved cannot be interpreted by the senses, cannot be 'experienced' in any real sense' (42). Rilke is careful to suggest that, on the contrary, we should consider 'the artist who develops the five-fingered hand of his senses (if one may put it so)' to be the one who 'contributes more decisively than anyone else to an extension of the several sense fields' (42; cf. Klima 2018, 231). The artist–poet, then, would in some respects be superior to the new scientific devices, widening those sections of reality available to us through our five senses.

Rilke's essay does not end in a defiant disregard of new technology; quite the contrary. He directs our attention to the grey areas between the five sensorial sections of experience to overcome the separation between them.[5] In Thoben's reading, the grey areas should be regarded as the ambient noise (the *Grundrauschen*) in all channels of communication. By extension, the placing of a phonographic needle on the coronal suture would open an intersection between the listener's five sections of sensory experience and a sound machine by tapping into the grey areas—or as Rilke put it at the end of his essay,

> But if we are looking for a way by which to establish the connection so urgently needed between the different provinces now so strangely separated from one another, what could be more promising than the experiment suggested earlier in this recollection?' (Rilke 1919, quoted in Kittler 1999, 42)

5 Klima 2018, 232 draws on Pasewalck's study of the poetics of Rilke's late works to point out that Rilke does not aim for the erasure of difference between the five senses, but rather argues for what Rilke described as a 'correspondence' between 'all five levers simultaneously'.

Rilke did not claim it was within the sphere of his own imagination to be able to 'complete' the sound produced by a needle running along the coronal suture. Quite the opposite, for he wished to put his experiment into the hands of technological experts, as was evident from a letter he wrote to the publisher Katharina Kippenberg (Thoben 2014, 183–4).

Sonification as hermeneutic negotiation

Returning to Mermikides' composition, the similarities with Rilke's essay are evident, but also the crucial differences. It is instructive to use the theoretical framework for analysing sonification practices proposed by Giacomo Lepri, because his interdisciplinary approach is particularly suitable for examining a composition inspired by what one might call Rilke's poetology of sonification *avant la lettre*. Lepri (2020) compares sonification practices with translation theories, finding common ground in the concern of 'the transfer of information from a semantic system to another' (212). A semantic system is defined as a 'set of information coherently organized (e.g. a sequence of data represented in a binary numeral system)' (212). Lepri, however, cautions against equating sonification with translation, since unlike translation between languages it 'comprises the transformation of data into acoustic signals where information traverse different media' (212). In order to capture the shift from one medium to another, Lepri regards 'adaptation' as a more apt term, drawing on Umberto Eco's understanding of translation and adaptation as a negotiation (Eco 2013). Whether translation or adaptation, something from the source text is inevitably lost in the process, but simultaneously is also made visible—or in our case, audible:

> The interpretation of complex and large data sources based on the isolation of *features* through digital signal processes can be considered as an example of such loss. For instance, while filtering and smoothing large data-sets we *ignore* a large amount of the original data; nonetheless, thanks to these processes, we are able to discover and convey hidden information out of complex data. (Lepri 2020, 215)

Mermikides' compositional process, which resulted in the track 'Primal Sound', is thus best understood as *sonification as adaptation*, a process in which certain features are isolated, filtered, and smoothed, whereas others are ignored, enabling the listener to experience something previously inaudible. Lepri also underscores the role of the interpreter–sound designer in this process, a role necessarily engaged in a hermeneutic practice guided by certain contexts and purposes, which in turn will influence the result (216). By turning to the various subcategories of translation proposed by Eco (literal translation, semantic interpretation and use, critical interpretation), Lepri demonstrates how different sonification practices can be categorized along such a spectrum, ranging from the goal of achieving 'unambiguous and faithful relations between data and sound' to sonification entailing 'semantic interpretations' on the part of the sound designer, aiming to 'propose further contents or suggest imaginative and emotional allusions in relation to the input data', and finally a 'critical interpretation' devoted to the analysis of expressive or creative acts of sonification (214).

Mermikides' description of his compositional technique, the overall compositional project, and the resulting track together expose the tension between literal and semantic interpretations and uses. The coronal suture is said to have been 'translated directly' by the use of digital software, but this translation between media (what Mermikides 2011a has as 'visual–audio translations') necessarily entails a loss of source data features, as Lepri points out. The subsequent steps in the design process—digital 'compositional structuring, panning and mixing'—make the crucial role of the composer–designer and their aesthetic choices evident. As opposed to Rilke's thought experiment (yet to be attempted) in which a phonograph needle is run along a coronal suture, the mediation process of Mermikides' project is a far more complicated, advanced technical affair. Further, Mermikides (2011b) describes the overarching aim of his album as being the exploration of 'the field of data sonification in that digital audio technology is employed in the systemized translation of biological processes to sound design'. Unlike Rilke's musings that the coronal suture resembled writing or Kittler's reading of it as an inscription 'encoding nothing', Mermikides' project does seem to suggest an information transfer of sorts between the source text (coronal suture converted into digital code) and the target text (musical composition). Mermikides' description, on the other hand, spells out how such a process of audio-visual translation is at one and the same time a process of artistic creation and a technological transformation, something captured in Lepri's concept of sonification as negotiation. Pasewalck (2013, 12) characterized Rilke's thought experiment as a practice 'oscillating between discovery and invention', testifying to a similar dynamic.

How Rilke would have reacted to Mermikides' track we will never know, but his 'poetical parallelization' of the human sensory apparatus and acoustic technology, uncovering hitherto unknown 'grey areas' in the human sensorial spectrum, suggests it would have piqued the poet's interest. Among Mermikides' key questions to be explored were echoes of Rilke's parallelization of artistic practice (poetry) and science: 'How can traditional and electronic composition, data sonification and collaboration with non-musician scientists most effectively interact?' (Mermikides 2011b). Mermikides' creative engagement with Rilke's thought experiment in 'Primal Sound' testifies to its ongoing relevance as a source of artistic, philosophical, scientific, and sonic speculation and experimentation.

References

Britannica (2020), s.v. 'Human skeleton' by A. Warren, 19 Nov., accessed 10 Feb. 2022. www.britannica.com/science/human-skeleton

Eco, U. (2003), *Mouse or Rat? Translation as Negotiation* (London: Weidenfeld & Nicolson).

Haffter, C. (2015), 'Das Andere der Musik: Weißes Rauschen, Ur-Geräusch', in C. Hongler, C. Haffter & S. Moosmüller (eds), *Geräusch—das Andere der Musik: Untersuchungen an den Grenzen des Musikalischen* (Bielefeld: transcript).

Herzogenrath, B. (2020), 'Some Notes on Sound Thinking', in B. Herzogenrath (ed.), *Practical Aesthetics* (London: Bloomsbury Academic).

Huss, M. (2016), 'Den sjungande kometen: Begäret efter historiens ljud och (re)produktion', in J. Hegardt & T. Lundemo (eds), Historiens hemvist, iii: *Minne, medier och materialitet* (Gothenburg: Makadam).

Kittler, F. A. (1999), *Gramophone, film, typewriter* (Stanford: SUP).

Kleiner, M. & P. Åström (1993), 'The Brittle Sound of Ceramics: Can Vases Speak?', *Archeology & Natural Science* 1, 66–72.

Klima, H. M. (2018), *Rainer Maria Rilkes Kunstmetaphysik* (Stuttgart: J. B. Metzler).

Lepri, G. (2020), 'Sonification as Negotiation: Learning from Translation Studies', in S. Spagnol & A. Valle (eds), *Proceedings of the 17th Sound and Music Computing Conference, Torino, June 24th–26th 2020*. DOI 10.5281/zenodo.3898761

Mermikides, M. (2011a), 'Primal Sound', track 1 of *Hidden Music: Sonic Translations of the Biological World*, released 24 Aug. miltonmermikides.bandcamp.com/track/primal-sound accessed 24 Feb. 2022.

Mermikides, M. (2011b), 'Hidden Music: Sonic Translations of the Biological World', sleeve notes, 24 Aug. openresearch.surrey.ac.uk/esploro/outputs/99515859202346 accessed 24 Feb. 2022.

Pantalony, D. (2009), *Altered Sensations: Rudolph Koenig's Acoustical Workshop in Nineteenth-Century Paris* (Dordrecht: Springer Netherlands).

Pasewalck, S. (2013), *'Die fünffingrige Hand': Die Bedeutung der sinnlichen Wahrnehmung beim späten Rilke* (Berlin: De Gruyter).

Rilke, R. M. (1919), 'Ur-Geräusch', *Das Inselschiff: Eine zweitmonatsschrift* 1(1), 14–20.

Rilke, R. M. (1999), 'Primal Sound', tr. G. C. Houston, in Kittler 1999, 38–42.

Schober, R. (2010), 'Translating Sounds: Intermedial Exchanges in Amy Lowell's "Stravinsky's Three Pieces 'Grotesques'", for String Quartet', in L. Elleström (ed.), *Media borders, multimodality and intermediality* (Basingstoke: Palgrave Macmillan).

Thoben, J. (2014), 'Die Stille der Bilder und die Macht der Töne: Spuren einer Medienästhetik der Audifikation in Rilkes Ur-Geräusch', in A. Schoon & A. Volmar (eds), *Das geschulte Ohr: Eine Kulturgeschichte der Sonifikation* (Bielefeld: transcript).

Woodbridge, R. G. (1969), 'Acoustic Recordings from Antiquity', *Proceedings of the IEEE* 8(57), 1465–6.

Beyond Sound Objects

Sandra Pauletto

It was Pierre Schaeffer who introduced the term *objet sonore* in his now famous *Traité des objets musicaux* (1966) and *Solfège de l'objet sonore* (1967), since then the English term object has been used in relation to sound in many contexts (Rocchesso et al. 2003; Godøy 2018). In this essay, I argue that while conceptualizing sound as an object has many benefits for the development of audio technology and production methods, it also obscures and undermines some fundamental and unique characteristics of sound. To exemplify how and when conceptualizing sound as an object seems to be unhelpful, I look at media production and specifically the creative practice of foley, and the use of sound in documentaries with examples from works by the documentary film-maker Erik Gandini and others. A better understanding of what sound is can be found in its unique, often contradictory, characteristics—its ability to help us trace what is relevant and truthful in what is in front of us—rather than what it might have in common with other creative materials such as images.

The puzzling nature of sound

Many find sound a mysterious topic. Those studying media production, for example, often find it a complex subject and its material difficult to control, being more at ease with the visual aspects. Despite the similarities between some of the processes used to manipulate images and sounds—we can filter both images and sounds, we can create

https://doi.org/10.37852/oblu.255.c611

analogous delay effects, and so on—sound and image are also fundamentally different.

