Introduction

The Noise of Sound Media

In today's world, close to half of the world's population carries a device that can easily transmit, record, and manipulate physical sound.[1] What is more, these smartphones often offer almost instantaneous access to unprecedented quantities of sound recordings: hours, weeks, months, years, decades, even centuries worth of music, speech, incidental sounds, and noise can be summoned up immediately in the palm of one's hand. More than one hundred forty years after the development of technological sound reproduction, listening to technologically (re)produced sounds has therefore become thoroughly mundane. Precisely because of this banality, however, it has also become increasingly difficult to grasp what *kind* of listening this actually is; to understand what technological sound (re)production implies; to judge whether listening to technologically (re)produced sound differs from or merely recapitulates our listening to non-technologically mediated sounds. Fundamentally, this book is about tracing the profound impact of the historical emergence of the kinds of technologically mediated sounds that we now take for granted, and understanding how they shaped how we listen, what we listen to, and what we listen for.

As a first suggestion, one might understand the experience of listening to technologically reproduced sound as a way of listening to the past. Sound reproduction technologies replay sounds that were captured at one point in time and then subsequently re-instantiated, again and again, at other times. As such, they contain the promise of halting time—of capturing a singular acoustic event in full and holding on to it forever. In this sense, it would even seem that sound reproduction aspires to overcome death itself, as it saves inherently finite events from fading away. Indeed, it allows them to be infinitely repeated. When one compares early reproductions made by crude machines like Edison's phonograph with the near-seamless digital operations of twenty-first-century devices, and considers the progress that has been made, it might

[1] "Number of Smartphone Users Worldwide from 2016 to 2021," Statista, accessed December 4, 2019, https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide.

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seem like this ideal of complete sonic replication might actually be fulfilled—if not today, then very soon. Given that sophisticated contemporary sound media developed from such simple origins, is it not only logical to suppose that we are slowly but steadily approaching perfect replication?

Indeed, much of the discourse on sound reproduction was, from its very beginnings, determined by exactly this ideal of total duplication—by the quest, as Jonathan Sterne puts it, to "capture the world and reproduce it 'as it really is.' "[2] If only technical components can be improved, the recording process streamlined, all external noise reduced, precision increased, the bandwidth widened—in short, if we can only prevent, eliminate, or at least maximally reduce all audible traces of the medium itself—then a perfect replication of sound will be achieved. In presupposing that what goes into a recording machine can, in principle, fully coincide with what comes out, this persistent, as I will call it, *myth of perfect fidelity* buoys the idea that complete similitude between originals and copies can ultimately be realized.

As a theoretical basis for understanding technological sound reproduction, however, this myth of perfect fidelity is fundamentally flawed, because it denies the very condition of possibility of technological sound reproduction. That is, it represses the material basis that defines all technologically (re)produced sound. Regardless of type, genre, tone, form, or function, the sound that flows from loudspeakers, headphones, or similar sound transducing devices was produced or recorded, reproduced, and transmitted, shaped and affected by many physical channels. This basic condition is what this book's eponymous concept, *the logic of filtering*, aims to capture: the fact that all technologically mediated sound travels through a great many channels (gates, gateways, carriers, passages), each of which physically affects and thus effectively *filters* the sounds it transmits. Because of this, when we listen to technically (mechanically, electro-acoustically, digitally) processed music, we do not just listen *through* the loudspeaker and all the channels that connect us to some sound that went in at the other end. We listen *to* the loudspeaker as it produces sounds, which contain sonic traces of each channel it encountered along the way.

"Every relation between two instances," writes Michel Serres, "demands a route. What is already there on this route either facilitates or impedes the relation."[3] In short, all sound media shape sound. They are not neutral channels or conduits, but active players that affect the signals they transmit in specific

[2] Jonathan Sterne, *The Audible Past: Cultural Origins of Sound Reproduction* (Durham: Duke University Press, 2003), 218.
[3] Michel Serres, *The Parasite*, trans. Lawrence R. Schehr (Baltimore: John Hopkins University Press, 1982), 150.

ways. If we accept the myth of perfect fidelity, this influence can—and indeed should—be maximally compressed or reduced, thus enabling signals to "get through" as clearly as possible. Ever since the invention of technological sound reproduction, inventors, engineers, and musicians have worked hard to achieve this goal. As we will see over the course of this book, however, the presence of material channels is an indispensable precondition of signal transmission. There is no journey without a route; no transmission without a channel. And notwithstanding the cleverest, most sophisticated technological solutions, the physical presence of these channels cannot be denied or ignored.

