identified by physicists and physiologists as universal and unchanging. By our definition of sound, the tree makes a noise whether or not anyone is there to hear it. But, even here, we are dealing in anthropocentric definitions. When a big tree falls, the vibrations extend outside the audible range. The boundary between vibration that is sound and vibration that is not-sound is not derived from any quality of the vibration in itself or the air that conveys the vibrations. Rather, the boundary between sound and not-sound is based on the understood possibilities of the faculty of hearing—whether we are talking about a person or a squirrel. Therefore, as people and squirrels change, so too will sound—by definition. Species have histories.

Sound history indexes changes in human nature and the human body—in life and in death. The very shape and functioning of technologies of sound reproduction reflected, in part, changing understandings of and relations to the nature and function of hearing. For instance, in the final chapter of this book, I discuss how Victorian writers' desire for permanence in sound recording was an extension of changing practices and understandings of preserving bodies and food following the Civil War. The connections among canning, embalming, and sound recording require that we consider practices of sound reproduction in relation to other bodily practices. In a phrase, the history of sound implies a history of the body.

Bodily experience is a product of the particular conditions of social life, not something that is given prior to it. Michel Foucault has shown that, in the eighteenth and nineteenth centuries, the body became "an object and target of power." The modern body is the body that is "is manipulated, shaped, trained," that "obeys, responds, becomes skillful and increases its forces." Like a machine, it is built and rebuilt, operationalized and modified.[27] Beyond and before Foucault, there are scores of authors who reach similar conclusions. Already in 1801, a Dr. Jean-Marc Gaspard Itard concluded, on the basis of his interactions with a young boy found living "wild" in the woods, that audition is learned. Itard named the boy Victor. Being a wild child, Victor did not speak—and his silence led to questions about his ability to hear. Itard slammed doors, jingled keys, and made other sounds to test Victor's hearing. The boy even failed to react when Itard shot off a gun near his head. But Victor was not deaf: the young doctor surmised that the boy's hearing was just fine. Victor simply showed no interest in the same sounds as "civilized" French people.[28]

While the younger Marx argued that the history of the senses was a core component of human history, the older Marx argued that the physical conditions under which laborers "reproduced" themselves would vary from society to society—that their bodies and needs were historically determined.[29] The French anthropologist Marcel Mauss, one of Foucault's many influences, offered that "man's first and most natural technical object, and at the same time technical means, is his body." What Mauss called *body techniques* were "one of the fundamental moments of history itself: education of the vision, education in walking—ascending, descending, running."[30] To Mauss's list we could add the education and shaping of audition. Phenomenology always presupposes culture, power, practice, and epistemology. "Everything is knowledge, and this is the first reason why there is no 'savage experience': there is nothing beneath or prior to knowledge."[31]

The history of sound provides some of the best evidence for a dynamic history of the body because it traverses the nature/culture divide: it demonstrates that the transformation of people's physical attributes is part of cultural history. For example, industrialization and urbanization decrease people's physical capacities to hear. One of the ways in which adults lose the upper range of their hearing is through encounters with loud machinery. A jackhammer here, a siren there, and the top edge of hearing begins to erode. Conflicts over what does and does not constitute environmental noise are themselves battles over what sounds are admissible in the modern landscape.[32] As Nietzsche would have it, modernity is a time and place where it becomes possible for people to be measured.[33] It is also a place where the human-built environment modifies the living body.

If our goal is to describe the historical dynamism of sound or to consider sound from the vantage point of cultural theory, we must move just beyond its shifting borders—just outside sound into the vast world of things that we think of as not being about sound at all. The history of sound is at different moments strangely silent, strangely gory, strangely visual, and always contextual. This is because that elusive inside world of sound—the sonorous, the auditory, the heard, the very density of sonic experience—emerges and becomes perceptible only through its exteriors. If there is no "mere" or innocent description of sound, then there is no "mere" or innocent description of sonic experience. This book turns away from attempts to recover and describe people's interior experience of listening—an auditory past—toward the social and cultural grounds of sonic experience. The "exteriority" of sound is this book's primary object of study. If sound in itself is a variable rather than a constant, then the history of sound is of necessity an externalist and contextualist endeavor. Sound is an artifact of the messy and political human sphere.

1 Machines to Hear for Them

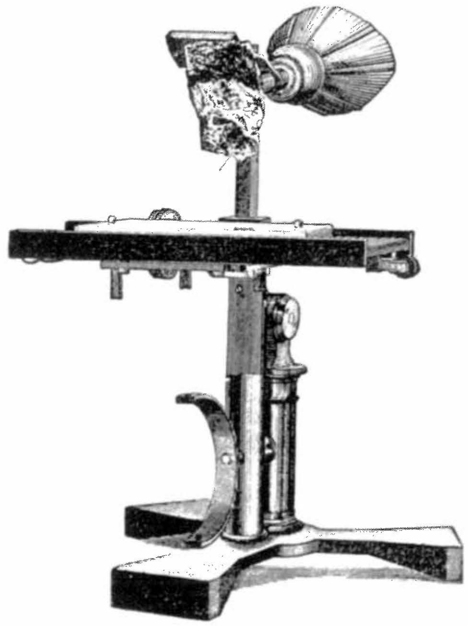
If at some later point, instead of doing a "history of ideas," one were to read the state of the cultural spirit off of the sundial of human technology, then the prehistory of the gramophone could take on an importance that might eclipse that of many a famous composer.—**THEODOR ADORNO,** "The Form of the Phonograph Record"

I would merely direct your attention to the apparatus itself, as it gave me the clue to the present form of the telephone.—**ALEXANDER GRAHAM BELL**

The ancestor of the telephone you are used to using remains the remains of a real human ear.—**AVITAL RONELL,** *The Telephone Book*

In 1874, Alexander Graham Bell and Clarence Blake constructed a most curious machine (figure 1).[1] A direct ancestor of the telephone and the phonograph, it consisted of an excised human ear attached by thumbscrews to a wooden chassis. The ear phonautograph produced tracings of sound on a sheet of smoked glass when sound entered the mouthpiece. One at a time, users would speak into the mouthpiece. The mouthpiece would channel the vibrations of their voices through the ear, and the ear would vibrate a small stylus. After speaking, users could immediately afterward see the tracings of their speech on the smoked glass. This machine, a version of the phonautograph invented by Leon Scott in 1857, used the human ear as a mechanism to *transduce* sound: it turned audible vibrations into something else. In this case, it turned speech into a set of tracings.