We tend to assume, for example, that we all see the same things and in the same way, while we are less confident that what we hear is the same as others hear. Partially this is due to the temporal nature of sound. If I were to hear something that someone else does not hear, it is unlikely that an exact replica of that sound will repeat just for someone else to be able to hear it too. Sounds, therefore, might be easily and forever missed. The things we see are often static. If my friend does not see something I see, they might have to move their head or redirect their eyes to see it. While sound is always transient, the things we see are usually, though not always, more stable in time.

Yet sound behaves even more strangely than that. It stretches our body, our sensory possibilities. Hearing allows us to perceive from all directions, even things that are far away from us. We can also hear sounds that come from inside our bodies, something that makes the delimitation between what is inside us and outside us porous. As Voegelin (2018, 120) puts it, 'sound is skinless'. Vision reaches far too, but it is directional and easily blocked; other senses, such as touch and taste, require vicinity. Sound is quite indifferent to physical barriers and passes through most things, almost unscathed. It is perhaps the only everyday aspect of our lives that behaves like a ghost. We hear the present as sound, but reverb means we can hear traces of the past, and because sounds are often made of cycles or patterns, when hearing a sound we will have expectations about the future too. Will the pattern continue, stop, or fade? Like a symphony, the sounds around us provide us with moments of suspension, unexpected turns, or reassuring resolutions.

Sound is ambiguous. It gives us information about some aspects of its source, but often not enough to be able to be certain about what produced it. We can easily be fooled into believing that frying bacon is instead the sound of rain. Sound allows us to imagine things we cannot see or even that do not exist; to formulate a range of reasonably plausible perspectives about what we are experiencing. Yet sound can also be extremely clear. From infancy we learn to understand and produce complex patterns of sound—speech and music—as well as recognize the sounds of our closest relations. This process of identification and production is soon embedded in us—something we can do effortlessly. In short, sound is many things simultaneously, and at times seems to create contradictory experiences.

Fact and fiction, evidence and doubt

Given the contradictory nature of sound, it is not surprising that it became the focus of Francis Ford Coppola's thriller *The Conversation* (1974). In the film, a professional wiretapper, Harry Caul, is tasked by a company director to record his young wife while she is walking in a public square accompanied by a young man, who is suspected to be her lover. While preparing the recordings, Harry discovers an ambiguous line: depending on where the accent lies in the sentence it could mean two completely different things. The evidence—what Harry recorded—is suddenly cast into doubt, the sound being both evidence and doubt, factual truth and traces with multiple interpretations. In *The Conversation* some of the contradictions inherent in sound—the way we conceptualize it, the way we listen to it—are Coppola's principal creative focus. In an interview at the time he said,

> Sound works on such a sneaky level. You can do things with sound that the audience doesn't know you're doing. With a picture in front of them, they're very aware of it. I just think that sound is very effective. (Rosen 1974)

For Coppola, the subject of *The Conversation* is eavesdropping, privacy, and surveillance. It is about audio technology, the signal on a tape, supposedly being a stable, objective fact and the eavesdropper's relationship with it (Turner 1985). And it is about listening. As Coppola said,

> as the film goes along, the audience goes with it because you are constantly giving them the same lines they have already heard, yet as they learn a bit more about the situation, they will interpret things differently. (De Palma 1974).

The film is thus also a comment on the way audio technology has developed and the way we think about it.

Recording allows for sound to be boxed into something graspable—an object that can be categorized and selected, and even used as evidence. It contributes to taming the contradictions of sound. The *Oxford English Dictionary* defines the noun 'object' in several ways. The first does not easily apply to sound as we experience it: 'A material thing that can be seen and touched'. Its definition as 'A thing to which a specified action, thought or feeling is directed' seems to fit better, because we can direct actions and feelings towards sound as we experience it. We can listen to sound, we can like it or dislike it, we can make it by, say, banging two things together or playing an instrument, but if we want to do more—repeat the same exact instance of sound, for example—we need to make it into something else, into something 'that can be seen and touched' as per the first definition of 'object'.

Speech and music were first turned into objects a long time ago as written text and scores. The transformation of these sounds into objects has been so successful that for some speech is its text or a piece of music is its score, and not its sound. While this has allowed speech and music to be communicated and evolve to an enormous degree, it has also obscured their sonic, contingent nature. Is a musical masterpiece still a masterpiece if the player is unable to produce its sound? Is a speech still truly inspirational if uttered by a toddler or an inexpressive synthesizer?

Transforming other kinds of sounds, everyday sounds and atmospheres for example, into objects has proven more difficult. The development of recording technology has been the primary factor in making these sounds into objects, and it is no coincidence that Schaeffer coined the concept of the sound object when recording and reproduction technology became established in the late 1940s. We were finally able to capture sounds and separate them from their sources, making them into something that could be seen and touched, first as tapes and later as discs and digital files. We built computer interfaces designed so we could virtually touch and see sound. Film sound, for example, works with these kinds of sound objects: a soundtrack is constructed by manipulating them. Sound files are categorized as voice, music, and sound effects in the editing window. Sound effects are selected from digital sound libraries and inserted where appropriate, sliced, grabbed and moved around like pieces on a chessboard.

Technology allows us to listen to any sound, even mundane sounds, differently. We can more easily attend to sound's acoustic characteristics—we can listen 'acousmatically'—rather than concentrating on its production mechanisms. It also allowed us to create new classifications and taxonomies, elevating any sound to the status of potential creative material, and changing the way we appreciate sound overall. Yet while this has provided a revolutionary freedom, with sound finally disconnected from the contingent, transient nature of its production, it has also obscured some of its unique characteristics. Examples from media production can help us see where it is unhelpful to make sound an object.

How it feels rather than what it is

In the documentary *Roadrunner: A film about Anthony Bourdain* (2021), the director Morgan Neville used artificial intelligence to recreate Anthony Bourdain's voice for three lines of text Bourdain himself had written but had never recorded. Many were outraged by this use of technology and called it a 'deepfake' (Rosner 2017). One of the fears was of 'a growing slippery slope surrounding what is real and what is fake' (Yang 2021). Karen Hao, an *MIT Technology Review* editor, in summing up the response, revealed a number of assumptions about documentary making.

> There's this visceral reaction of, Hey, whoa, you potentially manipulated our understanding of Anthony Bourdain—what he would have said, how he would have portrayed himself—without his consent and without our knowing. (Rosner 2017)

The idea that a documentary would do anything but manipulate our understanding of its subject implies there is one 'true' understanding of a subject, which the documentary should present. Plainly, any subject can be understood in a variety of ways, and a documentary is one possible representation of the director's understanding of the subject. Furthermore, the idea that the people represented in the documentary should consent to how they are portrayed is to misunderstand whose viewpoint the documentary expresses. A documentary is the expression of the director's point of view which does not need to coincide, require permission from, or be sympathetic to their subject. It is arguably unethical to seek that kind of consent. Should the director of a documentary about a brutal dictator obtain their consent for the way they wish to portray them? Even *cinéma-vérité*, a documentary style that seeks to capture reality 'as objectively as possible', often by favouring lightweight equipment, small crews, and location sound, ultimately expresses the perspective of the director, who chooses where to point the camera and how to edit the footage.

Perhaps the real issue with the technique Neville used was that the words Bourdain wrote were presented in the form of sound, rather than text. Neville defended himself by saying, 'I wasn't putting words into his mouth. I was just trying to make them come alive' (Yang 2021). As Bourdain was their author, why such outrage at the form in which they were presented? What if the director had made the words into a graphic? What if a different voice, not Bourdain's, had read out the words? What about intonation and prosody? And what if a recording of Bourdain saying the lines had existed? Surely their use in a different context is already manipulation? This is the same conundrum faced by Harry Caul in *The Conversation*: these are the words, but what did Bourdain mean by them? We seem to think that somewhere within sound, its emphasis and accentuations, we could track back to the truth. Or is the answer for us, the audience, to take greater responsibility by acknowledging the truth resides in how we interpret what is in front of us?

> Sound provides an incomplete picture and brings signifiers into doubt: it is not 'this' or 'that', as things defined against each other, a matter of differences and similarities; and it does not offer us a certain form, but is the moment of production of what the thing and the listener are. (Voegelin 2018, 120)

As 'the truth' does not simply reside in the materials recorded and their production, sound, with all its contradictions, is ideal material to express what Werner Herzog (1999) calls 'the deeper strata of truth in cinema'—a poetic, ecstatic truth—for as he continues, this deeper truth is 'mysterious and elusive, and can be reached only through fabrication and imagination and stylization'. So speech is not just its text, its graspable object, but it is also its contingent, ungraspable instantiation: its sound, be it an original recording or a voice-over fabrication. Through sound we 'feel' speech more directly and we arrive at our interpretation of what those words mean, of their truth.

Hao seemed to think that by recreating Bourdain's voice Neville had crossed a boundary that previously did not exist (Rosner 2017). I would suggest that this is not really new ground at all. We do not need AI to be able to create plausible new sounds, indistinguishable from sounds recorded in real life. Even speech, one of the most difficult sounds of all, can be edited together and altered by processing at the phoneme level, making someone sound more assertive or doubtful, younger or older (Pauletto 2012). It is sound's malleability that makes it possible.

Both factual and fictional media have made great use of sound's adaptability. In fiction and factual media alike, the sound of the characters' bodies and how they express their behaviour is treated in exactly the same way as Neville treated Bourdain's voice. The urgency with which someone bangs on a door, the love expressed by the sound of a kiss, the hesitation in the sound of a spoon stirring a cup of tea: they are likely to be faked, portrayed by a performer in a recording studio, not the person we see on screen (Pauletto 2019).

The agitation of the between-of-things

In the early twentieth century, technology developed to the point where films could be accompanied by a synchronized, recorded soundtrack. A technique was developed to perform and record sound effects corresponding to the film, which had its roots in theatrical sound effects and takes its name, foley, from the person who pioneered the practice. Though cinematic technology has since been transformed, foley remains the way a vast part of the sound is created for film, TV, radio, and so on. Foley artists generally produce the sounds of the characters on screen: footsteps, the sound of clothes when the character is moving, and the sound of interactions with objects. These are the sounds we hear in our daily life that we often pay little attention to, but constantly use to judge what is happening around us.