Instead of pushing the medium aside and skipping straight from performer to audience (from sender to receiver, input to output), we must therefore acknowledge the crucial role of the in-between. We must really, truly focus on what takes place in the middle if we are to begin to understand sounds emanating from loudspeakers. To begin to understand, that is, how music is produced not only by human beings, but also by media technological processes that often surpass and escape our sensory and mental capabilities. This requires a close look at the ways in which machines mediate between sender and receiver, affecting the signals they transmit. Invoking the term used in information theory to signify the influence of transmission channels, we have to look closely at the issue of "noise."

I will define this term more precisely further on in this introduction and return to it repeatedly over the course of the book. Simply put, though, in this context "noise" designates the traces that the medium inscribes on the signals it produces and transmits. It describes the channel's inerasable, irreducible influence over the signal. In traveling from a to b, a signal encounters many channels, gates, and passages, which shape and change it before it reaches our ears. These traces mark the difference between a system's output and input. The goal of this book is to take this journey seriously and see it for what it really is: the fundamental material condition on the basis of which all technologically mediated sounds exist. By focusing on this fundamental logic of filtering, I want to face up to the fact that media technological devices have been shaping the sound of music for almost a century and a half.

Against still-dominant ideals of perfect fidelity, full transparency, and absolute reproducibility, a close analysis of the processes that enable technological sound (re)production in the first place will show that noise is, in fact, inevitable. Accordingly, I argue that the traces of the material reproduction of sound or, in other words, the *noise of sound media*, are a defining feature of all technologically (re)produced music. This noise has decisively changed and continues to change the sonorous qualities of the music we hear. And with this, it changed our listening habits—that is, our presuppositions and predispositions, focal points and attention spans, likes and dislikes in listening to sound and music. As we shall see, noise is incidental, transient, contingent, random, and endlessly varied by definition. It is on account of precisely these qualities that noise makes the sound coming out of the speakers attractive, intriguing, appealing, *alive*. In the final analysis, therefore, the experience of listening and *re*listening to music (any music) shaped by the noise of sound media raises the prospect of reliving a singular acoustic event. Indeed, I even agree that it ultimately holds out nothing less than the promise of overcoming death. At the same time, and just as importantly, however, I will show that the irreducible influence of media technological channels also resonates with a deeply human sense of living with finitude and mortality in a fundamentally transient world.

Noise

In recent years, an increasing number of books have dealt with the history and theory of noise, both within and beyond the context of sound and music. Whereas Paul Hegarty's *Noise/Music: A History* (2008) provides a detailed and lucid history of the role of noise in twentieth-century musical practices, Caleb Kelly's *Cracked Media: The Sound of Malfunction* (2009) addresses instances of damaged, broken, and destroyed sound media being sourced for musical purposes.[4] In a more philosophical vein, Greg Hainge's *Noise Matters: Towards an Ontology of Noise* (2013) analyzes noise practices across various disciplines to develop its eponymous "ontology of noise," while Marie Thompson's *Beyond Unwanted Sound: Noise, Affect and Aesthetic Moralism* (2017) presents a nonbinary, more political interpretation of noise's formative role in musical practice.[5] This notion of getting "beyond" the assumption that noise embodies failure, transgression, or disruption also very much informs Hillel Schwartz monumental *Making Noise: From Babel to the Big Bang and Beyond*, which sets out to trace the importance and significance of noise beyond the "binary shackles of noise as good or bad" and the "all-too-common belittling of noise as mere epiphenomenon and fleeting byproduct."[6]

[4] Paul Hegarty, *Noise/Music: A History* (New York: Bloomsbury, 2008); Caleb Kelly, *Cracked Media: The Sound of Malfunction* (Cambridge, MA: MIT Press, 2009).

[5] Greg Hainge, *Noise Matters: Towards an Ontology of Noise* (New York: Bloomsbury, 2013). Marie Thompson, *Beyond Unwanted Sound: Noise, Affect, and Aesthetic Moralism* (New York: Bloomsbury, 2017).

