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Kursell, J.

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Alexander Ellis's Translation of Helmholtz's *Sensations of Tone*

Julia Kursell, *University of Amsterdam*

Abstract: This essay relocates Alexander J. Ellis's translation of Hermann von Helmholtz's book *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (1863) in a broader context. It discusses Ellis's various endeavors to make knowledge available to those with limited access to it and, more specifically, his attempts at making the sound of speech accessible to readers of printed text. Against this background, the essay then compares the central notion of tone sensation in Helmholtz's book to Ellis's rendition thereof. As will be seen, Ellis preferred familiarity to literal translation, but he also made great efforts to convey the quality of speech sounds where these became the object of investigation. This double strategy—which was not in line with Helmholtz's forging of a new theory of perception through defamiliarizing common terms—forced Ellis into exuberant explanations that eventually overgrew the carefully transmitted original, resulting in what amounted to a book of his own.

“Sound is a sensation,” begins *The Alphabet of Nature* (1845), “and is, therefore, like all other sensations, indefinable, as it is also inconceivable to those who have never experienced it.”¹ The name of the science of acoustics, the author, Alexander Ellis, explained, stemmed from the Greek ἀκούω, for “I hear”—to be pronounced “ἄkauo” in Eton and “akuo” in modern Athens, he added.

Such an emphasis on the “entirely subjective” nature of acoustics was not the rule in the mid-nineteenth century. Hermann von Helmholtz cautioned his readers in *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (1863) about mistaking acoustics for part of physics. So-called physical acoustics was “nothing but a section of the theory of the motions of elastic bodies.”² For the physicist, whether these motions could be seen or heard was a matter of indifference; physicists took hearing into account only for observing the phenomena. For Helmholtz, on the other hand, only the physiological study of the ear should actually be considered the basis of a science worthy of the name “acoustics.”

Julia Kursell is Professor of Musicology at the University of Amsterdam. She is coeditor of *History of Humanities*. With Rens Bod, she coedited the Focus section “The Humanities and the History of Science,” *Isis*, 2015, 106. Her current areas of research include the history of systematic musicology and twentieth-century history of Western music. Faculty of Humanities / Musicology, University of Amsterdam, Nieuwe Doelenstraat 16–18, 1012CP Amsterdam, Netherlands; J.J.E.Kursell@uva.nl.

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¹ Alexander J. Ellis, *The Alphabet of Nature* (London: Bagster and Sons; Bath: Isaac Pitman, Phonotypic Institution, 1845), p. 1.

² *Ibid.*, p. 18 n 43; and Hermann von Helmholtz, *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (Braunschweig: Vieweg, 1863), p. 5, here quoted from Helmholtz, *On the Sensations of Tone as a Physiolog-*

Both for Helmholtz and for Ellis, the notion of sensation provided a missing link in their approaches to knowledge on sound. In Helmholtz's study of hearing, sensation was operative in connecting rigorous formal description to experience. By suggesting a way to produce tones with only one frequency component, he turned a simple sinusoidal frequency into an audible phenomenon. If a single physiological reaction corresponded to any such tone, so Helmholtz hypothesized, this might explain how periodic sounds were distinguished in hearing. The formal distinction between two periodic waves by means of their mathematical analysis could be correlated to the distinctions between the timbre of two notes and thus to a distinction that was relevant for hearing: the ear operated like a Fourier analyzer, breaking down sound into sensations of single frequencies. Although Helmholtz was not able to prove that such was the case, the hypothetical sensation of tone brought him as close to the actual mechanism of hearing as one could possibly get without having the possibility to observe that mechanism. Sensation helped him in doing so not *although* it escaped generalization but *because* it linked a rigid formal description to an effective experience of hearing.