Why, then, can we not use a general library of sounds to create these 'noises'? Why do they need to be performed by foley artists uniquely for each film? After all, they are mundane sounds and hardly the focus of the production. I would argue that foley artists are still here because rather than a representation of 'sound objects' (footsteps, knocking), foley sounds are a representation of acting—an expression of how something or someone *feels* rather than what something *is*. As James Naremore writes, 'only the most vulgar empiricism regards the objects around us as inanimate. Once those objects have entered into social relations and narrative actions, they are imbued with the same "spirit" as the humans who touch them' (1988, 87): actors turn objects into 'signifiers of feeling. Sometimes the player's dexterity is foregrounded, but more often it is hardly noticeable, lending emotional resonance to the simplest behaviour'. That resonance can be provided by sound.

The enduring tradition of foley foregrounds the contingent as a fundamental quality of sound, contesting the idea that sound is a collection of discrete objects and categories.

> In sound we exist transiently and contingently not as signifier or definition, but as the agitation of the between-of-things. (Voegelin 2018, 121)

Foley is one of the most concrete examples of sound as 'the agitation of the between-of-things'.

Reaching deeper strata of truth

If sound is primarily a signifier of feeling, rather than an object, the distinction between what is real and what is fake is not just uninteresting, but almost impossible. The way any one sound was created becomes irrelevant, as long as the sounds we create make the audience feel the way we intended. And if the feeling is to be real and 'truthful', in Herzog's sense (1999), sound will be one of the most interesting ways to reach 'deeper strata of truth in cinema', rather than what Herzog calls the 'truth of accountants'.

Hao's assumptions about documentary making (Rosner 2017) have their roots in the traditional view that documentary films are representations of reality based on directness, transparency, and simultaneity (Nichols 1991). It implies a clear distinction between the observer and what is observed; an objectification of reality in all its aspects, visual and aural. From this standpoint, if we see something on screen, we want to trust it really existed and was in front of the camera when filmed, and if we hear a sound, we want to assume it was produced and recorded at the same time. Yet the history of documentary film-making presents us with many examples of creative tools firmly detached from reality, whether animation, staging, reconstructions, interventions, or various forms of participation on the part of the director.[1]

From this emerged an alternative idea of documentary: the 'creative documentary'. Italian-Swedish documentary film-maker Erik Gandini (2021) describes it as a hybrid film genre, which attempts to represent 'the real' in a creative, critical art form. The tension in the interaction with reality is central to creative documentary making and instead of sidestepping it, a creative documentary makes it a key element in the process. The film-maker no longer attempts to be a dispassionate observer of a reality evolving in front of them, and their voice is no longer

1 Documentaries have used re-enactments and animation from the start. Winsor McCay's short propaganda film, *The Sinking of the Lusitania* (1918), used only re-enacted or recreated footage. Peter Watkins's *The War Game* (1966) depicted a nuclear war and its aftermath, Errol Morris's *The Thin Blue Line* (1988) was deemed ineligible for an Oscar because it used re-enactments. Ari Folman's Oscar-nominated animated memoir *Waltz with Bashir* (2008) is told by an unreliable narrator and includes fictional characters. Other examples of untraditional documentaries are *Danish Into Eternity* (2010, Michael Madsen), *We Tell* (2012, Sarah Polley), *The Act of Killing* (2012, Joshua Oppenheimer), *The Stanford Prison Experiment* (2015, Kyle Patrick Alvarez), *Kate Plays Christine* (2016, Robert Greene), *Lucky One* (2019, Mia Engberg), and *Reconstructing Utoya* (2018, Carl Javér).

excluded, instead being the very thing on which the narrative relies—and at their disposal they have sound, one of the most flexible tools with which to shape reality.

Gandini's aesthetic deliberately encourages audiences to doubt the representation, and sound's resistance to being objective evidence is a great help. Gandini's two main collaborators, the film editor Johan Söderberg and sound designer Hans Møller, are key to his approach to sound. Throughout the production process, they discuss not so much the sounds present during filming, but how Gandini felt on location, the aim being to recreate that feeling rather than attempting to reconstruct the sounds of the reality. In that sense, Møller's notion—taken from fiction—of 'total freedom' is extremely valuable, 'as he really wants to create a universe, which is exactly what I like to do with these films' (Gandini 2021). The long-lasting collaboration with Johan Söderberg, a film editor with a background as a percussionist and vast experience of editing music videos and adverts, shapes not only the way the picture is edited, but also the rhythm of the edit—the interplay of audio and visual elements—and, at times, the musical choices.

Gandini (2021) describes the creative possibilities opened up by sound design as a 'revelation' and concludes that sound is a fantastic tool to 'show reality for how it feels, rather than how it is'. For his documentary with Tarik Saleh about Guantanamo Bay prison, *Gitmo* (2005), there were lengthy discussions about how the American soldiers were trying to present the place as if it were a tourist attraction, describing the wildlife, the golf course, and so on. Gandini (2021) said:

> I remember talking about the feeling that there was a lot of construction going on. And there were these dogs that were used for interrogation, I mean, simple things. … They had almost built like a platform for media where you could put up the cameras and shoot 'Gitmo by night'; it's bizarre, you know. … The situation was that suddenly, with this microphone, we could pick up the talking, the screaming from inside the camp. And this Lieutenant Mos was doing his best to sort of convince us that they were just talking to each other. And I am sure that Hans Møller added some voices there; it was definitely true that people were shouting and screaming and so on, but he enhanced it somehow. (Gandini 2021)

Similarly, the dogs barking and construction sounds were added later where the directors and sound designer felt they would provide the same unsettling, contradictory feeling they had discussed. But why cannot recorded location sound provide the right feeling? Gandini (2021) says it is often uninteresting. The recording equipment does not capture the feeling which the sound provoked in listeners when they were there and heard it the first time. Once again, sound cannot be reduced to its object—the signal in a file. A completely new synthesized, sonic atmosphere can be more 'authentic', evoking the original feeling. As Gandini (2021) puts it, 'to turn (the recorded material) into a scene you need more stuff'.

In more recent films, Gandini presents his themes almost as riddles—something he calls a 'Alice in wonderland approach' (2021). He looks at the present from unusual perspectives, be it Italian society in the Berlusconi years in *Videocracy* (2009) or Swedish society in *The Swedish Theory of Love* (2015), making the viewer look at the mundane as if for the first time, 'creating something that is recognizable, but feels somehow new. Almost making the banal exceptional' (Gandini 2021). Manohla Dargis's description (2010) of this feeling in her review of *Videocracy* is particularly fitting: 'it feels as if you were watching a transmission from another planet'.

Self-insemination scene from the film *The Swedish Theory of Love* (2015). With permission from Erik Gandini.

The Swedish Theory of Love is a film about the Swedish emphasis on individuality and independence. A single woman's ability to have a child by anonymous sperm donation is portrayed in the film as an example of such independence. Early in the film, there is a sperm bank scene, which shows robotic medical machinery and sperm moving around in a petri dish—an artificial construct in both images and sounds. The sound of the machines is reminiscent of sci-fi sound design, with each little movement or LED light accompanied by a small buzzing or beeping effect. The scene ends with the clearly unrealistic sound of sperm 'bubbling' under the microscope. The sound design gives a sense of an efficient, modern, aseptic system designed to produce something organic, moving, and pulsating—something alive. Another completely fictional insemination scene follows, in which a female narrator, accompanied by a choir of 'angelic' voices, reads out the instructions for the procedure in a tone that is both reassuring and unsettling. The scene ends abruptly with a woman pushing a pram and an implosion into almost silence, perhaps hinting that having a baby might not be as idyllic as the previous sounds seemed to imply. While many of the elements (the interview with the sperm bank owner, the sperm donors' descriptions) are factual, the images and sounds are intended to produce a feeling that in Gandini's case is often a feeling of doubt or suspension. The result is that the audience wonders, 'Is it really so simple? Is it really so good to be fully independent?'

Sound is again used to evoke feelings at the end of the film, which concludes with extracts from an interview with the Polish sociologist Zygmunt Bauman. Bauman talks about independence and interdependence, and the paradox that happiness is the result of struggle—the taming of troubles, not the absence of trouble. The syncopated music used for the scene seems a metaphor for this contradictory process. Bauman adds that society can solve some of its most pressing issues such as hunger and health, but it cannot resolve the human need for company. The buzz of a lone motorbike, the rattling sound of a man cycling, create the feeling of individuals going about as single entities in search of something. Independence erodes our socializing skills, Bauman continues, which are difficult and time consuming. Gandini here sequences a number of images of living rooms against a soundtrack of a ticking clock, inspired by visits to his relatives in Sweden, in contrast to his experience of Italian households (Gandini 2021). The sound of his personal memory, which hints at loneliness and a lack of socialization, becomes in this case the channel for authentic feelings experienced by the audience too.

As the concept of interdependence is introduced, a solo instrument softens the insistent rhythm of the music with a melody, accompanied by children's voices and the sound of people having fun and being together. The sound of doors creaking open follows, ending with one slamming shut. Gandini and Møller spent a great deal of time getting this sound exactly 'right' (Gandini 2021), a kind of suspended cadence, which is then followed by the explicit conclusion in Bauman's words: 'So at the end of independence is not happiness; at the end of independence there is emptiness of life, meaninglessness of life, and utter, utter unimaginable boredom.'[2]

Elusive truths

Sound is many, often contradictory things at once. It is clear and ambiguous, evidence and doubt, fake and real. Sound is a trace, a ghost, a signifier of feeling. It tells us about the past, the present, and the future; it is contingent and transient; it lives inside and outside our bodies. It is what connects the source to the listener, shaped by both and belonging to neither. Technological advances have made sound into graspable, collectable, classifiable objects, and there can be no doubt the process allows us to manipulate this strange material in many new, creative ways, but it also, at times, obscures its real nature, its potential for 'truth'. I have shown how conceptualizing sound as an object is not straightforward. In Coppola's *The Conversation*, the sound object—in this case a sound file—crumbles, degrading rapidly from evidence into traces so we, by listening, are implicated in the construction of a multitude of possible truths. In Neville's documentary, the

2 Bauman quote from 6:45: https://www.youtube.com/watch?v=07GL_HFCXbs

written word collides with its possible realizations as sound. Yet while we react strongly to the possibility of recreating a voice, film-making makes abundant use of foley—'faking' how an actor's body 'speaks'—without audience objections. It is only in uniquely produced sonic performances, and not simply the selection of sound objects (sound files) from a library, that an audience can trace the feelings the director and actors want to portray on screen. The use of sound in creative documentaries is an example of sound's contradictory nature lending itself to use as a tool for fabrication, imagination, and stylization: in short, as a way to reach elusive truths.

References

Dargis, M. (2010), 'Prime Minister, Primo Mogul', *New York Times* (11 Feb.).