[6] Hillel Schwartz, *Making Noise: From Babel to Big Bang and Beyond* (New York: Zone Books, 2001), 29.

Even if we leave aside the wider body of noise literature, and proceed on the basis of Schwartz's sprawling, often unruly book alone, it is abundantly clear that questions of noise cross a number of academic disciplines—from musicology, through physics and media studies, to mathematics, to name a few. Among these disciplines, the very definition of noise itself remains notoriously unstable. Noise can be a sonic object, social nuisance, physical phenomenon, therapeutic background, keyword in communication theory, musical genre, legislative issue, or obstacle in sound engineering. Summarizing this instability, Serres calls noise "a black thing, an obscure process, or a confused cloud of signals—what we shall soon call a problem."[7] Despite the growing critical study of this "problem," analyses of noise's role in music often continue to classify it, even if only implicitly, as transgressive or subversive: as something that might be sonically or musically relevant, inspiring, or even necessary, but nonetheless set in contrast to a presumed clarity and purity of "musical" sound. In the final analysis, noise remains an abject, transgressive, violent, and subversive element that forces itself into the musical domain. If it contributes anything at all, it is by means of contrasts and interruptions: noise is seen to confront order with chaos, harmony with dissonance, peacefulness with aggression, and social cohesion with disruptive subversion. More often than not, noise is considered "a disruptive and excessive area of sound practice," as Kelly puts it, a source of "joyful transgression."[8] Indeed, in the context of music, noise is widely regarded as the ultimate sonic Other.

This essentially binary conception of noise vs. information, noise vs. signal, noise vs. sound, or noise vs. music already informed Luigi Russolo's 1913 futurist manifesto *The Art of Noise*, which is often cited as a founding document of both noise as a specific musical genre and the broader theorization of noise in relation to music.[9] Although, admittedly, Russolo calls for the inclusion of all kinds of noises in music, as Michel Chion rightly observes, his manifesto still "confirms the idea of an absolute distinction—an essential distinction—between musical sounds and noises."[10] Similarly, Jacques Attali's seminal book *Noise: The Political Economy of Music* presents the history of noise as a

[7] Serres, *Parasite*, 17.

[8] Kelly, *Cracked Media*, 61. For a concise, although somewhat German-language oriented, overview of academic literature on noise in or as music, see: Dahlia Borsche, "Geräusch, Musik, Wissenschaft: Eine Bestandaufnahme," in *Geräusch—Das Andere der Musik: Untersuchungen an den Grenzen des Musikalischen*, eds. Camille Hongler, Christoph Haffter, and Silvan Moosmüller (Bielefeld: Transcript Verlag, 2015), 33–46.

[9] Luigi Russolo, *The Art of Noise (Futurist Manifesto 1913)*, trans. Robert Filliou (New York: Something Else Press), Reprinted by UbuClassics, 2004, accessed July 15, 2007, www.ubu.com/historical/gb/russolo_noise.pdf.

[10] Michel Chion, "Let's Have Done with the Notion of Noise," trans. James A. Steintrager, *Differences 22*, no. 2–3 (2011): 244.

dialectical interplay between musical order and disruptive noise. Although conceptualized as an emancipatory force that is essential in propelling musical innovation, here too noise's power fundamental derives from its ability to transgress and violate musical and, with it, social order. Attali argues that noise disrupts well-ordered music, and that musical order tames disruptive noise, in a continuous, cyclical interplay. To mention just one more adherent to this dialectic conception of noise, Hegarty's analysis also endows musical noise practices with subversive power. However, he emphasizes how this potential is inevitably lost: processes of inclusion and normalization strip noise of those very aspects that make it a potent force, meaning that noise in music will ultimately "always fail, as noise at least."[11]

In short, whether it is heralded as a savior of music, breaker of rules, or liberator of sound, noise is consistently defined negatively. It is articulated through contrasts with what it saves, breaks, or liberates: to wit, musical sound. To break this continuous back and forth between noise and music, and develop a different understanding of noise's role in the operations of technical sound media, I suggest that we go back to the discursive roots of the concept of noise in the context of physical acoustics, communication engineering, and information theory. As historian of science Roland Wittje has shown, in the period between the mid-nineteenth century and mid-twentieth century, a series of semantic and conceptual developments in German scientific discourse resulted in the emergence of three concepts of noise, roughly corresponding to the terms *Geräusch*, *Rauschen*, and *Lärm*.[12]