But the ear phonautograph did not use the whole ear: that folded mass of flesh on the side of the head—known as the *outer ear, auricle, pinna,* or



often simply *ear*—was loosely modeled in the mouthpiece and thereby rendered unnecessary; the inner ear was superfluous because the machine merely transduced sound for writing. The ear phonautograph was not an attempt to reproduce the actual *perception* of sound. This left only the middle ear, which in a living person ordinarily focuses audible vibrations and conveys them to the inner ear, where the auditory nerve can perceive them as sound. In using the tympanum or eardrum and the small bones to channel and transduce sonic vibrations, the ear phonautograph imitated (or, more accurately, isolated and extracted) this process of transducing sound for the purpose of hearing and thereby applied it to another purpose—tracing. Bell and Blake attached a small piece of straw directly to the small bones to serve as a stylus, producing tracings that were a direct effect of the tympanic vibrations. Inasmuch as we can say that the ear phonautograph embodies the basic principles of other inventions that followed it like the telephone, phonograph, radio, or microphone, we could claim for it a minor technological significance. But, here, I am interested in the ear phonautograph as a cultural artifact in a deeper sense.

How is it that a human ear came to be affixed to a machine at this time, in this way, and in this place? For Bell, the ear phonautograph was the clue

Figure 1. Bell and Blake's ear phonautograph

to the functioning of the telephone. For our purposes, it gives a clue to a more general characteristic of the machines and relations that follow it in time: it places the human ear, *as a mechanism,* as the source and object of sound reproduction. The ear phonautograph is an artifact of a shift from models of sound reproduction based on imitations of the mouth to models based on imitations of the ear. This is more than merely a matter of the choice between two models for imitation; it marks a shift in understandings of sound and practices of sound reproduction. As sound became problematized in physics, acoustics, physiology, and otology, these fields moved toward contemplating and constructing sound as a kind of *effect* in the world. As we will see, prior analyses of sound had been more oriented toward a particular source—theories of sound took the voice and the mouth, or music and a particular instrument (such as the violin), as ideal-typical for the analysis, description, and modeling of sonic phenomena. The mouths and instruments were taken as *general* cases for understanding sound. Sound-reproduction technologies informed by this perspective attempted to synthesize sound by modeling human sonic activities like speech or musical performance. In contrast, the new sciences of sound would in a sense (or, rather, in the sense of hearing) invert the general and the specific in theories of sound. No longer themselves general categories of sound fit for theory construction, the mouth, the voice, music, and musical instruments would become specific contenders for audition in a whole world of sonic phenomena. In this new regime, hearing was understood and modeled as operating uniformly on sounds, regardless of their source. Sound itself, irrespective of its source, became the general category or object for acoustics and the study of hearing. Thus, the ear displaced the mouth in attempts to reproduce sound technologically because it was now possible to treat sound as any phenomenon that excites the sensation of hearing. Under this new regime, the ear's powers to transduce vibrations held the key to sound reproduction.

Using the ear phonautograph as a nodal point in alternately commingled and twisted historical streams, this chapter traces out the tributary currents shaping the very possibility of sound reproduction as we know it. Although I argue that the ear phonautograph represents the maturation of a new sonic regime of sorts (two years before telephony actualized sound reproduction), this is not a strictly Foucauldian tale of a single epistemic or historical "break" between epochs. A multitude of cracks, fissures, tipping points, displacements, and inversions make up this history. So this chapter follows first one tributary current and then another. If you can understand

Phonica," basically a megaphone, included detailed illustrations of the author's theory of sound waves as they made their way through his invention, along with the following description:

In like manner, as to the Nature of Sounds and Voices; I must confess, that the circular Undulations of a Vessel of Water, by the percussion of any part of its Superficies, and the reverberations of those Undulations when they meet with opposition by the sides of such vessels, make it seem more than probable, that the percussion of the Air by any Sound, spreads and dilates it self by a spherical Undulation (greater, or less, according to the strength and virtue of that percussion) till it meet with some opposition, and so echoes back again. And there is great reason to believe that Voices being first modulated and articulated by the Glottis of the Larinx, and the several parts of the Mouth, make spherical Undulations in the Air, till they meet with the Acoustick Organ.[20]

The water analogy is apt here—the author clearly understood that sound functioned as a wave and therefore was able to represent sound graphically as a wave (figure 3). This was as much a depiction of sound's action as a written description—the images in *Tuba Stentoro-Phonica* are clearly imaginative renderings.

Over the course of the nineteenth century there emerged another kind of visual representation of sound. To use the language of C. S. Peirce, these were "indexical" images of sound, where the sound bears some kind of causal relation to the image itself (and, therefore, the image does not have a wholly arbitrary relation to the sound that conditioned it). These images were artifacts of devices that could be affected by sound and thereby create images ordered in part by sonic phenomena. The use of these devices reflected an emergent interest in the scientific use of graphic demonstration and automatic inscription instruments, a practice that developed slowly in the last quarter of the eighteenth century and did not become prevalent until the nineteenth century. Graphs, and later automatic recording devices, represented to their users a new kind of scientific "natural language," where images would reveal relations hitherto unavailable to the senses. Attempts to represent sound visually were themselves artifacts of a larger process through which sound was isolated as a phenomenon and by means of which it would become an object of theoretical and practical knowledge in its own right. In fact, modern acoustics was very much shaped by this reliance on automatic imaging devices and the assumptions that this reliance embodied.[21]