For Ellis, sensation played a different role. It explained the limitations in accessing knowledge about sound. To become acquainted with a sound, one had to experience it. This was particularly problematic for pronunciation—a field that busied Ellis all his life and eventually became his main occupation. Sensation tied pronunciation to individual experience. Ellis, a “gentleman-scholar of private means”³ who had studied mathematics and philology at Cambridge, has often been taken to be a philanthropic dilettante who was striving to overcome his own limitations. His entry in the *Grove Dictionary of Music*, for instance, cautions that the rumors about him being tone-deaf were probably overstated.⁴ His various publications in the field of mathematics, which were partly educative in character—such as “Arithmetical Crutches for Limping Calculators and Gymnastics for Weak Ones” (1876)—and partly intended to develop his own theory about a quantitative approach to algebra, were “received courteously by fellow mathematicians, though hardly enthusiastically,” according to the *Oxford Dictionary of National Biography*.⁵ His various attempts to establish a phonetic alphabet met with varying success. Having supported the printed version of Isaac Pitman's shorthand by funding publication of transcriptions of the Bible, Shakespeare, Milton, and a primer for schoolchildren, he kept inventing phonetic transcriptions for various purposes and with various characters. The “Obituary Notices for Fellows Deceased” for 1890 honored the good cause of these endeavors by quoting Ellis at length—and in his “Glossic” orthography: “Too make dhi riseevd proanunsiashen ov Ingglish aksesibl too aul reeders, proavinshel and foren.”⁶

Whatever the sources of Ellis's empathy with those who had limited access to knowledge, his premise that some access could also be found when a gap separated the observer from his or her

ical Basis for the Theory of Music, translated with the author's sanction from the third German ed. with additional notes and an additional appendix by Alexander J. Ellis (London: Longmans, Green, 1875), p. 4.

³ Graham Shorrocks, “The Dialectology of English in the British Isles,” in *History of the Language Sciences: An International Handbook on the Evolution of the Study of Language from the Beginnings to the Present*, ed. Sylvain Auroux, E. F. K. Koerner, Hans-Josef Niederehe, and Kees Versteegh, Vol. 2 (Berlin: De Gruyter, 2001), pp. 1553–1562, on p. 1558.

⁴ W. R. Thomas and J. J. K. Rhodes, “Ellis [Sharpe], Alexander J(ohn),” *Grove Music Online*, <http://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000008733> (accessed 2 Jan. 2018).

⁵ M. K. C. MacMahon, “Ellis [formerly Sharpe], Alexander John, Phonetician and Mathematician,” *Oxford Dictionary of National Biography*, <http://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-8683> (accessed 27 Nov. 2017). “Arithmetical Crutches for Limping Calculators and Gymnastics for Weak Ones” is listed in the obituary notice of the London Mathematical Society: R.T., [Obituary: Alexander J. Ellis], *Proceedings of the London Mathematical Society*, 1889–1890, 21:457–461, on p. 460.

⁶ W.P., [Obituary for Alexander John Ellis], *Proceedings of the Royal Society of London*, 1890, 49, Appendix (“Obituary Notices of Fellows Deceased”), pp. i–iv, on p. ii.

object worked very well in certain situations. For dialectology and ethnomusicology Ellis provided viable tools. The cent scale he introduced for measuring musical intervals has become a standard in ethnomusicology and acoustics; the IPA—international phonetic alphabet—is based on the characters that Ellis developed together with Pitman; and the publications on English dialectology that are part of his five-volume study *On Early English Pronunciation* (1869–1889) have only gained in importance during the past decades.⁷ These tools measured the gap, although sensation, which explained why it was there, remained inaccessible.

* * *

On 24 August 1863 Ellis sent a bundle of letters, accompanied by his own extensive explanation, to Helmholtz. The letters came from publishing houses that had declined Ellis's offer to translate what would become *On the Sensations of Tone as a Physiological Basis for the Theory of Music*. The publishers referred to the "apathy of popular readers in matters of true science" and the "discouraging sale" of such works—or they declared the book to be "too abstruse to become popular in this country." "In Germany," one of them explained, "the musical profession appear to study such works; in this country few do so."⁸ For the time being, Ellis went on in his letter, the English reader would have to do without a translation of the book.