Geräusch denotes the sonic concept of noise that emerged in nineteenth-century acoustics, most importantly through Hermann von Helmholtz's extensive experimental analysis of sound and hearing, first published in 1863.[13] This conceptual framework defines noise more or less objectively as sounds that consist primarily of non-periodic frequencies. Through this emphasis on nonperiodicity, noise was distinguished from its opposite, periodic sound, thereby implying a structural opposition between harmonious (periodic, well-ordered) musical sound and unharmonious (nonperiodic, chaotic) unmusical noise.[14] Later, in the decades surrounding the beginning of the twentieth century, the recognition of physical similarities between this nonperiodic

[11] Hegarty, *Noise/Music*, 146.

[12] Roland Wittje, "Concepts and Significance of Noise in Acoustics: Before and After the Great War." *Perspectives on Science 24*, no. 1 (2016): 7–28.

[13] Hermann von Helmholtz, *On the Sensation of Tone as a Physiological Basis for the Theory of Music*, trans. Alexander J. Ellis (Cambridge: Cambridge University Press, 2012, 1875).

[14] For Helmholtz, Wittje explains, "the sensation of sound and the experience of music were interchangeable," which means that the perceived periodicity of sound in contrast to the nonperiodicity of noise always also implies an ideal of well-ordered music. Wittje, "Concepts," 10.

sonic noise and random disturbances observed in the transmission channels of newly developed communication media, meant that this sonic concept of noise "entered the theory and practice of electrical systems and communication engineering."[15] Scientists, inventors, and engineers began to describe these random disturbances in communication channels through reference to a more general physical concept of noise, or *Rauschen*. In English, such physical noise is often called random noise, to differentiate it from the everyday more generic use of "noise" denoting any unintended, undefined, or disruptive sound.

This more colloquial, everyday definition of noise, which roughly corresponds to the German word *Lärm*, became more prominent in early twentieth-century discussions on noise pollution and abatement.[16] The influence of these debates is also evident in the modernist associations among noise, speed, power, and industrial progress—as drawn, for instance, in Russolo's futurist manifesto. In the more specific context of communication engineering and signal processing in the 1920s and 1940s, the combination of the objective physical concept of noise as "random disturbance" (*Rauschen*) and this more subjective grasp of noise as "unwanted sound" (*Lärm*) merged into the communicational concept of noise that was developing in information theory.

Spearheaded by Claude Shannon's 1948 article "Mathematical Theory of Communication," information theory formalized the operations of communication media on the basis of statistical relationships between information and noise.[17] Significantly, this meant that noise was no longer strictly defined by its acoustic properties (nonperiodic frequencies) or physical properties (the random movements of particles). Rather, it was grasped solely on the basis of its role in signal transmission: from a perspective informed by information theory, every signal that hinders or affects the clear transmission of information is labeled noise. Significantly, Shannon's theory did not treat this statistically defined communicational noise as a threat from outside, but as something internal to the communication system itself—in other words, noise was seen as an inherent property of the transmission channel itself. In this way, Shannon's theory made it possible to calculate and thus potentially reduce the influence of noise. Precisely because it sees noise as internal to the

[15] Roland Wittje, *The Age of Electroacoustics: Transforming Science and Sound* (Cambridge, MA: MIT Press, 2016), 191.

[16] On noise pollution and abatement, see Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900–1933* (Cambridge, MA: MIT Press, 2002); Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century* (Cambridge, MA: MIT Press, 2008).

[17] Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1964).

system, however, information theory also shows that its complete eradication is fundamentally impossible.

