MPRG EPISTEMES OF MODERN ACOUSTICS
Max Planck Institute for the History of Science
Boltzmannstraße 22
14195 Berlin
Conference Room

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MAX-PLANCK-INSTITUT
FÜR WISSENSCHAFTSGESCHICHTE

Deutsches Museum

Sonderforschungsbereich 980
EPISTEME IN
BEWEGUNG

Working Group
Workshop I
September 15–16, 2016

SOUND OBJECTS IN TRANSITION:

KNOWLEDGE, SCIENCE, HERITAGE

Bells, stringed instruments, theater auditoria, pistols, phonographs, and synthesizers have a long history that is deeply entangled with the production of knowledge, science, and cultural heritage. The Working Group plans to bring these enmeshments to light, with a focus on three forms of sound objects: sound-generating, sound-transmitting, and sound-archiving objects. Alongside materially tangible objects (natural objects, artifacts, objets trouvés), the Working Group also considers immaterial sound objects (musical sounds, sounds of daily life, noise), passed on in written or pictorial form.

The Working Group asks when and how research objects became concrete objects, and what agency these objects have accrued in the domains of knowledge, science, and cultural heritage. We trace the role played by the objects' materiality in such processes. When did their materials, their value, their sound, their shape change? How did their spatial or cultural embedment mold their use? We are interested in the extent to which sounding objects formed part of codified actions, artistic or technological practices, and social networks. How did they collect or communicate tacit knowledge? At what points did sound objects mark the transition from practical action to scientific research? Did objects circulate between scientific disciplines? And where did sounding objects escape from their scientific contexts to become everyday, communicative, museum, or art objects? How was their sound described, visualized, measured, archived, exhibited, digitized? Finally, we ask where the history of these objects flows into conventional narratives and where they write their very own history over long periods of time.

Organizers:
Viktoria Tkaczyk (MPIWG)
Rebecca Wolf (Deutsches Museum)

REBECCA WOLF
Deutsches Museum, Munich

Music of Metallurgy: Bell-Founding Metal for Musical Instruments

There is probably no other substance more suitable for a *longue durée* study than bell-founding metal. Its elements are mined from the ground, molded with knowledge accrued in a long tradition of craft, and made for eternity with and under fire. This archaic procedure is used for making several instruments, including bells and parts of wind instruments. Writing in 1974 on the death knell or *glas*, Jacques Derrida showed that the word amalgamates implications of signal, noise, and call, especially by a trumpet or a bell. The production of such metals has also influenced the arts, especially music—most famously Richard Wagner's *Rheingold*. Miners developed their own connections between metallurgy and music. Besides singing folksongs and chorales, they played on instruments made of iron. The substance they worked with every day was used in a unique way to make music, primarily in percussion.

Wind instruments, which developed into melody instruments, are closely related to percussion instruments by way of similarities in their substance. Rhythm and melody are the basis of the wide range of musical elements that can be played on instruments made of bell-founding metal.

My paper focuses on the production of these different instruments made with the help of metallurgy, a very traditional craft with deep connections to nature and earth. It seeks similarities in the social and functional uses of music made by bell-founding metal. I begin from the twelfth-century description of bell-founding by Theophilus Presbyter (*Schedula diversarum artium*), who gives instructions for preparing the negative bell form for inscriptions and ornaments and producing a bell with rich harmonics. The paper's provisional end-point is a nineteenth-century report on a clarinet with a mouthpiece made of cast metal.

Rebecca Wolf leads the research group "Materiality of Musical Instruments: New Approaches to a Cultural History of Organology" at the Deutsches Museum, Munich. She worked on experiments with materials in musical-instrument building during a year at Harvard University's Department of Music in 2012, funded by the Alexander von Humboldt Foundation, and in 2015/16 was a research fellow in the Max Planck Research Group "Epistemes of Modern Acoustics" in Berlin. Rebecca Wolf completed her doctoral studies at the Free University Berlin and the University of Vienna. Her first book, *Friedrich Kaufmanns Trompeterautomat. Ein musikalisches Experiment um 1810* won the Award of Excellence of the Austrian Ministry for Science and Research. She teaches at the LMU Munich and the Technical University Berlin, and has published on organology, musical automata, music in peace and war, cultural history, and musical-instrument makers.