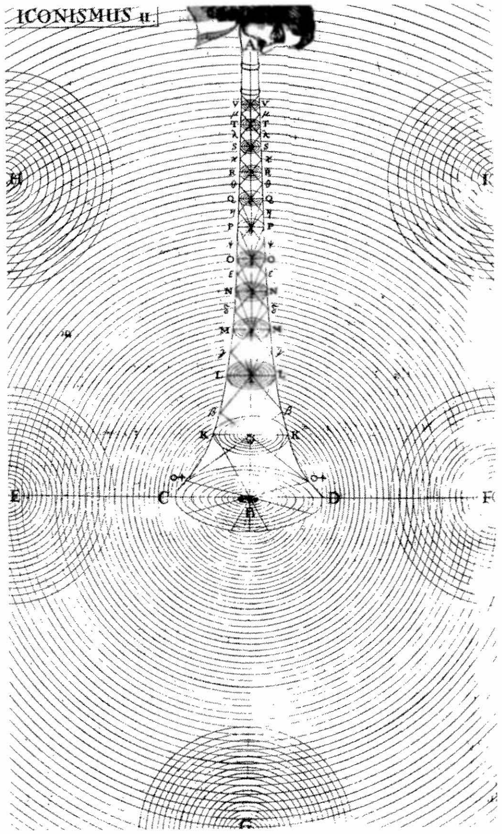


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Figure 3. Drawing of sound refraction from S. Morland, *Tuba Stentoro-Phonica: An Instrument of Excellent Use, as Well at Sea, as at Land; Invented and Variously Experimented in the Year 1670 and Humbly Presented to the King's Most Excellent Majesty Charles II in the Year 1671* (London: Printed by W. Godbid and Sold by M. Pitt, 1672)

Attempts to visualize sound thus coincided with the construction of sound as an object of knowledge in its right: where speech, music, and other human sounds were reduced to special categories of noises that could be studied by the sciences of sound. In acoustics, frequencies and waves took precedence over any particular meaning that they might have in human life: "Frequencies remain[ed] frequencies regardless of their respective carrier medium."[22] Ernst Florens Friedrich Chladni's work at the turn of the nineteenth century is considered to be the founding moment of modern acoustics, and it embodies this connection between objectification, of nervous matter has its peculiar endowment, independently of the others which are bound up along with it; and that it continues to have the same endowment throughout its whole length."[58] In other words, to borrow a phrase from Jonathan Crary, Bell was the first to put forth the hypothesis of the "separation of the senses."[59] The German physiologist Johannes Müller would expand on this thesis.

Müller is often regarded as the founder of modern physiology. Müller's physiology of hearing developed insights into acoustics and otology through experimentation, and he offered functional explanations for all parts of the external, middle, and inner ears across different species. His work is important for our purposes because he proposed that each sense is functionally distinct from the others, can be stimulated by a variety of internal or external stimuli, and therefore can be conceptualized functionally. Müller's discussion of hearing appears in several places in *Elements of Physiology,* his most systematic elaboration of human physiology. At each juncture where he discusses sensation, he is careful to discuss all the senses in turn; my emphasis on hearing in this discussion should be read in purely heuristic terms. But the reason that he attends to all the senses is in fact the key to his argument: everything on sensation in the *Physiology* follows from the basic premise that each sense is functionally and mechanically distinct from the others. In contrast to his predecessors, who (he claims) attributed to each nerve a "special sensitivity" to different phenomena, Müller argued that "each peculiar nerve of sense has special powers or qualities which the exciting causes merely render manifest. *Sensation, therefore, consists in the communication to the sensorium, not the quality or state of the external body, but of the condition of the nerves themselves, excited by the external cause.* . . . Sound has no existence but in the excitement of a quality of the auditory nerve."[60] Like Bell, Müller posited that each sense is separate because its data travel down separate nervous highways.

Müller followed up with the argument that sensation is actually sensation of the states of nerves and not necessarily external phenomena. As it was in acoustics, so it was in physiology: sound was conceptualized as an effect, a particular state of things. The external cause or stimulus for a sensation is of purely instrumental interest to Müller—it is simply a means to sensation, not the sensation in itself. Like Bell, he used the electricity example to argue that it can be seen as light, felt as heat, or heard as buzzing: "Volta states that, while his ears were included between the poles of a battery of forty pairs of plates, he heard a hissing and pulsatory

sound, which continued as long as the circle was closed." For Müller, the differences among the senses are almost entirely chemical and mechanical. The senses simply perceive and convey differently: "The sensation of sound, therefore, is the peculiar 'energy' or 'quality' of the auditory nerve."[61] Sound is the *effect* of a set of nerves with determinate, instrumental functions.

Not only are the senses separate and mechanical, but they are also almost purely indexical. That is to say, *any* stimulus of the nerves of sensation can register as a sense datum. Müller argues that there is no fundamental difference between interior and exterior sensation and that the nerves of hearing can be excited by several causes:

1. The mechanical influences, namely, by the vibrations of sonorous bodies imparted to the organ of hearing through the intervention of media capable of propagating them.
2. By electricity.
3. By chemical influences taken into circulation; such as the narcotics, or alterania nervina.
4. By the stimulus of blood.[62]

As Crary writes of Müller's theory of sight, so it was for Müller's audition: "Müller's theory eradicated distinctions between internal and external sensation," resulting in a mechanical, rather than a spiritual, ground for sensation.[63] Whatsoever stimulated the nerve could cause the sensation. Müller's conception of audition is, therefore, as antithetical to romantic notions of inner perception or even orality as possible. While the latter approaches imagine a willful subject immersed in a world of sensuous experience, Müller's sensing subject is more like an amalgamation of perceptual events connected to both internal and external stimuli.