De Palma, B. (1974), The Making of The Conversation: An Interview with Francis Ford Coppola', *Filmmakers Newsletter* (May), 30–33.

Gandini, E. (2021), personal interview with Sandra Pauletto, 28–29 Jan. 2021.

Godøy, R. I. (2018), 'Sonic object cognition', in R. Bader (ed.), *Springer handbook of systematic musicology* (Berlin: Springer).

Herzog, W. (1999), 'Werner Herzog Reads His Minnesota Declaration: Truth and Fact in Documentary Cinema', Walker Art Center, Minneapolis, 30 Apr. walkerart.org/magazine/minnesota-declaration-truth-documentary-cinema-1999.

IMDB (Internet Movie Database) (2023), s.v. 'Erik Gandini'.

IMDB (2023), s.v. 'Francis Ford Coppola'.

IMDB (2023), s.v. 'Gitmo (2005)'.

IMDB (2023), s.v. 'Hans Møller'.

IMDB (2023), s.v. 'Johan Söderberg'.

IMDB (2023), s.v. 'Morgan Neville'.

IMDB (2023), s.v. 'Roadrunner: A Film About Anthony Bourdain (2021)'.

IMDB (2023), s.v. 'Tarik Saleh'.

IMDB (2023), s.v. 'The Conversation (1974)'.

IMDB (2023), s.v. 'The Swedish Theory of Love (2015)'.

IMDB (2023), s.v. 'Videocracy (2009)'.

Naremore, J. (1988), *Acting in the Cinema* (Berkeley: University of California Press).

Nichols, B. (1991), *Representing reality: Issues and concepts in documentary* (Bloomington: Indiana University Press).

Oxford English Dictionary (2023), s.v. 'object'. www.oed.com

Pauletto, S. (2012), 'The sound design of cinematic voices', *New Soundtrack* 2(2), 127–142.

Pauletto, S. (2019), 'Invisible seams: The role of foley and voice postproduction recordings in the design of cinematic performances', in M. Filimowicz (ed.), *Foundations in sound design for linear media: A multidisciplinary approach* (New York: Routledge).

Rocchesso, D., R. Bresin & M. Fernström (2003), 'Sounding objects', *IEEE MultiMedia* 10(2), 42–52.

Rosen, M. (1974), 'Francis Ford Coppola interviewed by Marjorie Rosen', *Film Comment* (July–Aug.), 43–49.

Rosner, H. (2017), 'The Ethics of a Deepfake Anthony Bourdain Voice', *New Yorker* (17 July).

Turner, D. (1985), 'The Subject of The Conversation', *Cinema Journal* 24(4), 4–22.

Voegelin, S. (2018), *The Political Possibility of Sound: Fragments of Listening* (New York: Bloomsbury).

Yang, M. (2021), 'Anthony Bourdain documentary sparks backlash for using AI to fake voice', *The Guardian* (16 July).

Jacob Kirkegaard: Sounds Speak for Themselves

Henrik Frisk

In late August 2023 I met the composer and sound artist Jacob Kirkegaard to chat about how he thinks about sounds, their origins, and their agency. Kirkegaard is a highly original composer and sound artist with a meticulous method for exploring sound and the traces that sounds make. He often engages with materials that make sounds that are rarely heard, reflected on, or even accessible to listeners. He stages them in ways that allows them to speak for themselves and enables listeners to frame and understand them in their own ways.

Works such as *Crossfire* (2022), which has recordings of a barrage of gun and artillery fire, and *Aion* (2006), where four abandoned spaces in official exclusion zone around the Chernobyl nuclear power plant in Ukraine, are made to resonate. In light of these two pieces, I was interested in discussing Kirkegaard's opinions about the politics of sound. In the case of Chernobyl, for example, he makes the unheard heard in a double sense: most people cannot visit the site, and even if they could, the sounds heard in *Aion* would not be accessible. As an artist he gives a site a sound that perhaps was not there before, or at least was not heard, which might have political implications.

Our discussion began by mapping the meaningfulness of framing the politics of sound or sounds as a political utterance. Kirkegaard questioned whether there is anything political about his works. What he aims for is an exploration of a set of themes open to free, non-judge-

https://doi.org/10.37852/oblu.255.c612

mental listening with no particular purpose other than to evoke the themes embedded in the sound. The common thread in his practice was at the most basic level concerned with what it is to be human. Works such as *Labyrinthitis* (2007), *Testimonium* (2019), and *Membrane* (202) are evidence of his artistic, aesthetic intensions.

Even so, he continued, the world context changes, which reconfigures the possible interpretations of his works. The Russian invasion of Ukraine, for example, affects both *Crossfire*, with its evocation of the sounds of war, and *Aion*, where the contemplative place conjured up by Kirkegaard is now at the centre of a geopolitical conflict on a scale we have not seen since the Second World War. Yet despite the fact that his work clearly addresses contemporary and pressing themes, he has never sought to make overt political statements. Although world events may imbue any his work with new significance after its creation is thought-provoking, he maintained that its main identity remains unchanged. The fact his work is subject to evolving interpretations and can acquire new meanings and frames of reference, far removed from how it was once conceived, does not make it political.

This approach is part of Kirkegaard's view of his role as an artist. He is an artist and as such he asks questions about what is happening in the world. He uses his sensibility to devise new interfaces for listening, to make listening possible where it was not previously feasible. In the process he sets out to make objects, themes, and places speak for themselves. They speak their own language, he says. The sounds found in Chernobyl, he takes as an example, 'do not say yes or no, good or bad, left or right; they are not political.' Kirkegaard argues he is in no position to tell the listener what or how to feel: it is solely the responsibility of the listener to figure out what they think. Kirkegaard is firm on this point. He is not interested in deciphering the various meanings that may exist in his works, leaving that task to the listener. The sounds themselves are simply sounds and make no judgements about political matters, nor do they have opinions, and this is precisely his point: the sounds are *not* political. There is plenty of other kind of sonic communication today that tries to influence and manipulate the listener.

FIGURE 1. Photo from the working on *Aion* (2006) at the Zone of Exclusion in Chernobyl, Ukraine. With permission from Jacob Kirkegaard.

Space for sensuousness

Kirkegaard uses the concept of 'a space for sensuousness' that allows the listener to arrive at their own point of view by listening to his works. It is crucial, he says, to spell out that he has no interest in manipulating his listeners or convincing them he is right or that he favours one thing over another; however, no one should mistake his discussion of certain topics for neutrality, though it is the listener who has agency and thus the responsibility to arrive at their own understanding. Kirkegaard says he is interested in instigating change in the world, but more than anything he wants to create a 'breeding ground for a deeper kind of sensuousness', one that is less vulnerable to the onslaught of information and opinions that dominate contemporary Western society.

Kirkegaard's personal fears often feed into how he picks the themes of his works. Fear of radioactivity, fear of war or border walls, and the process of creating a space for listening to the objects that embody his fears evidently have an almost therapeutic role in his practice. He obviously makes choices about what sounds to work with, and how, and through these choices he influences the outcome. The way he uses microphones and sensors relative to these objects is one of the more important aspects of his work. But his goal is to allow the objects to find their own voices and for the artist to take a step back. The sounds 'really speak for themselves', he says, adding that, however much an abstraction, the sounds' comparison to language only amplifies their impact.

The ethics of sound

Kirkegaard's works and working methods often prompt ethical considerations, both in their conception and in the materials they use, and potentially influencing their interpretation. I was curious to learn what he thought of this. For him, some of the answer lies in social norms that have changed dramatically in recent decades. Such attitudes can be simultaneously positive, natural, and problematic, and he has observed that a certain wokeness has had an impact on his practice. It is essential to Kirkegaard's work to address difficult issues, and any narrowing in the boundaries of acceptability will present a challenge to the evolution of his artistic practice.

Kirkegaard's fascination with the quality of the sounds he records is what distinguishes him from some of the sound artists who emanate from the visual arts, and whose relation to sound can be purely conceptual. The sound quality he is talking about centres on a certain balance in the sound: 'that the sound, purely acoustically, has some bass, some mid register, high end—that it has a quality that allows you to get *in to the sound*.' This could be attributed, at least in part, to Kirkegaard's background in music. He describes a method of working in which he sets in motion an iterative process, perhaps only partially controlled by him, that yields new things and new sounds. The listening experience that can come from this is open to changes in a mental state 'that is right in between the alienated and the well known'. He again points to the neutrality and the quality of the sound as the factors that facilitate this.

In our discussion, Kirkegaard often returned to his point that the role of his art is not to dominate the listener with conceptual and political truths. As an artist he is merely a facilitator; what he offers

FIGURE 2. Photo from the working on *Aion* (2006) at the Zone of Exclusion in Chernobyl, Ukraine. With permission from Jacob Kirkegaard.

you, the listener, is the chance to expand your understanding of the world, but it is up to you to do the work. It is a beautiful ambition that music should create a sensuous space that allows for this communication, and also a challenging one: 'It is only here that you can actually tell what you really think.' In this space there are no predefined expectations and no binary distinctions laid on you, and as the listener you have the freedom to develop your own opinion.

When I explore Kirkegaard's works it is clear he has succeeded in his ambition: this rare space, the space for sensuousness, can indeed be created through his music. His art pushes boundaries, as art should do, and does not shy away from the awkward questions. His pieces ensure the sounds to stand for themselves in all their beauty. The nature of musical sound as Kirkegaard frames it—neutral, devoid of unequivocal meaning—sparks many questions. Metaphors abound in traditional music theory to explain the meaning of certain sonic events, of which harmony is probably the most salient exemplified by the *dominant* chord: a sound with a specific, relational meaning. One of the greatest contributions by the American composer John Cage (1912–1992), encouraging the shift towards an aesthetic of sound for its own sake, the cornerstone of Kirkegaard's music, was to abandon harmony.

The discussion with Jacob Kirkegaard also left me thinking of another reality, which also pertains to Cage: the American transcendentalist philosopher Henry David Thoreau's *Walden* (1854, p. 105). In a short passage he rejected the symbolic meaning of the sounds of industrialization and asserted our right to define for ourselves what musical meaning they have: 'If the engine whistles, let it whistle till it is hoarse for its pains. If the bell rings, why should we run? We will consider what kind of music they are like'.

References

Thoreau, H. D. (1854), *Walden; or, Life in the Woods (Boston: Ticknor & Fields).*

Affective Touch and the Auditory Envelopment Hypothesis

Thomas Lund

In this essay I develop one aspect of 'slow listening', a concept put to the Audio Engineering Society (AES) and Tonmeistertagung conferences (Lund & Mäkivirta 2018), and which resulted in the hypothesis that auditory envelopment has physiological commonalities with affective touch.