VIKTORIA TKACZYK
MPIWG, Humboldt-Universität zu Berlin

Inner Voices: A Long History of Soliloquies

This paper attempts a long history of the inner voice, discussing the role attributed to inner voices in the production of knowledge, science, and heritage. I focus especially on how historical concepts of the inner voice emerged, vanished, and reappeared in the period between 1500 and today—with the aim of developing a theory of "time leaps" in scientific concepts. The paper's pivotal point is French psychophysicist Gilbert Ballet's *Le langage intérieure et les diverses formes de l'aphasie* (1888). In this study, Ballet claims that human speech is accompanied by an "inner prompter." The inner prompter's voice is not identical with any real voice, but is a composite of many auditory impressions; it unfolds a life of its own in the memory and by that means gives the rememberer the ability to speak him- or herself. Ballet here connects two seemingly separate debates of his time: controversies among physiologists since the 1860s about whether or not the human faculty of speech (and the corresponding memory images) can be localized in the human brain, and long-standing philosophical debates about the origin of language and the nature and function of mental auditory images ("inner voices," "inner words"). My paper will, first, ask why and how these two debates could merge in the late nineteenth century, in response both to the interest of a wide range of scientific fields (such as speech therapy, psychoanalysis, or experimental aesthetics) in practices of soliloquy and to new technologies of sound recording and archiving. Second, it traces how Gilbert Ballet prepared the ground for continuing debates on the nature of what cognitive scientists today name "auditory imagery."

Viktoria Tkaczyk is director of the Research Group "Epistemes of Modern Acoustics" at the Max Planck Institute for the History of Science (MPIWG) and a professor at the Institut für Kulturwissenschaft, Humboldt-Universität zu Berlin. Her first book, *Himmels-Falten. Zur Theatralität des Fliegens in der Frühen Neuzeit*, was awarded the Ernst Reuter Prize in 2008 and the Book Award of the Amsterdam School of Cultural Analysis in 2012. From 2008 to 2010, she was a research fellow on the project "Theatrum Scientiarium. Performativity of Knowledge as Agent of Cultural Change" (Freie Universität Berlin), and in 2011 she carried out research as a Feodor Lynen Fellow at the Atelier de Recherche sur l'Intermédialité et les Arts du Spectacle (CNRS) in Paris. Between 2011 and 2014, she was Assistant Professor of Arts and New Media at the University of Amsterdam and a Dilthey Fellow at the MPIWG. Viktoria Tkaczyk is a member of the Junge Akademie at the Berlin-Brandenburg Academy of Sciences and Humanities. Recent publications include "Listening in Circles: Spoken Drama and the Architects of Sound, 1750–1830," *Annals of Science* 71/3 (2014), "The Shot is Fired Unheard: Sigmund Exner and the Physiology of Reverberation," *Grey Room* 60 (2015), and "The Making of Acoustics around 1800, or How to Do Science with Words," in *Performing Knowledge, 1750–1850*, ed. M. H. Dupree & S. B. Franzel (de Gruyter, 2015).

Thursday, September 15

10:00–10:15 Welcome Coffee

10:15–10:45 **Introduction**

Wave / Number

10:45–11:30
To Explain Consonance and Divide the Octave: Abstract Doctrines and Their Material Counterparts
H. Floris Cohen *Descartes Centre, Utrecht University*

11:30–12:15
Marin Mersenne and the Lost Knowledge of King David's Lyre
Jacomien Prins *University of Warwick*

12:15–13:15 Lunch

Glass / Metal

13:15–14:00
Music of Metallurgy: Bell-Founding Metal for Musical Instruments
Rebecca Wolf *Deutsches Museum, Munich*

14:00–14:45
Musical Glasses
Peter Pesic *St. John's College, Santa Fe*

14:45–15:15 Coffee break

Stage / Garden

15:15–16:00
Acoustic and Musical Realities: Performing Kunqu on Historical Stages and in Cultivated Gardens
Joseph S.C. Lam *University of Michigan*

Concert

17:00–18:00
Piano Recital "Music, Science and Nature"
Peter Pesic *St. John's College, Santa Fe*
Wayne Foster-Smith *Hochschule für Musik Hanns Eisler, Berlin*

Friday, September 16

10:00–10:15 Welcome Coffee

Air / Machine

10:15–11:00
Sounding the Voice Box: A History of Reconstructing the Avian Syrinx, 1750–Present
Joeri Bruyninckx *MPIWG*