The importance of Müller's hypotheses for sensation can hardly be overstated. Looking backward, his constructs of the senses can be thought of as *media* in at least two senses of the word. They mediate between the stimulus and the mind (or "sensorium"), and they transmit only certain sensations. It is, therefore, possible to read Müller's theory of hearing anachronistically as a "telephonic" theory of hearing, where only certain vibrations become perceived as sound and vibrations are transmitted down the line as impulses, to be decoded in the brain as sound. Moreover, the auditor will not necessarily be able to distinguish between noise on the line and noises on the other end. Hearing, in other words, is already an instrument. More important, it is for Müller a specific kind of instrument, a transducer. Transducers, like microphones and speakers, change audible vibrations into electric impulses and back again.[64]

Müller's most detailed analysis of hearing bears out this interpretation. It also demonstrates the connections between physics, physiology, and otology. His full analysis of hearing begins with a theory of vibrations derived from the physics of Chladni and his followers. Having earlier made the point that, without hearing, there would simply be vibration and not sound (and having reminded his readers that vibration can also be perceived by sight and touch), Müller moves forward to discuss the specific characteristics of vibration as it affects the sense of hearing. From there, he moves to a detailed anatomic description of the "auditory apparatus"—an especially good name for his mechanical conception of the ear—highlighting the different forms of ears in lower and higher animals. Finally, the section concludes with a lengthy discussion of the relation between the form of each part of the ear and its function. For instance, he argues that our hearing is conditioned by the relative laxness of the tympanic membrane, which allows it to convey vibrations more effectively than a membrane with greater tension. He also claims that the labyrinth has particular acoustic properties that help shape our hearing. In other words, form is still related to function, but it is now *function* that is privileged in the theory of hearing.[65] Müller thus managed to develop an entirely functional and mechanical theory of hearing, one that separated it from the other senses and defined it as a complex mechanism.

Bell and Müller's contributions seem simple enough, but they mark a turning point in the history of ideas about hearing. The separation of the senses posits each sense—hearing, sight, touch, smell, taste—as a functionally distinct system, as a unique and closed experiential domain. Each sense could be abstracted from the others; its peculiar and presumably unique functions could be mapped, described, and subsequently modeled. Physiology moved questions of hearing from morphology to function and technics. Audition became a mechanism that could be anatomically, processurally, and experientially abstracted from the human body and the rest of the senses.

Despite my emphasis on Müller thus far, the work of Hermann Helmholtz probably represents the most influential account of auditory perception in the nineteenth century. While his anatomist predecessors understood the ear as a unique sound appliance and his physicist predecessors understood sound to be a set of organized vibrations, Helmholtz synthesized these two premises with the physiologists' attention to the separation of the senses. Hearing was an amalgamation of the acoustic properties of sound, the shape and mechanics of the ear, *and* the determinate function of the nerves. The work of Bell and Müller provided the foundation for Helmholtz's theory of hearing, but his synthesis of physiology with these other fields distinguishes his work. In fact, the first chapter of his *On the Sensations of Tone as a Physiological Basis for the Theory of Music* begins with a restatement of the separation of the senses:

> Sensations result from the action of an external stimulus on the sensitive apparatus of our nerves. Sensations differ in kind, partly with the organ of sense excited, and partly with the nature of the stimulus employed. Each organ of sense produces peculiar sensations, which cannot be excited by means of any other; the eye gives sensations of light, the ear sensations of sound, the skin sensations of touch. . . . The sensation of sound is therefore a species of reaction against external stimulus, peculiar to the ear, and excitable in no other organ of the body, and is completely distinct from the sensation of any other sense.[66]

Helmholtz's theory of auditory perception begins with the separation of the senses as a first premise. In fact, he can even parse out the meaning of the sense of hearing further than his predecessors. In bringing together several varieties of acoustics and aesthetics, Helmholtz sought to distinguish his inquiry from those that had come before him: "Hitherto it is the *physical* part of the *theory of sound* that has been almost exclusively treated at length, that is, the investigations refer exclusively to the motions produced by solid, liquid, or gaseous bodies when they occasion the sounds which the ear appreciates." Essentially, insights in physiological acoustics had to that point often been side effects of more general investigations into vibrating bodies. The ear was merely a convenient location for the study of vibration. But Helmholtz sought to study the ear as itself a phenomenon; the aim of physiological acoustics was to "investigate the processes that take place within the ear itself." This was, for Helmholtz, the key to connecting the science of hearing with the aesthetics of music. In particular, he would argue that "it is precisely the physiological part in especial—the theory of the sensations of hearing—to which the theory of music has to look for the foundation of its structure." In other words, while physical acoustics explained the movement of vibrations from their source to the ear, physiology would explain the means by which sensation itself was caused. Through investigating this physiological domain, "within the ear itself," Helmholtz would elaborate Müller's theory of hearing. While

Müller had essentially offered a dualistic theory of sense—with the sense and the stimulus—Helmholtz offered a tripartite schema where the stimulus, the sense, and the sensory perception were three different elements.[67]

Helmholtz's conception of "the ear itself," however, was in part a product of advances in otology and the anatomy of the ear. In particular, chapter 6 of *On the Sensations of Tone* contains lengthy discussions and detailed illustrations of the various components of the ear. This physical abstraction of the ear from the body both accompanies and conditions the physiological abstraction of hearing from the other senses. As we will see shortly, function still loosely follows form in Helmholtz: "Now, as a matter of fact, later microscopic discoveries respecting the internal construction of the ear, lead to the hypothesis, that arrangements exist in the ear similar to those we have imagined. The end of every fibre of the auditory nerve is connected with small elastic parts, which we cannot but assume to be set in sympathetic vibration by the waves of sound." Helmholtz concludes that "the essential result of our description of the ear may consequently be said to consist in having found that the termination of the auditory nerves everywhere connected with a peculiar auxiliary apparatus, partly elastic, partly firm, which may be put in sympathetic vibration under the influence of external vibration, and will then probably agitate and excite the mass of nerves." The ear is a mechanism of sympathetic vibration, and it is the ways in which the ear conducts and organizes this vibration that make possible the sensation of hearing. It is, therefore, no surprise that Helmholtz discusses Scott's phonautograph and Politzer's experiments with the auditory bone of a duck, where elements of the middle ear—the tympanic membrane and the small bones—are essentially conductors of vibration.[68]