Media

As his commentator Warren Weaver emphasizes, Shannon's statistical model of communication, and its corresponding (re)definition of information and noise, are "exceedingly general in [their] scope."[18] Because its basic principles can be applied far beyond its original context of telephone engineering, this model quickly came to influence a wide variety of topics in all corners of the academy and beyond. Given that Shannon's information theoretical logic underpins the basic operations carried out by contemporary digital computers, the impact of his model on contemporary media culture can hardly be overstated. Despite this broad influence, however, the context-dependent communicational concept of noise that developed out of Shannon's mathematical analysis is also notoriously fluid and unstable. With its broad scope, conceptual versatility, and general applicability, it has been applied "to everything and nothing at the same time" and is "subject to a whole host of mutually contradictory definitions and usages," as Hainge has written.[19] Some of this conceptual overload, I would argue, might be down to the fact that information theoretical approaches often fail to take into account the media-specific context of this model, which, as N. Katherine Hayles writes, "Shannon himself frequently cautioned, [. . .] was meant to apply only to certain technical situations," such as the transmission of signals across telephone lines.[20]

To counter discursive slippages in the communicational concept of noise, a critical assessment of its role in sound reproduction technologies should therefore take into account the discursive history of the concept of noise, as summarized by Wittje. At one level, in reinforcing the discursively dominant opposition between periodicity and nonperiodicity, harmony and dissonance, order and chaos, the sonic concept of noise is too restrictive. At another, the communicational concept of noise in information theory is often applied so generally that it risks becoming nonsensical. Conceptually positioned between these sonic and communicational understandings, the physical concept

[18] Shannon and Weaver, *Mathematical Theory*, 25.
[19] Hainge, *Ontology*, 8.
[20] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999), 19.

of noise was first conceptualized in response to the measurability of electrical signals. It can therefore be classified as what Christian Kassung calls "a media effect."[21] Because it takes the material basis of media-technological operations into account, this physical grasp of noise provides a conceptual go-between or middle ground between the statistical relativism of communicational noise and acoustic essentialism of sonic noise.

To further develop this more nuanced media historical reconfiguration of the relations among sonic noise (which is still of primary concern in the domain of sound and music), physical noise (which appears in the channels and circuits of technical media), and the communicational concept of noise (as it has developed in information theory), I turn to what the anglophone world often calls "German Media Theory," or media archaeology, and the work of Friedrich Kittler in particular. Although, as Jussi Parikka explains, Kittlerian media theory "insisted that the 'founding event' of modern media is Claude Shannon's and Warren Weaver's mid-twentieth-century model of noise," it is also true that its analyses always begin from a concern with the specific physical and technological conditions of mediatic operations.[22] It therefore allows for a complex and multifaceted understanding of noise that remains rooted in the physical reality of technical functions. Accordingly, as Kittler explains in a 1992 interview, German media theory takes noise "very seriously."

> We do not just treat it as "the Other." We try to make truly differentiated statements about specific filterings of noise, not just dealing with the single command that forever abolished all noise from the get-go, but with media- and time-specific selections that deal with noise to a greater or lesser extent.[23]

Following Shannon's mathematical redefinitions of noise and information, which was specifically developed to address the problem of random disturbances (or physical noise) in telephone lines, Kittlerian media theory consistently situates noise in the context of the physical operations of media-technological hardware. In this way, it limits the conceptual slippage inherent to the communicational concept of noise. Building on this

[21] Christian Kassung, "Falling Darts, a Lost Submarine, and a Blind Man: Notes on the Media History of Navigating Through Noise," in *Navigating Noise*, eds. Nathanja van Dijk, Kerstin Erzinger, Christian Kassung, and Sebastian Schwesinger (Köln: Verlag der Buchhandlung Walther König, 2017), 63.

[22] Jussi Parikka, "Mapping Noise: Techniques and Tactics of Irregularities, Interception, and Disturbance," in *Media Archaeology: Approaches, Applications and Implications*, eds. Jussi Parikka and Erkki Huhtamo (Berkeley: University of California Press, 2011), 256.

[23] Friedrich Kittler, "Wenn die Freiheit wirklich existiert, dann soll sie doch ausbrechen," interview by Rudolf Maresch, April 4, 1992, accessed March 18, 2013, www.rudolf-maresch.de/interview/16.pdf. All translations of otherwise untranslated German sources are my own.

approach, I propose to undertake a discursive analysis of both the technological processes and underlying physical and mathematical operations that produce noise in sound (re)production technologies. This will enable me to reassess the role of sonic noise in recorded sound and music without sacrificing the conceptual agility of information theory's communicational concept of noise.