11:00–11:45
Birds as Sounding Objects
Tiago de Oliveira Pinto *University of Music Franz Liszt Weimar & Friedrich Schiller University Jena / São Paulo*

11:45–12:00 Coffee break

12:00–12:45
Physical and Musical Objects: Vacuum Tubes throughout the Twentieth Century
Myles Jackson *New York University*

12:45–13:45 Lunch

Ear / Voice

13:45–14:30
The Ear and Its Objects: A *Longue Durée* View of Research in Auditory Physiology
Julia Kursell *University of Amsterdam*

14:30–15:15
Inner Voices: A Long History of Soliloquies
Viktoria Tkaczyk *MPIWG, Humboldt-Universität zu Berlin*

15:15–15:45 Coffee break

15:45–16:30
On the Nightingale: Myth as Sound Object(s)
Shane Butler *Johns Hopkins University*

16:30–16:40
Closing Remarks
Karin Bijsterveld *Maastricht University*

ABSTRACTS

JACOMIEN PRINS
University of Warwick

Marin Mersenne and the Lost Knowledge of King David's Lyre

In early modern Europe, the relationship between music, philosophy, and science underwent radical changes. While some of these transformations were recorded in texts, others have survived in non-verbal cultural media, notably in musical compositions, musical instruments, and scientific instruments used for studying acoustics. In my paper, I explore how the early modern scholar Marin Mersenne (1588–1648) made use of these various cultural forms to grapple with the venerable ancient doctrine of music's power to affect man's soul in the increasingly heterodox intellectual world of the seventeenth century.

In this period, music and the sense of hearing were seen as means of conveying order or disorder. Order, proportion, and harmony in music thus emerge as categories related to the structure of the universe as well as to the nature of humans. From the perspective of universal harmony, Mersenne emphasized the spiritual, moral, and healing power of music to affect man's soul. He saw music and the sense of hearing as important sources of spiritual and mental health, but also of disorder and disease. Inspired by the biblical example of David, who cured Saul of his mental illness by playing the lyre, Mersenne asked in his *Quaestiones celeberrimae in Genesim* ("The Most Frequently Asked Questions about Genesis," 1623) what kind of music is capable of curing a disordered rage. This question was part of Mersenne's main scholarly project to discover if it was possible to compose the most beautiful and powerful song, to identify the most superb consonances and ideal rhythms, and to determine how one might become the most perfect musician. Ultimately, these questions all converge in a ruling desire to recapture the affective power and beauty of ancient music.

In order to place this historical topic in the *longue durée* of ideas about healing song and musical instruments as auditory objects, I will analyze how Mersenne took the fifteenth-century humanist Marsilio Ficino as his guide in his *Quaestiones* and the sixteenth-century humanist Girolamo Cardano in his *Traité de l'harmonie universelle* ("Treatise on Universal Harmony," 1627). I will demonstrate how the history of the auditory objects of song and instruments influenced the European debate about the therapeutic potential of auditory perception in modern times.

Jacomien Prins is a Global Research Fellow at the Institute of Advanced Studies (IAS), the Centre for the Study of the Renaissance (CSR), and the Department of Philosophy of Warwick University. She has worked extensively on the interaction between music theory and philosophy in the Renaissance. Her work includes *Harmonisch labyrint* (Verloren, 2007), *Echoes of an Invisible World: Marsilio Ficino and Francesco Patrizi on Cosmic Order and Music Theory* (Brill, 2014), and an edition and translation of Marsilio Ficino's commentary on Plato's *Timaeus* (for the "I Tatti Renaissance Library" series, Harvard University Press, forthcoming). She is currently working on a project entitled "*A Well-tempered Life": Music, Health and Happiness in Renaissance Learning*.

TIAGO DE OLIVEIRA PINTO
University of Music Franz Liszt Weimar & Friedrich Schiller University Jena / São Paulo

Birds as Sounding Objects

My question is whether birds can be regarded as sounding objects. Certainly not in nature, but when trained and kept by humans, birds acquire characteristics of sounding or even music machines. Teaching songs to birds during long training sessions and having them compete in singing contests is a traditional practice still in use in several countries. The old skill of training the finch or the canary is linked to broader rituals such as Pentecostal celebrations or spring festivities. It preserves and puts into action the practitioners' tacit knowledge of the art of teaching birds "to sing beautiful songs." Singing bird contests have recently gained broader recognition as intangible cultural heritage on the basis of the UNESCO Convention of 2003.