One of Helmholtz's most lasting contributions was his theory of upper partials or overtones—a principle still widely applicable every time someone listens to a telephone. Any given sound is made up of a wide range of frequencies of vibration, potentially from the lowest to the highest ranges of human hearing. It contains a lower partial (now called a *fundamental*) and a series of harmonic overtones that determine its sonic and timbral character. Through his research, Helmholtz learned that sounds could be best distinguished from one another by their upper partials, that is, through their higher frequencies. Thus, while telephone receivers do not produce the entire range of audible sound, we can recognize the voice at the other end because we can hear the upper partials. Our brains then perform a little psychoacoustic magic, and we hear the rest of the sound, including the very low tones. In addition to telephony, this principle accounts for a major dimension of twentieth-century music. Helmholtz's emphasis on timbre in his theory of musical perception foreshadows distorted styles of guitar playing (heavy metal, hard rock, grunge, etc.) by about a century. As Robert Walser argues, much of the musical force from "power chords" on guitar comes from a lower note that is essentially synthesized when two higher notes a fourth or fifth apart are played. Essentially, upper partials create a lower tone.[69]

The theory of upper partials is important because it treats sound fundamentally as an effect that can be reproduced, rather than something that is tethered to a specific and local cause. Because sounds are made up of a range of frequencies, Helmholtz reasoned that it would be possible to synthesize almost any sound through the production of the right harmonic overtones. As John Peters writes, "Helmholtz levels all modalities and is indifferent to bodily origins: sound is sound is sound. What matters is the wave form and not the source (though, in practice, some sources are extremely hard to mimic, the voice above all)."[70] Frequencies are frequencies. For Helmholtz, sounds are *effects* because (1) sounds can be synthesized and (2) sound is a process that takes place "within the ear itself." If you can get the same reaction in the nerve, you create the same sensation. The cause is irrelevant.

This is a very important condition for sound reproduction as we know it. Since sound is an effect indifferent to its cause, the various processes of hearing can be simulated (and, later, reproduced) through mechanical means. Instrumentation was, in fact, central to Helmholtz's hearing research. His resonators were machines built to embody and test his resonance theory of hearing: these were glass bottles with openings at both ends, covered with pigskin membranes, shaped so that each would resonate at a different pitch. Once trained to hear the various upper partials, the listener could conceivably pick them out from a potentially infinite number of sounds. But it becomes difficult to parse out what is a model and what is a copy in Helmholtz's engineering. The nervous system itself becomes "an analogic extension of media," just as the instruments in Helmholtz's studies become analogical extensions of the middle ear.[71] At one point or another, pigskins, pianos, and telegraphs all become for Helmholtz analogues of aspects of human hearing. Conversely, he is at crucial moments also able to substitute the human ear for its simulation, for instance, by adapting one of the holes in the resonator "for insertion into the ear" and thereby substituting his tympanic membrane for the pigskin.[72]

Helmholtz's piano theory of hearing, which held sway into the twentieth century, is a curious combination of this instrumental (in both senses of the word) understanding of hearing and an extension of the separation-of-the-senses hypothesis. Essentially, Helmholtz argued that the tiny hairs inside the cochlea were like the strings of a piano, each tuned to perceive a particular frequency. As combinations of tones, sounds excited particular hairs in the cochlea and, in turn, produced unique and determinate sensations: "This is a step similar to that taken in a wider field by Johannes Müller in his theory of the specific energies of sense. He has shown that the difference in the sensation due to various senses, does not depend upon the actions the excite them, but upon the various nervous arrangements which receive them. . . . The qualitative difference of pitch and quality of tone is reduced to a difference in the fibres of the nerve receiving the sensation, and for each individual fibre of the nerve there remains only the quantitative differences in the amount of excitement."[73] So, for Helmholtz, it is a separation of the senses all the way down to the partial tones that makes up a single sound. In fact, this approach would lead several later researchers to believe that it would be impossible to reproduce the human voice since doing so would require an instrument with as many fine gradations of pitch as the hairs in the ear itself. Alexander Graham Bell would attempt to build "'a sort of piano-sized musical box-comb with between 3000 and 5000 tines to replicate the hair-like organs of Corti within the human ear.' . . . With Bell we have the effort not just to envision the ear as a piano but to build a piano *as* an ear."[74] Later, Emile Berliner would write that Helmholtz's piano theory of hearing nearly derailed a line of research leading up to the telephone and phonograph because it posed such a significant obstacle to synthesizing the human voice.[75]

Contra Berliner, Helmholtz's research fits nicely within the longer history of the tympanic function that I am describing here. Helmholtz took the earlier physiological hypothesis of hearing's functional uniqueness and developed it into a processural theory of sensation. He treated sound as a determined *effect* that could be created irrespective of its cause, and he offered a theory of hearing as sympathetic vibration that would be borne out in later sound-reproduction technologies. In fact, Helmholtz understood that the tympanic membrane worked to focus and direct sound into and through the middle and inner ear.

Tympanic machines would rely on this same principle. Sound is first focused and directed into the machine through a microphone or recording diaphragm and stylus and then forced out of the machine, thereby vibrating the diaphragm in the speaker, which sets our own eardrums in sympathetic vibration. Hearing is thereby tripled—once by the machine hearing "for us," a second time by the machine vibrating a diaphragm in reproducing the sound, and a third time in vibrating our own tympanic membranes so that the sound may be conveyed into the inner ear. Helmholtz physically abstracted the ear from the body (as is illustrated by his extensive use and discussion of anatomic drawings in his work). He conceived of it as physiologically abstracted and separated from the other senses; he treated hearing as a physiological effect rather than as the result of a particular external cause. In this way, Helmholtz's work marks a crucial conjuncture in the history of hearing. His interest in hearing as a pure function abstracted from the practical research of acousticians, otologists, and anatomists.