Thanks to non-invasive in vivo experimental techniques, we have a better understanding of human perception, including the verification or rejection of psychological theories. The big questions are being revisited, such as how much we actively seek stimuli rather than receiving them, the many ways in which time can affect sensation, the distinctions between dynamic and static conditions, pattern recognition, unexpected sensory connections, or identifying signalling mechanisms in the body that complement neural pathways, to name a few. The immediate sensory recognition of external stimuli was an obvious place to start when we began investigating ourselves, and that is still the premise of most listening tests, relying for example on ABX comparisons (ITU 2015). However, the sensory system is constantly bombarded with competing information, leading to a data deluge that cannot be processed in real time. The brain is no larger or more energy-consuming than it absolutely must be, so an efficient way of cutting down on both size and energy is to rely more on prediction and less on sensory input. This is now an accepted model of perception—and

https://doi.org/10.37852/oblu.255.c613

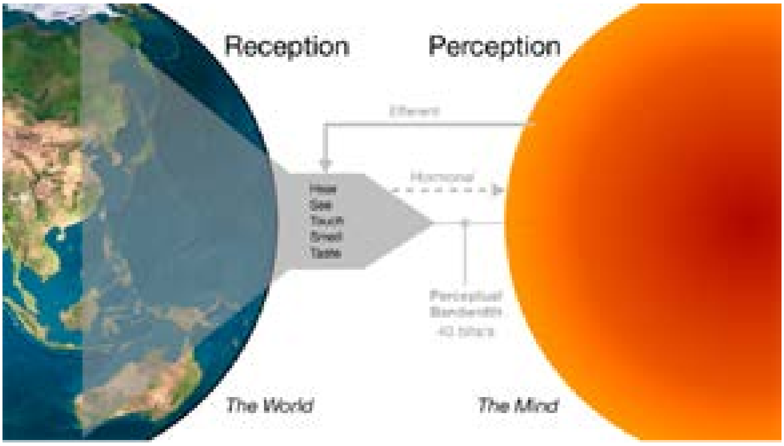


FIGURE 1 The five primary senses involved in exteroception, including the two funnels of human apprehension, afferent pathways and a modest perceptual bandwidth, efferent pathways, and hormonal longer-term modulation, the latter shown shown as a dotted line.

a recognized difference between children and adults (Gregory 1980; Siegler 1996; Friston 2012; Parr 2021). Therefore, we have to distinguish between the *reception* of stimuli, and how it is *perceived*, personally and dynamically.

Reception has a steep funnel associated with it (Fig. 1). Our sensory organs are attuned to conditions that pertain on Earth (the relevant mechanical waves, appropriate electromagnetic spectrum, suitable change-rates, etc.) and generally matter for the survival of a creature our size and composition, with our lifespan. Perception is distinguished from reception and based on a second funnel between the exterior world and our mental notion of it (Fig. 1).

Perception is entirely subjective. It is the outcome of sentient brain processing based on experience, expectation, mood, attention and—to some extent only—reception, and the perceptual bandwidth is known to be surprisingly low from a number of studies based on diverse methodologies (Lund & Mäkivirta 2018). New evidence for a human perceptual bandwidth of only around 40 bits/s is also given in a study of oral information rate across 17 languages (Coupé 2019) as 'biology

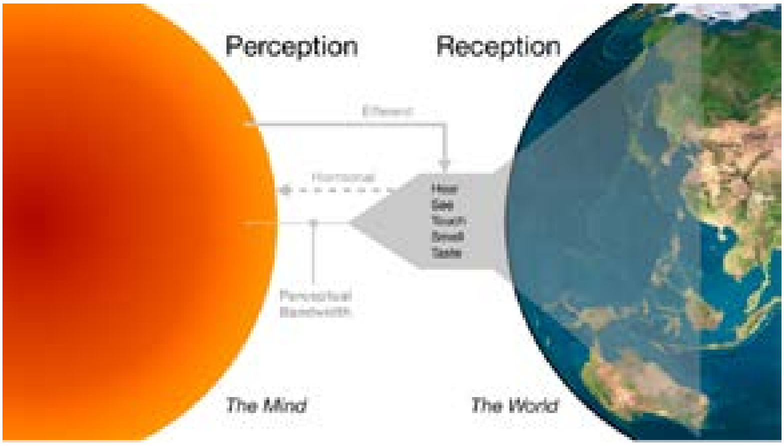


FIGURE 2 Human perception in adults in an updated model where active inference plays a major role. We are not passive receivers; we primarily reach out, based on prior experience and expectation.

under communicative pressures'. Due to the low perceptual bandwidth, perception is primarily a reach out, driven process (active inference) in humans and animals alike; sometimes, but not always, including overt behaviour (eye movements, sniffing, whisking). The brain is also a highly active participant in hearing, not only in the decoding of minute temporal information, but also as the main element of a sense that relies systematically on dynamic adjustments, comparable to saccadic movements of the eye (Friston 2012). In hearing, we overtly adjust head and body position when listening, but we also invisibly make use of a substantial number of efferent nerve fibres. Efferent fibres in the auditory nerve send information back to the middle and inner ears, adjusting each ear of the reception system itself, frequency selectively over a range of more than 60 dB. The active aspects of sensing (Fig. 2) say more than the traditional picture of reception (Fig. 1).

The systemic conditioning of the body may be driven by hormones rather than by neural pathways—for example. by the release of monoamines such as 5-hydroxytryptamine/serotonin, dopamine, melanin, or histamine into the tissues and bloodstream—by circadian rhythms, or by reward and pleasure responses by the brain. In a recent review (Lund & Mäkivirta 2018), we proposed the term 'slow listening' and with it the appropriate procedures for any attempt at a comprehensive, subjective assessment of sound, to complement untrained and trained listening, used in standard testing. Trained listening, for example, is required when detecting and understanding short-duration sounds, such as the phonemes or syllables of a particular language. Time thus plays a determining role in sensation, imposing formative changes on a lifetime scale, but it can also have an influence on intermediate timescales, where the word 'feeling' might be more appropriate than the immediacy of 'sensation'.

Sense of change

Our senses are tuned towards detecting change and movement, especially as identifiable patterns. We separate static from dynamic on timescales that are relevant to us; for example, to distinguish other agents from the scenery. Physiologically, the senses have change thresholds and/or filtering. The Eustachian tube is an example of such an ancient mechanical filter, focusing hearing on the kind of dynamic pressure changes that matter most in an evolutionary perspective. The same is true of eye physiology. We are highly sensitive to certain movements, and 99 per cent of our visual field (outside the fovea) is specialized in retaining important functionality in low light (scotopic vision). In a recent study, the responsible rod receptors in the retina are also found not to sacrifice detection of movement, while obtaining more light sensitivity than the cone receptors of the fovea (Field 2019).

From an evolutionary perspective, the next step is to determine if change and movement are threatening or benign. At close range we use touch for such assessments, and a class of low-threshold C-tactile mechanosensitive skin fibres are the biological substrate for the newly discovered affective and rewarding properties of touch, the Sahlgrenska Academy in Sweden being global pioneers in the field. C-tactile receptors respond to skin stroking of just the right force, speed and temperature, triggering a rewarding reaction from the striatal cluster in the brain. This causality is now widely accepted and regarded a potentially socializing mechanism of friendly touch (Vallbo 1993; Olausson 2010; McGlone 2014).

However, permitting other living beings to be intimately close to confirm their friendliness is risky, so we naturally use additional cross-modal indicators to evaluate movement, behaviour, and motives in others. Hearing is involved when interpreting sounds and words, but as described below, the auditory system might possibly also detect 'Goldilocks conditions' comparable to friendly touch, which might serve a soothing and socializing purpose too.

Envelopment

Listener envelopment (LEV) has an agreed meaning in acoustical engineering, but that is not how the term is used in this essay. Here, envelopment is a definable sensation or feeling, requiring a human listener to be part of the equation. There may also be a measurable, biochemical component to encountering it, for example a local or systemic release of monoamines.

Natural places where we tend to experience envelopment include sharing a large acoustical space with an orchestra or choir, where the concert hall or the church is part of the listening experience. The swirling sound patterns created in such pristine spaces were studied and described decades ago (for example, Griesinger 1998), and noted by the author when responsible for widely recognized reverb designs, used with music for playback in relatively small reproduction rooms. On those occasions when envelopment is felt outdoors, observable movement is generally involved: breaking waves when standing on a seashore, trees in a forest, or falling rain. Generally, though, we do not come across envelopment outdoors, where the norm is sound from uncorrelated, discrete sources located at different places in 3D space. Floyd Toole has recently suggested[1] using 'immersive' to describe an

1 Private Communication with Floyd Toole. Oak Park, CA. January 2020.

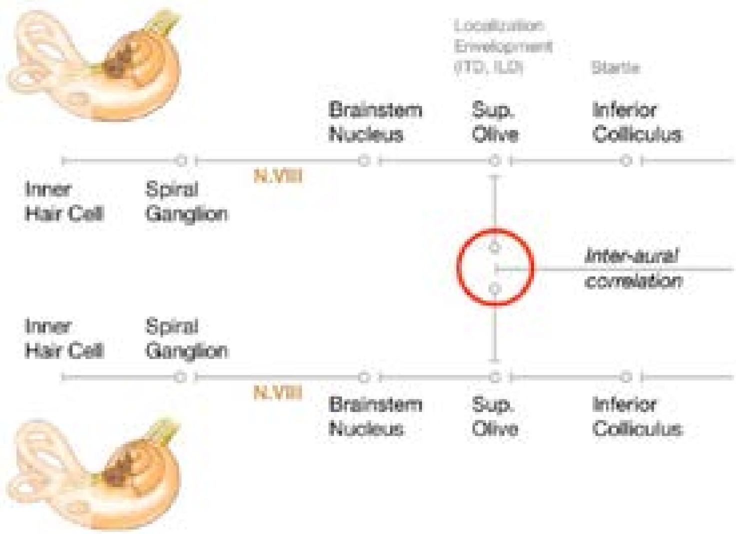


FIGURE 3 Elements of the early, primary auditory pathway, connecting to the thalamus and auditory cortices. Fast interaural synapses of the brainstem (e.g. calyx of Held) are illustrated by the red circle.

outdoor sound scenario, which is often how sound for cinema or drama is produced, but 'enveloping' when qualifying an in-door music recording.

The early auditory pathway of the brainstem has several ahead-of-consciousness qualities associated, for example, startle reflex, localization, proximity, and detection of change (Fig. 3). The inter-aural correlation nodes include the fastest firing synapses of the body (Hermann 2007), up to 700 Hz or 20–50 times the norm, with increased fidelity at low frequencies (Kaczmarek 2023), and they remain largely active also during sleep.