Based on fieldwork in Germany, Brazil, and Thailand, my research project applies two different approaches to this phenomenon. The first focuses on transcultural aesthetics, when birds' songs are evaluated, classified, analyzed, and passed on to young birds; the second focuses on birds as culturally conceived and produced musical objects, not greatly different from sounding machines. I attend particularly to the mechanisms of song transmission, which in the past was carried out by mechanical means using "bird-song machines" and nowadays is achieved through electronic media such as audio devices. Unlike in the natural environment, birds growing up in a cultural setting learn to sing from human-made machines and devices. Does this explain why they become music machines themselves? Or is a home-kept singing bird the aesthetic achievement of human beings, inspired by nature to elevate natural sounds into culturally defined and appreciated, music-like sounds?

The intrinsic narratives of singing birds' sounds, which have been described, measured, and exhibited for a very long time, reveal much about people's deepest desire for aesthetic values and the emotions so closely attached to them. Bird singing contests offer an exceptional opportunity to appreciate a universal anthropological practice—the search for aesthetic satisfaction—which differentiated humans from animals in prehistory, determining much of our social and cultural evolution.

Tiago de Oliveira Pinto, born and raised in São Paulo, Brazil, received his PhD in Musicology from the Free University of Berlin in 1989. In 1990 he joined the International Institute for Traditional Music as a researcher. From 1996 to 2002 he worked for the Brazilian Foreign Ministry as director of the Brazilian Cultural Institute in Germany. In 2001 he was appointed full professor of social anthropology at the University of São Paulo (USP). He is Chair of Transcultural Music Studies at the University of Music Franz Liszt, Weimar, and since 2013 has served as an expert for the Intangible Cultural Heritage Committee of the German UNESCO Commission. Tiago de Oliveira Pinto has carried out fieldwork in Brazil, Portugal, Turkey, South-East Asia, Mozambique, Tanzania, and South Africa. He has published books, book chapters, and articles in international journals and curated art and ethnological exhibitions, as well as producing records and organizing musical festivals and cultural events.

JOERI BRUYNINCKX
MPIWG

Sounding the Voice Box: A History of Reconstructing the Avian Syrinx, 1750–Present

This paper traces the curious history of the avian voice box as a sounding object of scientific investigation. In the mid-nineteenth century, researchers discovered that birds are unique in their production of sounds. Unlike humans, who use primarily the larynx to generate sound, avian species possess a special vocal organ, the syrinx. Situated much lower than the human vocal cords, the syrinx long escaped study as a living, functioning organ, leaving scientists to guess at its mechanisms of phonation. Unable to tie the avian voice to its physical origins, at least anatomically, ornithologists relied on a wide variety of proxies: analogies, models, and experimental mechanical reproductions. Anatomical dissections of vocal organs, analogies with existing musical instruments, reconstructions in sensational speaking machines, or crude imitations through mechanical automata all provided important clues as to how the vocal apparatus of birds and humans might work. In the twentieth century, acoustical analyses seemed to confirm that the syrinx produces two simultaneous voices, leading to a reconceptualization of voice in both mechanical and linguistic terms. As biologists integrated their bird subjects with elaborate technological systems (hearing aids, miniature speakers, or cameras) that allowed the voice box to be studied and manipulated from the inside, the understanding of bird voice shifted again. In this paper, I survey the long history of bird-song physiology between 1750 and the present to trace how the avian voice box has been conceptualized and reconstructed alternately as a mute theoretical object and as a live, sounding object. This involves examining the various conditions under which such sound objects embodied preexisting conceptions of voice production or helped to materialize new kinds of insights—scientific or otherwise.

Joeri Bruyninckx is a research scholar in the Max Planck Research Group "Epistemes of Modern Acoustics," Max Planck Institute for the History of Science (MPIWG), Berlin, and at Maastricht University (Netherlands). He is completing a manuscript on the history of sound recording and listening in ornithology (forthcoming with MIT Press), and preparing a research project on psychotechnics and acoustics in the workplace. He has published in the *Oxford Handbook of Sound Studies*, *Acoustic City*, and *Social Studies of Science*.