From the earliest beginnings of sound recording, inventors, sound engineers, and musicians have been confronted with the noise inherent in technological sound reproduction, encompassing all of the ways in which the operations of technical media might physically affect and shape the sounds they (re)produce. This noise of sound media designates multiple phenomena. First, it includes the physical noise (or random disturbances) that occurs in electronic circuits and transmission channels. Such physical noise always qualifies as communicational noise, and sometimes (but not always) becomes audible as sonic noise as well. Second, it also encompasses distortion, linear or otherwise. Although distortion does not qualify as physical noise because it is not random, it is still considered communicational noise and can also manifest as sonic noise. Lastly, it includes all kinds of other interferences and changes to the spectral contours of sound. These might not even qualify as (random) physical noise or as (nonrandom) distortion, and they are not always directly apparent as sonic noise either. Nevertheless, these phenomena can still be classified as communicational noise, in that they affect signal transmission, coloring the sound on its way from input to output.

Over the course of this book, I will bring this media-technological analysis of noise back into the domain of music. Doing this, however, requires a theoretical and historical framework in which the discourse on technical media, and that on sound and music, can meet. To establish such a framework, I undertake a historical assessment and theoretical analysis of some of the most fundamental principles of physical acoustics and technological sound engineering as they developed from the nineteenth century onward. These basic conceptions—such as the idea of spectral analysis, and the acoustical concepts of "sine waves" and "frequencies"—informed contemporary discourses on sound and music. Significantly, they are also deeply rooted in discourses on signal processing and technical media. Because of this discursive overlap, my assessment of these concepts in turn allows for a better understanding of the interaction between music and media. Ultimately, the historically informed and media-specific analysis of the noise of sound media developed in this book thereby offers new insights into the decisive impact of technical media on the music they produce.

Music

A soft layer of background noise fades in. After a few seconds, it is interpolated by rhythmic scratching, like a piece of paper being torn in two. Thirty seconds in, a low, rumbling synthesizer drone begins, and the stereo sound alternates rapidly between left and right as a pattern of sharp clicks, striking the ear like sonic needle pricks, becomes more and more prominent. After about two minutes, the piece breaks down—only to quickly start up again. Stuttering and hesitant, starting and stopping, picking up complex rhythmic patterns that soon disintegrate, the composition pushes onward by continuously introducing new sounds, new timbres, new rhythms. Over its entire thirty-minute duration, Pauline Oliveros's *A Little Noise in the System* (1968) never stays in one place.[24] Combining and sequencing seemingly endless shades of noise, it forces listeners to stay with the sound constantly, having no time to search for structure, form, or meaning beyond the intricacies of sound itself. As such, the piece is a compelling illustration of my concerns of this book—not as a piece of "noise music" in and of itself, but through its explicit thematization of noise as a defining aspect of technological sound production. In *A Little Noise in the System*, as in this book, noise emerges as the audible residue of the materiality of transmission channels—and thus of a precondition for transmission itself. It appears as both a partial obstruction hindering clear reception and a random element that increases sonic complexity and goes on producing new sounds.

"Noise," writes Serres, "is at the three points of the triangle: sending, reception, transmission. [. . .] The smallest increase, in one direction or another, can transform the entire communications system from top to bottom."[25] Oliveros's piece revels in this, noise's transformative power. It explores the sonic, timbral, and rhythmic possibilities produced by the countless potential combinations of electronic oscillators, filters, and modulators that constitute the circuitry of the Moog Synthesizer on which it was composed. Listening to this music, one hears the audible traces of the electronic processes through which its sounds took shape. As such, the piece is a product not only of Oliveros's subtle handling of the machine, but also of the machine's own unruly and sometimes unpredictable operations, which bring forth these sounds in the first place.

[24] Pauline Oliveros, *A Little Noise in the System, Bandcamp, track 1 on An Anthology of Noise and Electronic Music #1*, Sub Rosa, 2017.

[25] Serres, *Parasite*, 194.