Politzer and his students would reconnect Helmholtz's physiological insights with the more practical orientation of otology, cutting ears out of corpses as they went along. Blake's work built on that of his teacher Politzer, who built on that of his teacher Helmholtz, who built on the work of physiologists, physicists, and anatomists. Blake rendered the ear as a functional mechanism within the body, but one that could be extracted, examined, and made operational independently of the rest of that body. This is the intellectual history of the ear phonautograph. But the history of the ear phonautograph, and the entry that it offers us into the history of sound reproduction, is not purely a history of ideas.

Above, I argued that the theoretical abstraction of the ear required its physical abstraction from the human body. Dissection was a key to medical knowledge, and dissection was a hotly politicized practice. The aesthetic, professional, or scientific tones of anatomic and physiological texts theorizing hearing performed a usefully euphemistic function. Despite the resolutely sober tones of the scientific and medical texts that we have been examining, science and medicine were eminently social and political practices. This is to say that the theoretical, practical, and physical abstraction and extraction of the ear from the rest of the human body has a distinctly political valence—a valence rendered most clearly in the history of dissection. As Paul Starr has argued, the creation of professional organizations, the growth in size and prestige of medical schools and hospitals, the unification of the industry through the reorganization of the American Medical Association, and the standardization of licensing all played a part in the institutional growth of medicine. Medicine became more politically organized, more respectable, and more prestigious. The boat of otology rose with this tide.[76]

Clarence Blake's career illustrates the state of medicine in the 1860s and 1870s. Blake's European education would allow him to return to Boston and take part in this larger process. He eventually became Harvard's first professor of otology and would play a part in the promotion and advancement of the field as a whole. When he returned to the United States from Vienna in 1869, he also worked at the Massachusetts Eye and Ear Infirmary. While the establishment's name suggests work on otology, it was really a clinic of ophthalmology that had only reluctantly branched out into otology, largely because patients with afflictions of the ear were in the habit of going to ophthalmology clinics to seek help. Over the next few years, Blake turned the Infirmary's Aural Clinic into a center for research as well as treatment.[77] Understandings of the ear were thus closely tied to the institutions (as well as the technologies) that allowed access to the human ear. Access to the human ear meant access to both living ears in living patients and a steady supply of corpses for medical research. Dissection played an important part in medical education, and that meant that the profession needed access to corpses. The sources of the ears for the two ear phonautographs are worth considering for a moment.

Dissection and anatomy have been central parts of medical education since the late eighteenth century and date back to the thirteenth century. As in England (where medicine was more developed throughout most of the nineteenth century), early American medicine required many more bodies than it could get through legal means. Executed criminals were a common legal source of bodies for dissection, but, through the better part of the nineteenth century, grave robbing was the most common means of acquiring bodies for medical students and researchers. In some cases, the students themselves were the grave robbers. Needless to say, this did little to enhance medicine's public reputation. The historians Ruth Richardson and Suzanne Shultz have both documented numerous instances of crowds descending on medical schools in response to the discovery of an empty grave.[78]

Over the course of the nineteenth century, anatomy acts became the solution for medical schools in need of bodies. By providing a plentiful and legal source of corpses for dissection, they were designed to curb grave robbing, enhance the public image of medicine, and, in almost every case, assure middle-class and upper-class citizens that they would no longer have

to worry about being disinterred. Prior to the acts, people from all classes could fear grave robbers for several days after a burial: it was a textbook case of Ulrich Beck's argument that risk does not necessarily correspond with social class.[79] The anatomy acts compensated for this by connecting medicine with the state-based enterprise of burying the poor. Although no act could guarantee a sufficient supply of bodies (and, therefore, the acts did not entirely stamp out grave robbing), they did provide a steady supply.[80]

Most American anatomy acts were modeled on the British Anatomy Act of 1832, which offered to medicine any corpse that would otherwise have to be buried by the British state: people who died in workhouses or who would otherwise receive a parish funeral. In the United States, since workhouses were not as widely institutionalized, this simply meant that unclaimed corpses or the bodies of people whose families could not otherwise afford a funeral were now offered up to medical science. Ruth Richardson understands the act as a form of class warfare on the poor: "It paved the way for the systematic dismantling of older and more humanitarian methods of perceiving and dealing with poverty."[81] Both the British and the American acts made the bodies of the poor the raw material for medical knowledge.[82]

Since Blake acquired his bodies for study from the Harvard medical school, he was likely a beneficiary of the Massachusetts Anatomical Act, which in 1831 was the first such act in the United States. After discussing with Bell the virtues of using a real human ear in the phonautograph, Blake "went to the Harvard Medical School to get it." In fact, he got two—one for Bell and one for himself.[83] Thus, the construction of the ear phonautograph—as an event—is made possible by a distinct set of social relations. The expropriation of anonymous corpses as fixed capital for the production of knowledge is illustrated nowhere better than in the history of an ear attached to a machine. The medical historian Charles Snyder casts the "donors" of the ears in Bell and Blake's experiments as the "true heroes" of the research. The part played by these people was almost certainly involuntary, and their lesson is less about heroism and scientific progress than about the social relations on which science and technology depended for their existence. This was a human sacrifice of the second order: although death was the result of natural causes, the bodies of the dead were to be sacrificed at the altar of experimentation and medical education. All achievement in history is piled on top of anonymous bodies;[84] the ear phonautograph is rare in that it gives us a glimpse of what lies beneath it. A certain distanced brutality underlies the fundamental mechanism in