SHANE BUTLER
Johns Hopkins University

On the Nightingale: Myth as Sound Object(s)

My paper will seek to sound out a particular myth by considering three sound objects key to it: the human voice, poetry, and the nightingale. The first object (voice) is, of course, both paradigmatic to sound studies and source of many of its deepest puzzles. The sounds of the second (poetry) have become so unfashionable that recent critics seldom refer to them except disparagingly or with embarrassment, though they were uncontested elements of poetic value until at least the nineteenth century. The third (the nightingale) makes a surprising (or not) cameo at the start of one of the most important contributions to contemporary theories of sound and voice: Mladen Dolar's *A Voice and Nothing More*. That this third object might have something to do with the second will already be suspected by anyone who knows John Keats's "Ode to a Nightingale," a famous poem if there ever was one. But Dolar's anecdote reaches farther back, to classical antiquity, where the nightingale and other songbirds thought to sound human exerted a particular hold on the poetic and mythographic imagination. The ancient triad of voice, poem, and birdsong achieves its finest and most horrific expression in the story of Philomela as told by Ovid in his *Metamorphoses*, to which my paper will devote most of its attention.

Shane Butler, Professor of Classics at Johns Hopkins University (Baltimore, USA), works on Latin literature from antiquity through the Renaissance. His special interests include media history and theory; sensation, cognition, and aesthetics; rhetoric and poetics; the history of sexuality; classical reception; and the history of classical scholarship. His most recent monograph explores the role of the voice in the making and reading of classical literature, with insights drawn from later analogues (*The Ancient Phonograph*, 2015). His most recent edited volume considers how the study of a distant, buried, and never fully recoverable past reflects and enables other aspects of our relationship with our lives and our world (*Deep Classics: Rethinking Classical Reception*, 2016). He presently is co-editing a volume that surveys the soundscapes of the ancient world (*Sound and the Ancient Senses*, with Sarah Nooter, forthcoming 2017). He also is drafting a monograph on passion.

PETER PESIC
St. John's College, Santa Fe

Musical Glasses

Glasses have a long history as sound objects used to demonstrate the connection between numbers and musical intervals. Already in the fifteenth century, illustrations of ancient Pythagorean scenes included sets of glasses, raising the question of their real antiquity. In this paper, I would like to explore the changing technology of glass-making in relation to its use for such sonic demonstrations. By the eighteenth century, glasses had become autonomous musical instruments, assembled into the armonica by Benjamin Franklin. I will examine the use that Franz Mesmer made of these glasses as an important part of his controversial "magnetic" therapy. Combining musical skill with medical training, Mesmer improvised on the armonica to accelerate or modulate the "crises" of his patients. I plan to explore the contemporary accounts of medical crises in relation to the ancient view that such crises had an intrinsic and fixed rhythm. My working hypothesis is that Mesmer's practice introduced a new factor: via the musical glasses, medicine could now alter the timing of therapeutic crises and thereby affect the course of the disease. If so, this musical manipulation of crises represented an important alteration of medical practice at a fundamental level.

Peter Pesic, a historian, pianist, and physicist, is director of the Science Institute and Musician-in-Residence at St. John's College, Santa Fe, NM. He is the author of five books published by MIT Press: *Labyrinth: A Search for the Hidden Meaning of Science* (2000); *Seeing Double: Shared Identities in Physics, Philosophy, and Literature* (2002); *Abel's Proof: An Essay on the Sources and Meaning of Mathematical Unsolvability* (2003); *Sky in a Bottle* (2005); and *Music and the Making of Modern Science* (2014), which received the 2015 American Publishers Award for Professional and Scholarly Excellence in Music and the Performing Arts. He has written sixty papers on the history of science, music, and ideas and has edited works by Max Planck, James Maxwell, Carl Gauss, and Hermann Weyl. An associate of the department of physics at Harvard University, he serves as editor-in-chief of *Perspectives in Physics*.

JOSEPH S.C. LAM
University of Michigan

Acoustic and Musical Realities: Performing Kunqu on Historical Stages and in Cultivated Gardens