Such refined, energy-hungry anatomical structures must have good evolutionary reasons, which could be to detect aural patterns of movement precisely and quickly, possibly pre-categorizing them as friendly or threatening. If this were the case, it would be reasonable to theorize that it influences behaviour from positive (bonding) via neutral (relaxation) to negative (hostile or mobilization), with a suitable urgency.

Threat reactions would be triggered by fast internal signalling (neural pathways), while positive assessments of just the right type could be slower with systemic conditioning (hormonal), such as in response to friendly touch. Besides a general understanding of song and music as signs of friendliness or bonding, specialized physiology could contribute to such ubiquitous human reactions associated with music (Salimpoor 2011), or possibly even be their foundation.

Because of the way acoustics work, singing or playing music indoors is an effective way of promoting inter-aural fluctuation patterns in listeners. How such patterns move around, as a result of varying pitch, depends on the acoustical space, but classic concert halls all share this quality when music is played. Most listeners also find that kind of spaces remarkably stimulating, and there is experimental, qualitative evidence that our striatal system indeed engages when we listen to music or sing in certain indoor conditions—when envelopment is experienced. However, music in general has also been shown to trigger striatal responses in listeners (Zatorre 2013), so our experiments were done with neutral, non-music, low frequency (LF) test signals to investigate listener responses when subjected to varying degrees of inter-aural correlation. Further, tests were done with untrained as well as trained listeners.

We found everyone could hear a difference, and even children aged 6 associated correlated LF sound with a small space and uncorrelated LF sound with a larger space. In one experiment, delivering audio using open Sennheiser HD600 headphones, seven children aged 6–9 were asked if they could tell a difference, and then explain what they heard in their own words. They all could hear a difference and used words with similar meanings, such as 'small' or 'locked up' (Dan. *lille, spærret inde*) about correlated LF stimuli and 'large' or 'free' (Dan. *stor, fri*) about uncorrelated, abstract LF stimuli. Additional studies are required, but qualitative results from experienced listeners and the pilot study with children (Fig. 4) suggest humans from an early age naturally distinguish between three classes of enveloping auditory stimuli between 20 and 700 Hz, noted across all test subjects: (1) a high, static LF correlation, associated with a small listening space; 2)

FIGURE 4 Child aged 6, listening to a selection of loudness-normalized, correlated and uncorrelated abstract LF sounds.

a low, dynamic random LF correlation, associated with movement and/or a large, indoor listening space; and (3) a low, dynamic pattern LF correlation, again associated with movement and/or a large, indoor listening space.

The prerequisites for a hall or test signal to generate a pronounced feeling of envelopment appear to be a low interaural correlation at low and very low frequencies at the listening position, with a sensation of identifiable, moving patterns possibly amplifying the effect further. In the case of dynamic patterns, to maximize the feeling of envelopment, the perceived velocity of movement should likely remain within the 'Goldilocks' conditions at least in terms of velocity and strength. Further studies are required, but angular velocities around 0.5 rad/s have been used successfully in pilot studies.

The research agenda

Based on the present hypothesis, reactions to auditory envelopment are a potential confounder when the striatal effects of music listening are investigated, so the two should be studied separately. To investigate the outcome when subjects are only experiencing pleasantly dynamic interaural LF conditions, non-music, 20–700 Hz interaural test signals should be used as stimuli. In addition to self-reporting and behavioural assessment, dynamic (long-term) brainstem and/or brain responses can be used as objective measures of the physiological response, for example by means of functional near-infrared spectroscopy (fNIRS) or functional MRI (fMRI). The latter, however, has proven a challenge, due mainly to interfering noise generated by the scanner itself. If stimuli are administered through over-ear, on-ear, or in-ear headphones, care must be taken to restore an LF and VLF influence comparable to a natural in-room experience, for example similarly stimulating both aural and haptic pathways. If stimuli are administered via an in-room loudspeaker system, it is important not to distort test signals significantly by the reproduction room acoustics, which is not trivial with small rooms and LF test signals (Fig. 5).

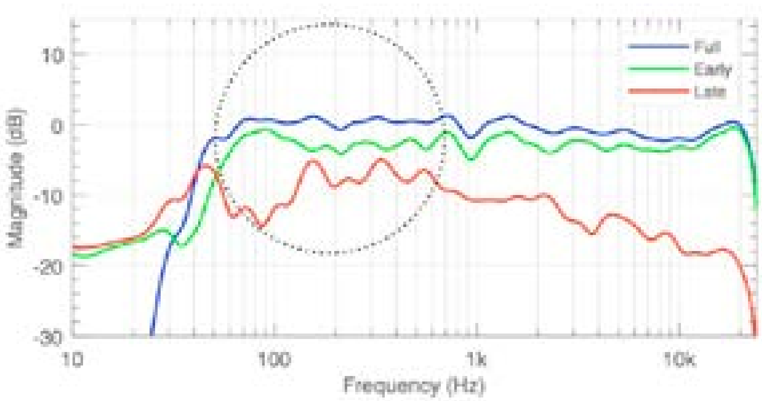


FIGURE 5 Test signals investigating audibility or reaction to potentially enveloping stimuli must ensure the reproduction room does not distort the stimulus, especially in the important 50-700 Hz range (the dotted circle). Measurement for a given loudspeaker and subject placement in a particular room. Genelec GRADE acoustical report.

More than just music

For thousands of years people have sung or played music indoors, whether in caves, cathedrals or concert halls, and it has a recognized potential for stimulating listeners. There are, however, theoretical reasons and qualitative evidence that the sensation or feeling of envelopment in itself, and not only the music, could be a factor in striatal engagement and therefore an important quality to preserve in the recording, distribution, and reproduction of audio.

The hypothesis may be further studied using quantitative subjective trials and a mix of music and test sounds, or by the objective measurement of activity in the striatal system. If proven, certain auditory patterns of 'friendly movement' are not just personally stimulating, they could also promote bonding and social behaviour.

References

Coupé, C., Y. M. Oh, D. Dediu & F. Pellegrino (2019), 'Different languages, similar encoding efficiency: Comparable information rates across the human communicative niche', *Science Advances* 5. doi: 10.1126/sciadv.aaw2594

Field, G. D., V. Uzzell, E. J. Chichilnisky & F. Rieke (2019), 'Temporal resolution of single-photon responses in primate rod photoreceptors and limits imposed by cellular noise', *Journal of Neurophysiology* 121, 255–268. doi: 10.1152/jn.00683.2018

Friston, K., R. A. Adams, L. Perrinet & M. Breakspear (2012). 'Perceptions as hypotheses: Saccades as experiments', *Frontiers in Psychology* 3. doi: 10.3389/fpsyg.2012.00151

Gregory, R. L. (1980), 'Perceptions as hypotheses', *Philosophical Transactions of the Royal Society B: Biological Sciences* 290(1038).

Griesinger, D. (1998), 'General Overview of Spatial Impression, Envelopment, Localization, and Externalization', paper given at the 15th AES International Conference on Audio, Acoustics & Small Spaces (Oct.), paper 15-013. www.aes.org/e-lib/browse.cfm?elib=8095

Hermann, J., M. Pecka, H. von Gersdorff, B. Grothe & A. Klug (2007), 'Synaptic transmission at the calyx of Held under in vivo-like activity levels', *Journal of Neurophysiology* 98(2), 807–820. doi: 10.1152/jn.00355.2007

ITU (International Telecommunication Union) (2015), 'Recommendation BS.1116: Methods for the subjective assessment of small impairments in audio systems' (Feb.), updated 18 July 2023. www.itu.int/rec/R-REC-BS.1116

Kaczmarek, L. K. (2023), 'Modulation of potassium conductances optimizes fidelity of auditory information', *Proceedings of the National Academy of Sciences* 120(12). doi: 10.1073/pnas.2216440120

Lund, T. & A. Mäkivirta (2018), 'On Human Perceptual Bandwidth and Slow Listening', paper presented at the 2018 AES International Conference on Spatial Reproduction: Aesthetics and Science (July), paper P6-2.

McGlone, F., J. Wessberg & H. Olausson (2014), 'Discriminative and Affective Touch: Sensing and Feeling', *Neuron* 82(4), 737–755. doi: 10.1016/j.neuron.2014.05.001

Olausson, H., J. Wessberg, I. Morrison, F. McGlone & Å. Vallbo (2010), 'The neurophysiology of unmyelinated tactile afferents' *Neuroscience & Biobehavioral Reviews* 34, 185–191. doi: 10.1016/j.neubiorev.2008.09.011

Parr, T., N. Sajid, L. Da Costa, M. B. Mirza & K. J. Friston (2021), 'Generative Models for Active Vision', *Frontiers in Neurorobotics* 15. doi: 10.3389/fnbot.2021.651432

Salimpoor, V. N., M. Benovoy, K. Larcher, A. Dagher & R. J. Zatorre (2011), 'Anatomically distinct dopamine release during anticipation and experience of peak emotion to music', *Nature Neuroscience* 14, 257–262. doi: 10.1038/nn.2726

Siegler, R. S. (1996), *Emerging minds: The process of change in children's thinking* (Oxford: OUP).

Vallbo, A., H. Olausson, J. Wessberg & U. Norrsell (1993), 'A system of unmyelinated afferents for innocuous mechanoreception in the human skin', *Brain Research* 628. doi: 10.1016/0006-8993(93)90968-s

Zatorre, R. J. & V. N. Salimpoor (2013), 'From perception to pleasure: Music and its neural substrates', *Proceedings of the National Academy of Sciences* 100(supp. 2), 10430–10437. doi: 10.1073/pnas.1301228110

Listening to the Universse

Leif Lönnblad

My topic is listening to the universe.[1]

Listening to the smallest things and the biggest things in the universe. Keep in mind that I am a theoretical physicist, so when I hear the word 'sound' I think of wave motions in a medium as particles. The small wave motions I work with lead to phenomena such as quantum mechanics. I will also discuss things that sound in space (there are still some waves, though actually you cannot really hear anything in space). I will concentrate on two fairly new discoveries. One is the discovery of the Higgs particle, which gave Peter Higgs and Francois Englert the Nobel Prize in 2013. The other is the discovery of gravitational waves, which gave the Nobel Prize to Kip Thorne, Rainer Weiss and Barry Barish in 2017.