Nevertheless, Ellis took up work on the translation. He was an eminent candidate for tackling the task. When Helmholtz met him on the occasion of a visit to England in 1864, Ellis was involved in the newly founded Early English Text Society; that same year he was also elected to membership in the Royal Society and the London Society of Mathematics. It took Ellis more than ten years to complete a first version of his translation, during which the original saw two revised editions, in 1865 and 1870. The translation that eventually came out with Longmans, Green & Company in 1875 was based on the third German edition of 1870. By the time the translation was published, Helmholtz had established connections with scientists in England, and in 1873 he was honored by the Royal Society with the Copley Medal. By the time he published a fourth and last revised edition in 1877, it went without saying that Ellis would also prepare a revision of the English translation, which came out in 1885. Ellis, again, was "not content with translating excellently the 640 closely printed pages of the original"; as one contentemporary commentator remarked, "he ornamented it with a mass of elaborate theoretical matter of his own, amounting in notes and appendices, to about 60 per cent. more."⁹

* * *

On the Sensations of Tone as a Physiological Basis for the Theory of Music is a unique example of a translator's scrupulous effort both to stay true to the original and to embed the result in a different context. This required, along with copious additions, some degree of change and compromise. "An English reader," Ellis cautioned in one of his abundant footnotes, "could not be safely trusted to keep this very peculiar and important class of musical tones, which he has very rarely or

⁷ For the cent scale see Jobst Fricke, "Cent," *MGG Online*, <https://mgg-online.com/mgg/stable/12721> (accessed 1 Jan. 2018); and Mark Lindley, Murray Campbell, and Clive Greated, "Interval," *Grove Music Online*, <http://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000013865> (accessed 4 Jan. 2018). For the development of the IPA see J. Alan Kemp, "The History and Development of a Universal Phonetic Alphabet in the Nineteenth Century: From the Beginnings to the Establishment of the IPA," in *History of the Language Sciences*, ed. Aroux et al. (cit. n. 3), Vol. 2, pp. 1572–1584. For an acknowledgment of Ellis's work as a dialectologist see Shorrocks, "Dialectology of English in the British Isles" (cit. n. 3), p. 1559.

⁸ Herbert Hörz, *Brückenschlag zwischen zwei Kulturen* (Marburg: Basilisken, 1997), p. 217.

⁹ W.P., [Obituary for Alexander John Ellis] (cit. n. 6), p. iv.

never heard separately, invariably distinct from those musical tones with which he is familiar."¹⁰ What the English reader should not be burdened with, he determined, was Helmholtz's new notion of "tone." Helmholtz redefined the German word "*Ton*" so as to denote the effect of a vibration with a single frequency component. Helmholtz was, in fact, the first to make such simple tones audible. No wonder, then, that their sound was unfamiliar to the English—or indeed any other reader. The sensation—as conceived by Ellis—was not available to them.

While tone was a concept common to both German and English, it was more difficult to find an English equivalent for the term Helmholtz reserved for periodic sound. He used "*Klang*" for the impression of harmonic frequency compounds. In Helmholtz's nomenclature, "*Ton*" and "*Klang*" became the basis of a distinction between sensation and perception that was crucial for the design of his theory of hearing and of perception more generally. Defining the terms was therefore of utmost importance. In common German usage, "*Ton*" designated the sounds of music—in contradistinction to "*Geräusch*" (a singular occurrence of a noise), "*Laut*" (an occurrence of an articulate sound, mostly but not exclusively made by a human), and also "*Klang*," which referred to periodic sound when it occurred not in the context of music or, if used for musical notes, to their quality.