Since its 2001 designation as a UNESCO Masterpiece of Oral and Intangible Cultural Heritage of Humanity, kunqu, a 600-year-old genre of classical Chinese opera, has been performed in diverse and innovative ways. Among them, those involving authentic or newly constructed "historical stages" (*guxitai*) and "cultivated gardens" (*yuanlin*) raise many challenging questions on interrelationships between acoustics, aesthetics, cultural and historical memories, marketing, performance dynamics, and staging technology. Unlike contemporary stages that face audiences sitting in cavernous auditoria, historical stages can be viewed and heard from three sides. Furthermore, the stages feature specially designed ceilings that would, theoretically, help project performed music to the audience. As described in historical documents, traditional kunqu was regularly performed inside cultivated gardens at outdoor or open venues, such as roofed pavilions (*ting*) with pillars but no walls. How historical stages and cultivated gardens shaped the traditional composition, performance, and listening of kunqu arias is a phenomenon that has yet to be examined. Why such traditional venues are "revived" is another question that needs to be answered—contemporary microphones and speakers have rendered acoustic attributes and functions of the traditional venues irrelevant. Is the revival merely a matter of preserving heritage or marketing shows? This paper will discuss archived and fieldwork data on several historical stages and cultivated gardens found in the contemporary cities of Shanghai, Suzhou, and Kunshan. By contrasting documented theories and demonstrable results, the paper posits that kunqu performance venues make up complex and interactive sites of sonic and non-sonic performance negotiations.

Joseph S. C. Lam is Director of the Confucius Institute at the University of Michigan and Professor of Musicology in the School of Music, Theatre & Dance at the University of Michigan. Lam specializes in Chinese musics and music cultures of Southern Song (1127–1275), Ming (1368–1644), and modern China (1900 to present; *kunqu*). Lam's recent publications include "*Escorting Lady Jing Home:* A Journey of Chinese Gender, Opera, and Politics," *Yearbook for Traditional Music* 46 (2014), and *Songdai yinyueshi lunwenji: lilun yu miaoshu* (Historical Studies on Song Dynasty Music: Theories and Narratives; Shanghai Conservatory of Music Press, 2012). Currently, he is finalizing *Kunqu, the Classical Opera of Globalized China* (monograph under review) and drafting *Musical Reminiscences (Huaigu yinyue): Remembering and Performing Music from Southern Song China*.

H. FLORIS COHEN
Descartes Centre, Utrecht University

To Explain Consonance and Divide the Octave: Abstract Doctrines and Their Material Counterparts

In my 1984 book *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650*, I briefly discussed certain doctrines about consonance and the division of the octave from their Greek origins up to Vincenzo Galilei, and then at much greater length how these doctrines were subsequently transformed in truly revolutionary fashion by certain seventeenth-century pioneers (Kepler, Galileo, Beeckman, Descartes, Mersenne...). Some of these ideas had material implications. In my paper I shall list a few, and explain in each case how precisely it is linked up with the ideas and concepts that underlie it. Examples are a split G sharp / A flat key present on the keyboard of the 1596 organ "in cornu Evangelii" in San Petronio cathedral in Bologna; several experiments undertaken or at least described by father and son Galilei; how Marin Mersenne sought to determine pitch; how differently the organist Arnolt Schlick in 1511 and, over a century later, the natural philosopher Isaac Beeckman dealt with beats (*Schwebungen*), and the story (to be pursued up to the present day) of Christiaan Huygens's proposed division of the octave into thirty-one equal tones.

H. Floris Cohen is professor of the comparative history of science at Utrecht University in the Netherlands. He is also the editor of *Isis*, the quarterly journal of the History of Science Society. He is the author of *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650* (Reidel, 1984); *The Scientific Revolution: A Historiographical Inquiry* (University of Chicago Press, 1994); *How Modern Science Came Into the World: Four Civilizations, One 17th-Century Breakthrough* (Amsterdam University Press, 2010), and a short version in Dutch of *How Modern Science Came Into the World*, translated into German as *Die zweite Erschaffung der Welt. Wie die moderne Naturwissenschaft* entstand (Campus, 2010) and into English as *The Rise of Modern Science Explained: A Comparative History* (Cambridge University Press, 2015).

MYLES JACKSON
New York University

Physical and Musical Objects: Vacuum Tubes throughout the Twentieth Century

I am interested in tracing the history of vacuum tubes throughout the twentieth century with a particular emphasis on how they gave rise to new musical instruments. Drawing on the work of John Ambrose Fleming, who invented the diode/vacuum tube that converted alternating current to direct current and assisted the conversion of radio signals into audio, Lee de Forest improved upon the vacuum tube in 1906. De Forest later realized that his vacuum tube, the Audion, could not only detect and amplify radio waves but also generate its own electrical vibrations. In 1913, Edwin Howard Armstrong directed the output of the Audion tube back into the input and noted an impressive increase in amplification. The hissing and whistling sounds made by the Audion at a certain volume could be tamed by proper circuitry, moving vacuum tubes from physics and electrical engineering into music. Leon Theremin's renowned invention of 1928 produced sounds based on the principle of heterodyning; it too employed vacuum tubes.