First, I will explain how I understand sound and waves in a medium. Sound is vibrations or pressure waves in the air—other waves I can mention are light, which is electromagnetic waves in electromagnetic fields, and gravitational waves, which are disturbances in the curvature of space-time. What is interesting is that there are different kinds of waves. Sound is a pressure wave. This means that we can describe sound by giving each point in space and time a number, which is the air pressure at that point. And this pressure can spread. Light is different as it has direction. It has a strength at every point, but also a

1 This essay is based on a lecture given at the Trances of Sound symposium at Lund University's Sound Environment Centre on 27 September 2021. I would like to thank Sanne Krogh Groth for transcribing the lecture.

https://doi.org/10.37852/oblu.255.c614

direction, and we sometimes talk about polarized light. When it comes to gravitational waves, things are even more complicated.

As a particle physicist, I study the smallest elements of the universe. I focus on quarks and gluons, which build up protons and neutrons, atomic nuclei (together with electrons), atoms, molecules, cells, and ultimately us. There are large orders of magnitude between these elements: I am about one metre in size; cells are about one-hundredth of a millimetre; molecules are down to nanometres; atoms are ten times smaller than that; atomic nuclei are even smaller. The particles I study are smaller than a billionth of a billionth of a metre.

When it comes to such small things, things get a little tricky. A particle does not have a definite position. It is associated with uncertainty. So, what it really has is a probability distribution. There is a probability that it exists in one place *or* another. We call that distribution a wave function—it behaves like a normal wave in any medium. When you do not look at a particle, it behaves like a wave motion—it interferes with other particles, and it can be refracted like light is refracted in a prism—but when we observe it, then it acts as a particle. The fact that all particles can be described as waves also means that all waves can be described in terms of particles. We can describe the electromagnetic waves, or light, in terms of the flow of photons. It is the same for sound. Sound waves can be described as particles, which we call phonons. Normally, it is not practical to use the particle properties of sound, but when looking at vibrations in crystals it makes sense to use phonons.

The electrons and quarks I study are also wave motions in their respective fields. Electrons are waves in an electron field, and quarks are waves in a quark field. I work with the standard model for particle physics. What we know about the smallest constituents of the universe is that everything is made up of quarks and leptons. *All* matter is quarks and leptons. We talk of 'down-quarks' and 'up-quarks'. The usual leptons are the electrons, but there are also some called 'neutrinos'. We have several different varieties: we have heavier varieties of quark. They are not normally found in nature, but can be formed in violent collisions. There is another family of lepton, and there are also antiquarks and antileptons, all of them with their own fields, in which they can be described as wave motions. That is what everything consists of.

Then there are forces, such as the electromagnetic force. These forces are also described by wave motions in a field and can therefore also be described in terms of particles. There are photons for the electromagnetic field, and other particles and fields that I will not go into here.

Every force and every particle is described by quantum field theory. Take the Lagrange density function for the standard model of particle physics. It describes how different quantum fields, such as quark fields, interact with different force fields, such as the gluon fields. Or how leptons interact with the electric field. It has proved to be an extremely successful formula: almost all observations we have ever made in the microcosm are consistent with it; all matter and all forces are described by it. In theory, it is almost all we need to know. [See fig. 1]

The key word being almost. It describes everything we can see in the universe, but there are things in the universe we cannot see. In addition, the formula was initially inconsistent, because the fields in quantum field theory require that all particles are massless. They are not. Electrons and quarks do have mass, which was a significant problem

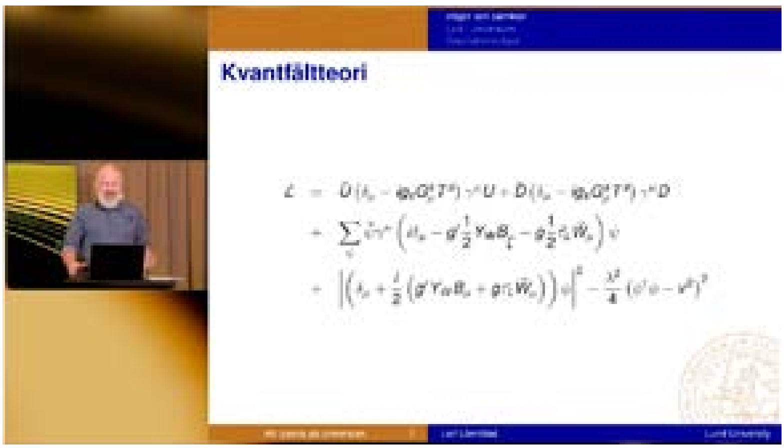


FIGURE 1 Lagrange density function.

for the theory. It was not until the 1960s that the last term was added. What was added is the Higgs field, and it is rather special because it solves the problem with masses in the following way. The Higgs field is assumed to be found all over the universe, and everywhere it has a value that is not zero. Different particles interact with the Higgs field in different ways. Heavy particles interact with the Higgs field more, and for them the field becomes quite difficult to get through. This means that a particle does not really have a mass, but it looks like that when it moves forward due to its interaction with the Higgs field. This worked exceptionally well, except for one detail: if there is a field, where there can be wave motions, there must also be a particle, the Higgs particle. And no one had seen it, and in the end it took 40 years to find. It has a mass and interacts with its own field. It acts as a resonance in the field. The field is special, as it is scalar: just like sound, it does not have any direction; it is just a change in density in the field.

How to find the Higgs particle? Use the Large Hadron Collider at CERN in Geneva. It consists of a 27-kilometre circular tunnel, where we accelerate protons and collide them with one another. The tunnel has superconducting magnets to get the protons up to extremely high energies. The protons travel both clockwise and anticlockwise in two separate tubes, and in some places the beams have been aligned so that they can collide. At these collision points are gigantic detectors to see what comes out. What we get when we collide two protons is enormous: in just one collision the energy is so high that hundreds of particles are formed and are spread out in all directions. The question is, how to find a Higgs in such a collision? [See fig. 2]

From the theory we can calculate that the probability of a Higgs particle being formed in a collision like this is small. So, there will be a great many collisions that we do not care about—that are just noise. In the noise we try to find the tiny signal of a Higgs particle by using the way it decays. We do a kind of frequency analysis. By looking at light particles coming out of the collisions, we search for the frequency corresponding to the resonance frequency of the Higgs field. [See fig. 3]

We have a background that is a green line that is equivalent to noise. Just as in a regular frequency spectrum of sound, noise gives you a

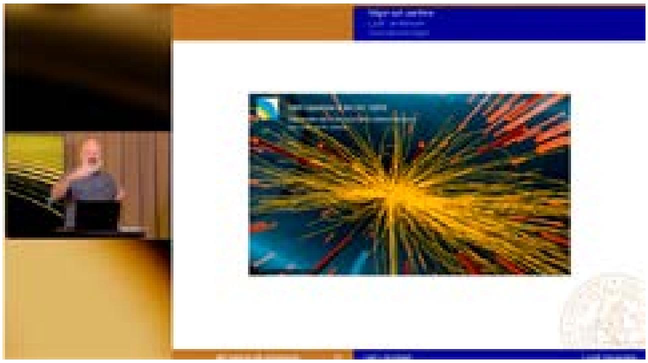


FIGURE 2 Higgs particle.

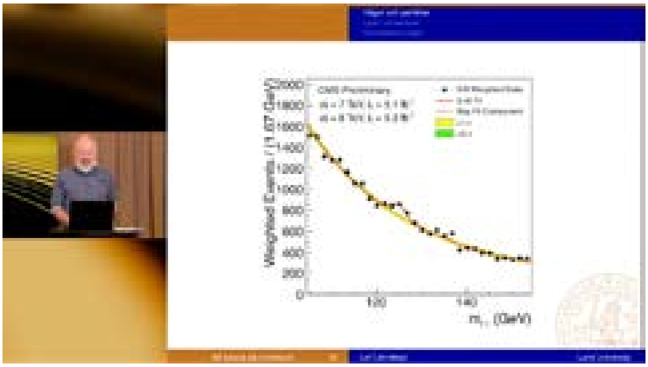


FIGURE 3 Hearing the Higgs particle.

smooth curve. The little bump is a resonance that we can 'hear'. It is the Higgs particle. A little simplified, but in principle this is how we look for particles in the microcosm. We listen.

If we now turn to large, even cosmic, scales, we can still listen to the universe. It is said that in space no one can hear you scream, because sound must have a medium—air. And in space there is a vacuum. Although that is not completely true, because there is a good deal of gas in space, and this can in principle transmit sound. Not the kind of sound we can hear, because the wavelengths are too long to hear. In the beginning the universe consisted of dense gas, following the Big Bang, about 15 billion years ago, when everything was hot—so hot that

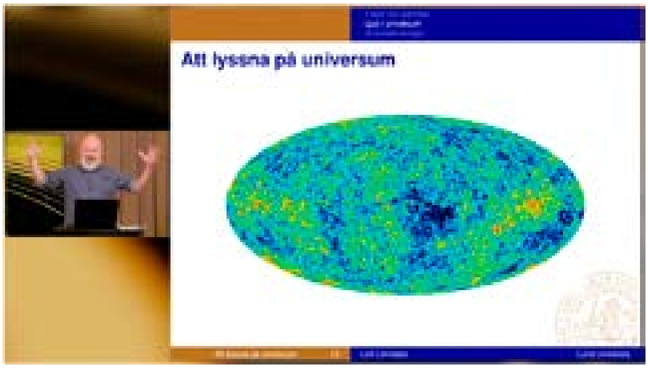


FIGURE 4 The universe 13 billion years ago.

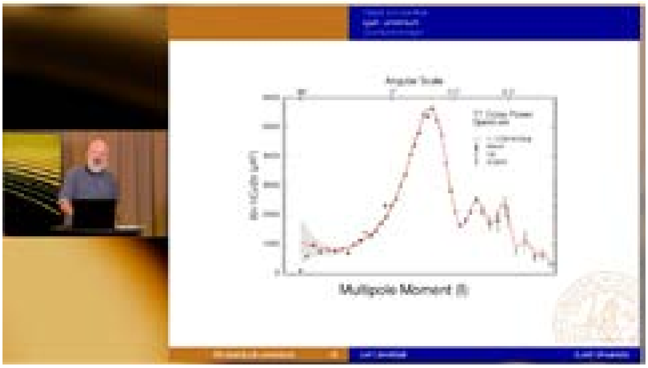


FIGURE 5 A frequency analysis of the universe.