Pairing *Ton* and *Klang*, Helmholtz crossed the boundaries of musical and nonmusical contexts. But even more problematic was the fact that musical notes most often were heard to have only one pitch—although in Helmholtz's terminology they had to be said to consist mostly of more than one frequency component.¹¹ Pitch apparently created a unit from the components, and this unit was what one usually called tone. Helmholtz excluded this aspect from his definition, as he also aimed at excluding music from his new nomenclature.

Ellis's rendition discussed the problem, rather than translating the text:

We have hitherto used the expression tone and musical tone indifferently. It is absolutely necessary to distinguish in acoustics first, a *musical tone*, that is, the impression made by *any* periodical vibration of the air; secondly, a *simple tone*, that is, the impression produced by a *simple* or pendular vibration of the air; and thirdly, a *compound tone*, that is, the impression produced by the *simultaneous* action of *several* simple tones with certain definite ratios of pitch as already explained.¹²

At this point an interpolation ensued in the main body of the text, in which Ellis explained that musical tones may be either simple or compound, that for the compound tones the word "note" would also be used, and how and why pitch (meaning the lowest partial in the compound) was attributed to notes; he even introduced the musical term "chord" for Helmholtz's deliberately nonmusical "*Zusammenklang*."

There are many reasons why a literal interpretation of Helmholtz's text was difficult. Not only did some of the terms he used not exist in English, but in fact their use in the German original was deliberately awkward. The new definitions were meant to prevent the reader from falling back on the familiar context of music. Ellis acknowledged the aim of avoiding common notions in Helmholtz's definitions. Yet he did not deem it a good idea to imitate the German terms for this reason. Instead, he intended to "employ terms which should be thoroughly English, and should not in any way recall the German words."¹³ Comparing his own choices to those of John

¹⁰ Helmholtz, *On the Sensations of Tone*, trans. Ellis (cit. n. 2), p. 36.

¹¹ Helmholtz, *Die Lehre von den Tonempfindungen* (cit. n. 2), p. 39.

¹² Helmholtz, *On the Sensations of Tone*, trans. Ellis (cit. n. 2), p. 26.

¹³ *Ibid.*

Tyndall, who had written an introduction to the study of sound that was based on Helmholtz's work, Ellis dismissed the translation of "*Ton*" as merely "tone" without adding the qualifier "simple" and the translation of "*Klang*" as "clang" because of the connotations of clashing metal in expressions like "the clang of arms." These sounds contained inharmonic components and therefore were inappropriate for denoting periodic sound.

At first glance, Ellis's options resemble a choice between, say, the poetics of translation in Alexander Pope and August Schleiermacher's work translating ancient Greek. Pope hoped to find the "just pitch" of Homer's style in doing justice to the effects his poetry achieved with no words other than those common at his time. Half a century later, and in the context of translating Plato into German, Schleiermacher emphasized that the foreign language will and should always remain foreign.¹⁴ Although one aspect of Ellis's translation practice is certainly that he addressed the common sense of his readers and therefore avoided words with awkward connotations, another aspect is no less important for his *modus operandi* as a translator.

That aspect is music. In the preface to his first translation, Ellis declared that the object of Helmholtz's book was to show "what the Science of Physiological Acoustics has done, and can do, for the Theory of Music." Undeniably, this was a book about music. However, Ellis's claim that the book proved not only that musicians would do better if they were exposed to acoustics, "but that they really cannot get on without Acoustics at all," went in a different direction than Helmholtz's work.¹⁵ Ellis identified a readership and sought to address its specific needs. In Helmholtz's work, however, such a notion was absent.

Helmholtz's physiological acoustics parallel his physiological optics. In both fields he published a voluminous treatise—the *Handbuch der physiologischen Optik* came out in three parts between 1856 and 1866, while Helmholtz was working on the *Lehre von den Tonempfindungen*. Together, the two works instantiate a theory of perception that integrates physiology and is formulated to its full extent in a lecture with the title "Die Thatsachen in der Wahrnehmung" (1878). The two treatises on vision and hearing contributed an important distinction to the theory of signs Helmholtz proposed there: the physiological apparatus provided sensations that were then, on a higher level, synthesized into perceptions.