Electric music began to appear in Germany during the 1920s, centered on Berlin and in particular two institutions there, the Heinrich Hertz Institute for Research on Oscillations (established 1928), and the Rundfunkversuchsstelle that opened in 1928 as part of the Staatliche akademische Hochschule für Musik to research the technical and musical possibilities associated with the new medium of radio broadcasting. This included funding research on new electric musical instruments, many of which contained vacuum tubes. Vacuum tubes were used in the earlier instantiations of synthesizers, giving way in the 1960s to cheap silicon transistors. The same was true for the vacuum tubes in the various electronic music studios, such as the Siemens studio in Munich or the Westdeutscher Rundfunk studio in Cologne. But while solid-state technology has dominated the field of electronics, vacuum tubes were still thriving in the late twentieth century in musical-instrument amplifiers, processing devices in recording studios, and high-end fidelity equipment.

This episode belongs to a much longer history of experimentation on the relationship between sound and vacuums. In 1660 Robert Boyle and Robert Hooke noted that sound could not travel through a vacuum. By the early twentieth century, however, vacuum tubes themselves had become sounding objects.

Myles Jackson is the Albert Gallatin Research Excellence Professor of the History of Science, NYU-Gallatin; Professor of History, Department of History, NYU-FAS; Director of Science and Society, NYU-CAS; and Professor of the Division of Medical Ethics, NYU-Langone School of Medicine. He has written on the history of nineteenth-century German physics as well as the history of molecular biology in the United States. Among his publications are *Harmonious Triads: Physicists, Musicians and Instrument Makers in Nineteenth-Century Germany* (MIT Press, 2006 / paperback 2008); *The Genealogy of a Gene: Patents, HIV/AIDS, and Race* (MIT Press, 2015); and *Music, Sound, and the Laboratory from 1750 to 1980* (co-edited with Alexandra Hui and Julia Kursell), *Osiris* 28 (2013).

JULIA KURSELL
University of Amsterdam

The Ear and Its Objects: A *Longue Durée* View of Research in Auditory Physiology

My contribution focuses on auditory physiology. In an attempt to review Jonathan Crary's pathbreaking account of sensory physiology in modern science, I will examine the characteristics of hearing as an object of research. My contribution will argue that the ear, as an inaccessibly secluded organ in the human body, produces a different regime of knowledge acquisition than the eye does. This regime is characterized by what I will call its "slowness," which results from the alleged necessity of referring to sound objects that substantiate, embody, or challenge the missing knowledge about the organ. Taking its inspiration from Crary in this respect as well, my paper will locate Johann Wolfgang von Goethe's work on sensory perception as a turning point in this history. He used and reshaped eighteenth-century theories, and encompassed a wide range of human interaction with acoustic phenomena. With little to no original knowledge of the anatomy and physiology of the ear, Goethe does not undertake to shed light on the organ. Instead, he observes the process of object-creating in aural perception and discovers a specific "fastness" in the use of hearing, as opposed to the slowness of the knowledge acquisition about the ear. From this vantage point, I look at the theories of hearing before and after Goethe, emphasizing their use of materialities and the ways in which they relate to the notions of fastness and slowness. The trajectory will end with the last major contribution to a mechanics of the ear, by György Békésy. Yet even after that point, the contrast between fast and slow in hearing has remained an issue in the study of the ear.

Julia Kursell is professor and chair of the Institute of Musicology at the University of Amsterdam. She studied musicology, Slavic philology, and comparative literature in Munich, Moscow, and Los Angeles, and completed her doctoral studies at Munich University with a thesis on music in the early Russian avant-garde. Before coming to Amsterdam, she was assistant professor at the Slavic Department of Munich University and research fellow at the Center for Literary and Cultural Studies, Berlin. From 2004 to 2011, she worked as a research fellow at the Max Planck Institute for the History of Science in Berlin. Her book *Epistemologie des Hörens*, on the role of music in Hermann von Helmholtz's physiology of hearing, is forthcoming with Fink Verlag. She is editor of the journal *History of Humanities* and co-director of the Vossius Center for History of Humanities and Sciences at the University of Amsterdam.