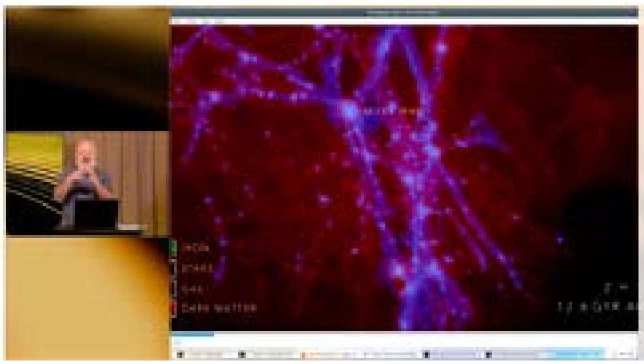


FIGURE 6 A simulation of the universe.

it was plasma. After 300,000 years, the plasma cooled so much that atoms were formed everywhere. The whole universe was filled with a dense, hot gas. [See fig. 4]

That is what the universe was like more than 13 billion years ago. Everything was a gas and it had almost the same temperature, 3000 degrees. Cosmic background radiation tells us there were small differences and the gas was in places one-tenth of a degree warmer and in some places one-tenth of a degree colder. So, a gas that was hot, under high pressure, and expanding, but with differences—and pressure differences. And those differences created sound. [See fig. 5]

Look at a frequency analysis of the universe and we see clear resonances from which we can tell what the universe looked like in the beginning, and from that, what exists in the universe. It turns out that only 5 per cent of the energy is matter we know about. There is also a great deal of energy that comes from dark matter and dark energy that we know little about. Put it altogether and we can find the initial state of the universe. We can do simulations of the universe over billions of years, as in an example by my colleagues in Lund, Oscar Agertz and Florent Renaud. [See fig. 6]

There were different temperatures, and different pressures in different parts, that made gravity put things together in a specific way. We see how stars were drawn together into galaxies and how they travelled around. We see what would soon be the Milky Way—our galaxy. We see how everything interacted as galaxies collided and gas dispersed in all directions. The gas expanded and there were whirlwinds in the gas, which meant there was also sound there. Thus there are sounds in the universe. We cannot hear them, but we can simulate them.

Turning to gravitational waves, it helps to know something of the general theory of relativity. Most people know of Einstein's theory of relativity and will have seen the formula $E = mc^2$. This is the special theory of relativity; the general one is more complicated. [See fig. 7]

One place to begin is the Pythagorean theorem for a right-angled triangle: the square of the hypotenuse is the sum of the squares of the other two sides. But this is not true for all triangles. If you make a triangle from, say, the North Pole that goes down to the equator and

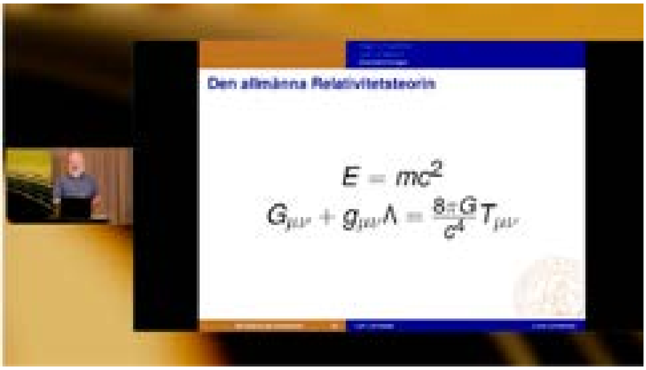


FIGURE 7 The general theory of relativity.

FIGURE 8 Two neutron stars.

measure the lengths of the sides and the base, the Pythagorean theorem no longer applies. That is because the earth's surface is curved; because the earth is a globe the Pythagorean theorem does not apply to large triangles on the surface of a sphere—sorry, Flat Earth Society. However, we can take the curvature of the earth into account by using modified Pythagorean theorem in three dimensions rather than two. In the theory of relativity we can even add the time dimension. That is exactly what is in the form of the general theory of relativity. It tells us, if we are looking at a coordinate system in space and time, how the Pythagorean theorem works there.

Yet even the four-dimensional continuum (three dimensions of space and one in time) is curved. It is curved by heavy things. If we have a coordinate system and a heavy star, the space-time will curve in some way. If something is curved and something moves, the curvature will spread. This is a state of two neutron stars. [See fig. 8]

They are terribly heavy and roll around each other in a closed system. They send out waves in the fabric of space-time. These waves had never been seen when Einstein claimed that they existed in 1915, but now we have finally been able to see them. The way we saw them—because they are difficult to see—is that we imagine an even heavier system. Take two black holes that are gravitationally bound to each other, that spin around each other: when they emit gravitational radiation, they lose kinetic energy and get closer to each other and spin faster and faster. Eventually, the two black holes will collapse into one. In the collapse, an immense quantity of energy is emitted, and that energy could perhaps be seen as waves that spread from the collapse.

These gravitational waves are special. When the wave hits the earth, the space will stretch out in some directions and shrink in other, in a wobbling kind if motion. The waves are not one-dimensional like neither sound, nor two-dimensional like electric waves. At the same time as the space expands in one direction, it contracts in another, so the waves are almost three-dimensional. What we saw was an exaggerated effect on the earth. What really happens is that the waves expand and contract the space by tiny amounts, smaller than the size of an atomic nucleus. They are weak waves: even though a lot of energy goes out, the waves become weak because the gravity is weak.

An experiment has been done using laser interferometers, where researchers accurately measure distance differences in two directions. They send in a laser beam that is divided into two in a semi-transparent mirror. They send the beams four kilometres in different direction to mirrors, sending them back in the opposite direction, and combining the beams again so that they interfere destructively with each other. If the mirrors at each end are perfectly still you will not measure any light coming back; move a mirror even the tiniest bit, however, and the interference is broken and you get a signal.

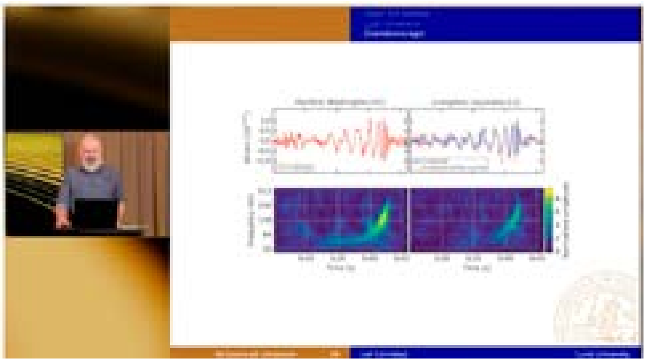


FIGURE 9 Measurements taken during the 2015 tests.

It is complicated. There is a lot of noise, things vibrate all the time, there are thermal movements, a lorry driving by, small earthquakes. To accommodate that we have two almost identical laboratories—one in Washington State and one in Louisiana—and we look at things in exactly the same way in both places. In 2015, when they were testing the equipment before starting proper measurements, they found a signal that appeared to be noise, but looking at one place, they could see it looked the same as in the other place. [See fig. 9]

This is exactly what we would expect to find if there was a gravitational wave, which first hits one place and a fraction of a second later hits the other. That is how the first proof was found that it is possible to detect gravitational waves. Calculations were made and they came to the conclusion it was a collision between two black holes, one weighing 30 times more than our sun, the other 35 times more, which had collapsed into a single black hole that weighed 62 times more than our sun. The rest of the three solar masses had been sent out as gravitational waves. The energy emitted was greater than the total radiation from all the stars in the entire universe. Thankfully it was far away—1.2 billion light years—so there is no cause for concern.

The striking thing about it is that the wave motions are in the audible spectrum. So we can listen to what it sounds like when two black holes collapse. A weak, squirp-like sound. That is what the biggest explosion ever recorded sounds like.

Publications from the Sound Environment Centre at Lund University

20. Henrik Frisk and Sanne Krogh Groth (eds.) *Traces of Sound. Reflections of Sound Unheard*. 2023.
19. Sanne Krogh Groth and James G. Mansell (eds.) *Negotiating Noise. Across Places, Spaces and Disciplines*. 2021
18. Gunnar Cerwén, Frans Mossberg (red.). *Tysta områden i Sverige. En kartläggning av initiativ, kunskap och erfarenheter*. 2018
17. Huotilainen Minna, Irene van Kamp, Kerstin Persson Waye, Anita Gidlöf-Gunnarsson, Mette Sörensen, Bridget Shield, Jonas Christensson, Frans Mossberg (red.). *Child & Noise. How does the child percieve the sound environment?* 2017
16. Frans Mossberg, Skärbäck Erik. *Grönska och ljudkvalitet i närmiljön. Hårda fakta för mjuka värden*. 2016
15. Barbro Westerholm, Maria Albin, Magnus Lindqvist, Dag Glebe, Erik Skärbäck, Mette Sörensen, Kerstin Persson Waye, Frans Mossberg (red.). *Bo i Ro. Texter från ett tvärvetenskapligt symposium om boende, buller och hälsa. Läkaresällskapets hus i Stockholm, den 20 oktober 2016*. 2016
14. Mats Arvidson, Mikael Strömberg, Anders Mildner, Louise Wassdahl, Ola Stockfelt, Frans Mossberg (red.). *Ord om Ljud. Skriftställare om ljudmiljöer och ljud*. 2015
13. Frans Mossberg (red.). *Sound, Safety & Society - Research on Sound & Sustainability*. 2015
12. Frans Mossberg (red.). *Care for Sound. Sound Environment, Healing & Health Care*. 2014
11. Frans Mossberg (red.). *Buller i blåsväder. Texter om ljud från vindkraftverk*. 2011
10. Jonas Brunskog, Viveka Lyberg Åhlander, Anders Löfqvist, David Pelegrin Garcia, Roland Rydell. *Speakers Comfort and voice disorders in classrooms*. 2011
9. Frans Mossberg (red.). *Ljudmiljö, hälsa och stadsbyggnad*. 2011
8. Frans Mossberg (red.). *Sound, mind and emotion - research and aspects*. 2008
7. Frans Mossberg (red.). *Ljud och tystnad för sinne och själ. Betydelser av ljud och tystnad för själslig och mental rekreation*. 2008

6. Frans Mossberg (red.). *Sounds of history*. 2008
5. Frans Mossberg (red.). *Ljud och inlärning*. 2007
4. Frans Mossberg (red.). *Skadliga ljud*. 2006
3. Frans Mossberg (red.). *Operativa ljud*. 2006
2. Frans Mossberg (red.). *Förföriska ljud*. 2006
1. Frans Mossberg (red.). *Buller och hälsa*. 2006
0. Stig Arlinger, Bengt Holmstrand, Henrik Karlsson, Leo Nilsson, Ludvig Rasmusson, Torbjörn Stockfelt, Ola Stockfelt, Mikael Strömberg: *Manifest för en bättra Ljudmiljö*. 2006 (ursprungligen publicerat av Kungliga Musikaliska Akademien 1995).