Although Helmholtz did not venture to speculate about neurological features of the brain, he did wonder about the connections between sensory apparatus and the higher levels of cognition. In both treatises he identified a first level of quasi-automatic synthesis that constitutes perceptions when humans learn to use their senses. He exemplified this level in vision by discussing stereoscopic vision and, especially, spatial vision. For audition, however, he had no evidence that the auditory nerves cross before reaching the brain—such a crossing was found only after his death. Therefore, a discussion of auditory space did not make sense, because any judgments about such a space would have been too remote from that first level of quasi-automatic synthesis. Instead, he turned to music as the realm in which the early synthesis occurs and is even exploited in an elaborate art of its own.¹⁶ The habits and opinions of the actual musicians of his own time, however, were of less consequence for this endeavor than the rhetoric engaged to sell the book to an audience at first glance suggests. If this was a book about music, it was not a book for educating musicians.

* * *

¹⁴ Alexander Pope, "Preface," in *The Iliad of Homer*, trans. Pope (London: Cassell, 1909), pp. 13–32, on p. 26 ("just pitch"); and Friedrich Schleiermacher, "Ueber die verschiedenen Methoden des Uebersetzens," in *Das Problem des Uebersetzens*, ed. Hans Joachim Störig (Stuttgart: Wissenschaftliche Buchgesellschaft, 1963), pp. 38–70.

¹⁵ For the quotations see Helmholtz, *On the Sensations of Tone*, trans. Ellis (cit. n. 2), p. v.

¹⁶ On this see Julia Kursell, *Epistemologie des Hörens* (Paderborn: Fink, 2018).

Ellis's cautions were not in vain. This is particularly apparent in his translation of the main experiment discussed in the book: the synthesis of vowels from simple partial tones. Helmholtz used the vowels of the German language as his experimental object for demonstrating that the ear could distinguish sounds that were composed from simple tones only. An "apparatus for the artificial construction of vowels" he had built for this purpose, in the first instance, produced sounds that could unambiguously be described with the help of Fourier analysis.¹⁷ This experiment reduced the task for hearing to distinguishing the sounds in question. Its main claim was that the ear could distinguish sounds that differ in nothing—not their pitch, not their loudness—apart from frequency patterns accessible to formal description. The additional claim that the sounds resembled vowels was not essential for the functioning of the experiment but made it more easily accessible to his readers.

The apparatus produced single audible frequencies with a set of tuning forks and resonators that were tuned to a Fourier series. These simple tones, in the narrowest sense of the word, could be combined so as to form various patterns of strong, low, or eclipsed partials. By playing various combinations on a keyboard that was connected to lids in front of the resonator's openings, the researcher could change the patterns of partials in quick succession. With this apparatus Helmholtz claimed to have been able to synthesize the vowels of the German language: A-E-I-O-U. He admitted, though, that some of the vowels were hardly recognizable. The highest partials of the apparatus were too weak to produce convincing results for I and E.

Alexander Graham Bell, who witnessed Ellis operating such an apparatus in 1867, noted that the "tuning forks speak vowel sounds."¹⁸ Ellis himself reported on the experiment in a more skeptical tone. "There is much more yet to be learned," he summarized both Helmholtz's and later attempts to generate vowels artificially, "before we can satisfactorily imitate spoken vowels."¹⁹ One obvious problem was that the artificial vowels modeled sung rather than spoken vowels. The very mode of production allowed only for stable, unchanging sound. This was in line with the purpose of showing that periodic sound can be discriminated on the basis of frequency patterns alone.