A little over a hundred years earlier, it took more than seven hundred pages for the French physician René-Théophile-Hyacinthe Laennec to make a strikingly similar argument for physicians to use stethoscopes to listen to their patients' bodies. Laennec, who is credited with inventing the stethoscope, published *A Treatise on the Diseases of the Chest and on Mediate Auscultation* in 1819 (a second, somewhat revised edition appeared in 1826).[4] Mediate auscultation is the act of listening to a patient's body through a stethoscope. Laennec's lengthy *Treatise* is a fascinating document because it explains to physicians *why* they would want to listen to patients' bodies, how to listen to patients with the stethoscope properly, and how to interpret the sounds thus heard. This level of explanatory detail was necessary at the time: although physical examination would become the dominant mode of examination in the 1800s, it was still an emergent practice in 1819; mediate auscultation developed at a moment when medicine itself was undergoing a major epistemic shift.[5]

This chapter and the next offer a story about changing meanings of listening. The techniques of listening that became widespread with the diffusion of the telephone, the phonograph, and the radio early in the twentieth century were themselves transposed and elaborated from techniques of listening developed elsewhere in middle-class culture over the course of the nineteenth century. Using the Laennec and Brandes documents as end points, chapters 2 and 3 offer a genealogy of *audile technique,* or *techniques of listening.* By this emphasis on technique I mean to denote a concrete set of limited and related practices of listening and practical orientations toward listening. I follow audile technique through three very different cultural contexts: modern medicine in Western Europe and the United States from the 1760s into the 1900s, American sound telegraphy from the 1840s into the 1900s, and sound-reproduction technologies in Europe and the United States between 1876 and 1930. After introducing the concept of audile technique, this chapter examines the emergence of audile technique in modern medicine. The next chapter considers audile technique in the contexts of emergent sonic media: sound telegraphy, telephony, phonography, and radio.

As should be obvious from the long time span and diverse contexts that I cover, this is not and cannot be an anthropological history of listening practices. It is not meant as a systematic account of how people actually listened, and it certainly does not pretend to exhaust the descriptive possibilities of listening history or catalog all the contexts in which audile technique plays a role.[6] My goal is not to describe what it felt like to listen at any given place or time. Nor do I mean to suggest an evolutionary narrative of listening, where the sense of hearing undergoes a naturalized process of modernization. This is why I use the term *genealogy:* I aim to chart the emergence of a practical orientation in diverse contexts over a long period of time. I am interested in family resemblances among otherwise diverse practices, theoretical or "idealized" constructs of listening, and how those constructs were supposed to be put into practice. In other words, this is a history of "regimes" of listening practices. Even if we acknowledge that many of the programs for conduct considered below were never fully realized, they still tell us a great deal about the construction of the institutions and practices that they sought to organize or explain.[7] To take but one example, despite the fact that physicians were supposed to be virtuoso listeners, at the end of the nineteenth century many America doctors were still poorly trained and haphazardly combined methods of diagnosis and treatment. Yet the medical textbooks and medical education of the time were very much oriented toward turning doctors into rational, scientifically minded, virtuoso listeners. The stethoscope was a symbol of the diagnostic power of the medical profession, even if some doctors were not very good at using it.[8]

My use of the word *technique* in relation to listening is derived from Marcel Mauss's notion of "techniques of the body." "The body is man's first and most natural instrument," writes Mauss: "Or more accurately, not to speak of instruments, man's first and most natural technical object, and at the same time technical means, is his body. . . . Before instrumental techniques there is the ensemble of techniques of the body. . . . The constant adaptation to a physical, mechanical or chemical aim (e.g., when we drink) is pursued in a series of assembled actions, and assembled for the individual not by himself alone but by all his education, by the whole society to which he belongs, in the place he occupies in it."[9] Mauss compiles an extensive list of techniques for investigation: sleep, waking and rest, walking, running, dancing, jumping, climbing, descending, swimming, forceful movements, hygiene, eating, drinking, sexuality, and care of the sick. Although he does not include sensory activities—looking, listening, tasting, smelling, touching—these are certainly implied and even occasionally mentioned in the context of the other techniques.[10] So my argument makes a very short leap from Mauss's list of techniques to a history of techniques of listening in modernity. It is something of an extrapolation: ethnographers can go somewhere to learn about cultural practices through participation and observation; historians and genealogists must reconstruct domains of physical practice from documents and artifacts. But the issue of technique remains salient.

Techniques of the body are constructed through "physical education of all ages and both sexes," and, as we will see, techniques of listening are also the result of physical education, whether this education is institutionalized in professional training or simply accomplished through shared and repeated practice.[11] The term *technique* also conjures up names like Aristotle, Martin Heidegger, and Jacques Ellul. It connotes a connection among practice, technology, and instrumental reason: it is a form of "reasoned production," "a way of revealing," a "means with a set of rules for the game." Under the sign of modernity, technique carries a special value and a special valence—it is connected with rationality. Technique brings mechanics to bear on spontaneity.[12]

This is an incredibly important point for a history of communication technology: after Mauss, the body is the first communication technology, and all the *technologies* of listening that I discuss emerge out of *techniques* of listening. Many authors have conceptualized media and communication technologies as prosthetic senses. If media do, indeed, extend our senses, they do so as crystallized versions and elaborations of people's prior practices—or techniques—of using their senses. So, although *technique* and *technology* are terms that clearly bleed into one another, the distinction is crucial for the history of sound. *Technique* connotes practice, virtuosity, and the possibility of failure and accident, as in a musician's technique with a musical instrument. It is a learned skill, a set of repeatable activities within a limited number of framed contexts.

Listening involves will, both conscious and unconscious—perhaps a better word than *will* would be *disposition* or even *feel.* Orientations toward and styles of listening are part of what sociologists and anthropologists have come to call *the habitus.* Following Pierre Bourdieu, *habitus* denotes a set of dispositions, what he calls *a feel for the game.* The habitus is socially conditioned subjectivity: it combines all those forms of informal knowledge that make up social life. Habitus is a mix of custom, bodily technique, social outlook, style, and orientation. Because habitus is socially conditioned, social position and subjective disposition go together—each influences the development of the other.[13] Industry, bureaucracy, science, rationalism, and the new middle class are all so central to the genealogy of

audile technique precisely because techniques of listening represent dispositions articulated within a range of social possibilities.