This book is about neither noise as a musical genre nor the concept of noise as such. Rather, it focuses on how noise is a fundamental aspect of the sonic and musical sensibility that emerged in the age of technical media. As such, it describes what Marc Katz calls a "phonograph effect": the ways in which, as the subtitle of his book has it, "technology has changed music."[26] Katz's work, however, deals with "any change in musical behavior [. . .] that has arisen in response to sound-recording technology," thus focusing on instances of technology changing the explicitly human activity of making music. My book, in contrast, focuses on different agencies: it is concerned with the ways in which processes of technological mediation themselves produce sounds, beyond human control, and with how these sounds subsequently make sense to humans as music.[27] As a central concept in discourses of both music and media, the issue of noise provides a theoretical entry point for thinking about the interplay between the two. It offers a way of rethinking the "sound" specific to sound media. Indeed, current discussions around noise are an occasion to explore how the sounds produced by technical media differ from pretechnological sounds, foster new ways of making music, give rise to new modes of listening, and persist in making musical sense. The study of noise, in short, will help us understand how the transmission channels of technical sound media have shaped the sound of music.

In making an approach to noise's centrality in how technical media shape sounds, chapter 1 offers a brief history of the noise of sound media. In so doing, it explores the many ways in which inventors, engineers, producers, and musicians have sought to prevent, reduce, and eliminate the noises produced by technical sound media—from the invention of the phonograph in 1877 to the onset of digitalization in the late twentieth century. It traces the historical and discursive context of the emergence of different concepts of noise, which developed in dialogue with, and reaction to, ever more complex and sophisticated sound technologies. In describing these developments, the chapter also draws the contours of the myth of perfect fidelity: the idea that a reproduced "sound" should—and indeed plausibly can—be separated from the supposedly external "noise" produced by recording and reproduction media themselves. Finally, the chapter illustrates the predominance and conceptual limitations of this myth by engaging with two examples of noise-related technological operations in the analogue and digital domains: the famous noise reduction systems developed by Ray Dolby in the 1960s, which

[26] Mark Katz, *Capturing Sound: How Technology Has Changed Music*, Revised Edition (Berkeley: University of California Press: 2010), 2.

[27] Katz, *Capturing Sound*, 2.

actively reduce the noise of sound media, and the practice of "dithering" in digital recording, which introduces small amounts of random noise as a means of reducing errors in sound digitization.

To establish a better understanding of the conceptual framework underlying the myth of perfect fidelity, these two case studies are further explored in chapter 2. At first, noise reduction and dithering seem to represent two diametrically opposed approaches toward noise: whereas the former explicitly diminishes noise, the latter deliberately adds it. On closer inspection, however, both approaches serve the myth of perfect fidelity in that both strive to achieve the most accurate reproduction of the "original" sound signal. In actively concealing the physical limitations inherent to both analog and digital sound reproduction, noise reduction and dithering both support the conceptual *logic of noise reduction* that underpins the myth of perfect fidelity. Whereas this logic perpetuates the belief in the ultimate possibility of transmitting pure, noiseless "sound" or music without distortion or interruption, information theory has already unequivocally shown that every transmission channel affects and changes the signal—all efforts to reduce, conceal, or filter out this influence notwithstanding. The chapter addresses this apparent contradiction at the heart of sound technology (the basic observation that every channel, in Serres's words, both "facilitates or impedes" transmission) by introducing and elucidating a new concept: the *noise resonance of sound media*. In contrast to the myth of perfect fidelity, this idea of a "noise resonance" suggests that noise, distortion, and randomness are key to how technologically reproduced sound makes sense to—or resonates with—human listeners.

Replacing the myth of perfect fidelity with the idea of a noise resonance of sound media, however, first requires a better understanding of how its underpinning logic is historically anchored in physical discourses on sound and sound technology. Accordingly, chapter 3 takes a closer look at the historical and conceptual developments through which the differences between noise and sound, and noise and signal, emerged in the first place. More specifically, it looks at the development of the mathematical principles of Fourier analysis, and its application to the study of sound over the course of the nineteenth century. This development gave rise to the now-familiar representation of physical sound waves as series of superimposed frequencies (a "sound spectrum") and the corresponding idea of a "sine wave" representing one pure frequency. Because Fourier analysis represents sound spectra as entirely periodic and essentially noiseless, it provided a seemingly scientific basis for age-old ideals of musical harmony and sonic purity that still nestle in the myth of perfect fidelity to this day.