For Ellis, the problem did not end with recreating spoken rather than sung vowels:

We should bear in mind that each speaker has his personal quality of "voice" . . . by which he would be recognised . . . so that there are really millions of different qualities of tone all recognised generically as the same vowel. And yet in the artificial vowels just considered I could not recognise any exact form of human vowel with which I was acquainted, although I have made speech sounds an especial study for more than forty years.²⁰

Ellis realized that the only way to grasp the difference between the vowels depended on the speed with which the change between patterns could be achieved. "When taken in rapid succession, the ear at once recognised that these sounds were meant for oo, oh, ah, and perhaps ay, ee." The longer a sound persisted, the more difficult it became to associate its quality with any vowel quality, let alone that of a spoken vowel. This effect could be compared to what Robert Willis had

¹⁷ For the quotation see Helmholtz, *On the Sensations of Tone*, trans. Ellis (cit. n. 2), p. xiii.

¹⁸ Quoted in David Pantalony, *Altered Sensations: Rudolph Koenig's Acoustical Workshop in Nineteenth-Century Paris* (Dordrecht: Springer, 2009), p. 218.

¹⁹ Hermann L. Ferdinand von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Theory of Music*, 2nd English ed., translated, thoroughly revised and corrected, rendered conformal to the 4th (and last) German ed. of 1877, with numerous additional notes and a new additional appendix, bringing down information to 1885, and especially adapted to the use of music students by Alexander J. Ellis (London: Longmans, Green, 1885), p. 543.

²⁰ *Ibid.*

noted earlier in a study of vowel sounds. Even a parrot's imitation of language could be understood, though it did not resemble a human voice; so could the distorted voice of the puppet character Punch in *Punch and Judy*, for which the actor had to put a piece of metal in his mouth. The context of the linguistic utterance made up for the distortion. As long as the change in quality in the vowel experiments followed the pace of human articulation, the distinctive qualities seemed apparent, but they disappeared in longer tones.²¹

Helmholtz chose vowels for the reason that they were characterized by frequencies within the range of his apparatus. Yet this was not the whole story. Vowels not only fitted best with his minimal definition of sound discrimination; they also formed a set of sounds that could be denoted in printed text, thereby also making the argument more accessible to the reader. The vowels were familiar, which in turn created a rhetorical effect of evidence. This rhetorical effect changed considerably in the English translation. The straightforward relation of the German vowel system to its notation did not apply in the English language. Ellis was well aware of this difficulty, and—as Willis, for instance, had done before him—he supplied English words to give an idea of the sounds in question. Ellis's earlier work, and especially the collaboration with Isaac Pitman, inventor of a phonetic shorthand, on a phonetic alphabet, had brought the lack of an unambiguous relationship between letters and sounds to his attention. Translating vowel qualities—that is to say, the material basis of Helmholtz's experiment—was by no means simple.

CONCLUSION

English pronunciation is characterized by particularly great differences among speakers: any utterance immediately betrays the speaker's provenance. Such concerns, which George Bernard Shaw later hypostasized in the figure of Professor Higgins in his play *Pygmalion*, led Ellis to search for a way of notating sounds that would avoid ambiguity. The translation of Helmholtz's study of hearing opened up another area in which the accessibility of sound could be improved. Yet the central notion of sensation of tone only confirmed the problematic issue. To guarantee accessibility, a description of a sound always had to do more than just find the best sign to denote it. Helmholtz's idea to capitalize on the systemic effect of vowel pronunciation worked well in a language whose alphabet supported unambiguous reference. Ellis, however, had to make considerable extra efforts to retain consistency while achieving a similar rhetorical effect. His strategy was to supply explanation and context that made up for the lack of directly congruent terms. His translation eventually amounted to a second book: Helmholtz on hearing was complemented by Ellis on Helmholtz, music, and language.

²¹ *Ibid.*; and Robert Willis, "On the Vowel Sounds, and on Reed Organ-Pipes," *Transactions of the Cambridge Philosophical Society*, 1830, 3:231–268.