Modern audile technique combines a relatively stable set of practical orientations toward sound and listening. Although there may be other distinctively modern techniques of listening, the following list represents the orientations common to medicine, telegraphy, and the sound-reproduction technologies considered in this chapter and the next:

1. Listening gets articulated to notions of science, reason, and rationality. Listening becomes a technical skill, a skill that can be developed and used toward instrumental ends. This is hard to describe, and harder to stress, since there are few English words to connote the sonic equivalents of *gazing* or *observing.* We are used to the idea that new orientations toward looking, often thematized as "the gaze," have something to do with changing ways of knowing during and after the Enlightenment. As it was for looking, so it was for listening: audition becomes a site through which modern power relations can be elaborated, managed, and acted out. Starting in a few select contexts, the very meaning of listening drifts toward technical and rational conceptions. Over the long nineteenth century, listening becomes a site of skill and potential virtuosity.
2. In order for listening to become useful as a tool of rationality (and for itself to be rationalized), it had to be constructed as a discrete activity. Chapter 1 introduced the "separation of the senses" and the isolation of hearing in Bell, Müller, and Helmholtz. In the actual practice of audile technique, listening was similarly separated from other sensory activities. As we will see, audile technique is oriented toward a faculty of hearing that is separated from the other senses. Once so separated, it can be intensified, focused, and reconstructed.
3. Concurrent with the separation of hearing from the other senses is a reconstruction of the shape of acoustic space. Audile technique was not simply a representation of acoustic space; it aimed actively to transform acoustic space. The space occupied by sounds becomes something to be formed, molded, oriented, and made useful for the purposes of listening techniques. It can be segmented, made cellular, cut into little pieces, and reassembled. Acoustic space becomes a kind of bourgeois private space. As I will show, even collective conceptions of listening assume that collectivity is entered through this prior, private auditory space.

4. As audile technique problematizes the shape of acoustic space, it also problematizes the content of acoustic space. The previous chapter showed how sound gets constructed as an object in physics, acoustics, and physiology. Whereas voices or music had been privileged instances of sound, now they were merely instances of a more general category of sound. In audile technique, sounds also became meaningful precisely for their sonic characteristics, in a manner parallel to the way in which timbre became a central concern of nineteenth-century acoustics after Helmholtz. On the basis of their sonic character, sounds become signs—they come to mean certain things. Technical notions of listening depend on the establishment of a code for what is heard but exist without an effective metalanguage. A metalanguage of sound would consist of a nonspecialized set of terms that enabled people to describe the details of audile experience in a purely abstract manner. While visual experience has a well-developed metalanguage, sonic experience does not. We have abstract words to describe color, texture, shape, direction, shading, and so forth. Conversely, most of the language used to describe elements of auditory phenomena is metaphoric: aside from specialized languages in musicology, sound engineering, acoustics, and general descriptors such as *loud* or *quiet,* there are very few abstract words in common English for describing the timbre, rhythm, texture, density, amplitude, or spatiality of sounds.[14] Because of the difficulties involved in constructing a metalanguage of sound, audile technique would come to stress listening practice and practical knowledge through listening, rather than formal and abstract descriptions of sounds.
5. Techniques of listening are based in and described through a language of mediation. Audile technique is premised on some form of physical distance and some mediating practice or technology whereby proximal sounds become indices of events otherwise absent to the other senses. This was in part a component of rationalizing listening and turning it into a skill. It was also in part a component of isolating and intensifying hearing as a faculty.
6. Finally, audile technique could come to hold a great deal of symbolic currency: virtuosity at audile technique could be a mark of distinction in modern life. Both doctors and sound telegraphers used representations of listening as part of their professional mystique. The more generalized audile technique associated with sound-reproduction technologies was widely understood as an index of those technologies' modernity.

Speaking generally, audile technique articulated listening and the ear to logic, analytic thought, industry, professionalism, capitalism, individualism, and mastery—even as it required a good deal of guesswork in practice. The history of audile technique thus offers a counternarrative to Romantic or naturalistic accounts that posit sight as the sense of intellect and hearing as the sense of affect, vision as the precise, localizing sense and hearing as the enveloping sense.[15] Some medical historians have suggested that there is a uniquely modern medical gaze. If this is the case, then modern orientations toward medical listening were a necessary precondition for this gaze as we know it. If, as many media historians have suggested, electric telegraphy heralds the age of modern mass communication, then listening is at the very core of modern media history. If technologies of sound reproduction depended on and actuated versions of audile technique, they drew together a diverse field of practices that had been developing for decades. To capitalize and commodify sound, sound media industries deployed a preexisting notion of sonic space as private property.

Audile technique emerged as a distinctively modern set of practical orientations toward listening. As a way of knowing and interacting with the world, it amounted to the reconstruction of listening in science, medicine, bureaucracy, and industry. It helped constitute these fields. Audile technique was also a distinctly bourgeois form of listening; it corresponded with the emergence of *middle class* as a salient cultural category. Thus, the orientations toward listening that accompanied sound-reproduction technology in the late nineteenth and early twentieth centuries are part of a longer-term historical current. Many writers in the 1920s and 1930s pinned radio's cultural significance on its use of hearing—"a novel sense." Rudolph Arnheim understood radio perception as a kind of blindness, an aesthetics of the audible with the visual component subtracted. For Hadley Cantril and other radio researchers, radio represented a unique psychological phenomenon, where *listening* became synecdochic for all activities of audiencing.[16] These primarily developmental accounts posit the existence of a history of listening and at the same time close it down—radio, film, and sound recording become the agents of acoustic modernity. They treat sound-reproduction technologies as positing a new way of hearing. In contrast, this genealogy of audile technique begins an argument for listening that will be continued throughout the book: over the course of the