Mathematically, however, these idealized representations of sound spectra require the symbolic removal of sound's temporal development: Fourier analysis may produce clear and noiseless representations of sound spectra, but it cannot account for the fact that physical sounds not only extend in space, but also develop over time. In highlighting this shortfall, chapter 3 reveals the difference between an idealized mathematical or metaphysical plane—in which perfect reproduction always seems possible—and a physical or technological domain, in which randomness, transience, and noise inevitably haunt every transmission and affect every signal.

My aim in chapter 4 is to connect the historical and technological analyses put forward in the first three chapters with the question of noise's role in recorded sound and music, and further explore the ways in which the myth of perfect fidelity might be replaced by the noise resonance of sound media. To these ends, the chapter develops a more philosophical reading of the contrast between mathematical models that operate on the basis of idealized filters, which realize the purity of the sine wave and leave no trace, and the operations of sound media based on technical filters, which always affect the signals they (re)produce. The ideal representations of Fourier analysis can only be produced by completely ignoring the temporal development of sound. The temporal flow of sound, however, introduces contingency, randomness, transience, and, indeed, noise. Beginning from Kittler's analysis of the figure of the sine wave and Jacques Derrida's emphasis on temporality basic to all mediatic operations, I argue that this close interrelation between noise and time is a fundamental to how technologically (re)produced sound makes sense for human listeners. In stark contrast with the myth of perfect fidelity and the logic of noise reduction, which are predicated on the timeless clarity and purity produced by Fourier analysis, the noise resonance of sound media admits the inherent temporality of both sound and mediatic operations. As such, it registers both the inherent pastness of technologically reproduced sound and its continuous flow through the present.

Building on the media-archaeological analyses of the relation between noise and sound technology developed in chapters 1 and 2, and the more philosophical assessments of the logic underlying noise reduction in chapters 3 and 4, chapter 5 establishes a conceptual framework for the noise resonance of sound media. This conceptual approach, I argue, offers a new perspective on how the sounds produced by technical media shape the experience of listening. I maintain that the operations of technical sound media are not based on ideal filtering operations, which, as the myth of perfect fidelity would have it, leave no trace of what occurs between sender and receiver. Instead, the noise resonance of sound media reveals that every channel is, by definition, a gate, a passage, or a filter that affects and shapes whatever passes through and emerges as output in specific ways. Instead of a logic of noise reduction, sound media are therefore subject to a logic of filtering; and just as the myth of perfect fidelity is supported by the logic of noise reduction, the noise resonance of sound reproduction is supported by the logic of filtering. This logic does away with the fallacy that sound reproductions are incomplete versions of some "original," or that noise is "external," "extra," "excess," or "added." Our primary point of reference in understanding how the sound of technologically (re)produced music takes shape, this logic supposes, should be neither input nor output, but rather all of the physical processes that happen in between. Taking place inside the black boxes of technical media, these processes escape direct sensory perception. Nevertheless, the random traces they leave behind—the noises, distortions, transients—fundamentally shape the sounds they produce.

The remainder of chapter 5, like the book's conclusion, spirals back to the question of how sounds produced on the basis of the logic of filtering come to resonate emphatically in listeners' ears as something we call "music"—or: how technologically reproduced music makes sense for human listeners. Today, the autonomous agency of human composers, musicians, and audiences has become partially replaced, or at least augmented, by that of media-technological processes, the precise influence of which can never be fully reduced or controlled. This age of technical media, I therefore claim, has produced a new musical sensibility based on the fundamental principles of communication engineering, physical acoustics, and the logic of filtering. Building on an intriguing though undertheorized concept of Kittler's, I call this sensibility the "other music." "Media studies," Kittler writes, "only make sense when media make senses."[28] Indeed, I would add that studying music in the age of technical media only makes sense when one recognizes that mediatic operations are the sine qua non of technologically (re)produced sound. The sound of the "other music" appeals to human listeners not despite but precisely because of the way in which all technologically (re)produced sound is shaped by the noise of its own reproduction. In this way, examining the role of noise in sound reproduction (all those disturbances, distortions, disruptions, and interferences that shape a sound) can help us understand how technical media make musical sense.

[28] Friedrich Kittler, "Number and Numeral," *Theory, Culture & Society 23*, no. 7–8 (2006): 55.