Words and Numbers: The Many Languages of Nineteenth-Century Pitch Standardization

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ABSTRACT

During the late eighteenth and nineteenth centuries, classical music was increasingly perceived as a universal language in Western countries. At the same time, intensifying processes of globalization and growing historical knowledge about the musical past revealed the plurality of musical systems in use across nations and time. In response to this complexification of the Western musical field, attempts were made to standardize pitch as a way of helping to regulate and secure such historical and geographical exchanges. Throughout the second half of the nineteenth century, musical pitch was at the center of intense debates across Europe and the United States, which resulted in successive transformations of the languages used to represent this phenomenon. International negotiations to determine a musical standard for musical practice and instrument building provided the conditions for fresh, universal, and number-based representations of pitch to emerge. But this new approach to musical pitch also opened the door to relativist approaches to sound that relied on new, verbal kinds of explanations. Examining the shifting languages of nineteenth-century pitch standardization and drawing on the example of British scholar Alexander J. Ellis's activities, this essay recovers the complex genealogy of pitch data, at the crossroads of art, science, and the humanities. If, at first sight, pitch quantification seems to belong to physics and mathematics, in fact musicology, linguistics, and other "soft" practices played a key part in bringing pitch data into being. Its study thus requires us to go back and forth across the humanities and the sciences and attend to many soft practices, challenging established boundaries in the history of knowledge.

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The latest edition of the *New Grove Dictionary of Music and Musicians*, one of today's main musical encyclopedias, defines musical pitch as the combination of two elements: "a frequency value with a note name." Arguing that "it is only when [frequencies and pitches] are connected to pitch standards that they take on a musical dimension," and defining pitch standards as "convention[s] of uniform pitch . . . understood, prescribed and generally used by musicians at a given time or place," the author of this text defines frequencies and pitches as "simply natural phenomena."[1]

Drawing a line between a "natural" and a "cultural" dimension of pitch, the *New Grove*'s definition suggests that measuring sound frequencies and embedding them in specific musical contexts come under the purview of two separate domains of scholarly activity, each located on one side of the "two cultures": physics, on the one hand, and musicology, on the other. This article undermines this distinction by attending to the ways in which pitch quantification itself cuts across the sciences and the humanities. At first sight, measuring sound frequencies seems to belong to physics; yet as this article demonstrates, linguistics, musicology, as well as other "soft" knowledge domains played a key part in bringing pitch data into being. And while frequency values seem to offer transparent representations of a "natural phenomenon," I argue that pitch quantification is an operation with high cultural stakes that challenges established disciplinary boundaries, thus offering a unique entry point into the complex genealogies of sound knowledge.

To start disentangling the rich history of pitch quantification, one first has to take note of the differences between current and historical conceptions of musical pitch. Today, this notion is defined as a perceptual category. Since the development of psychoacoustics in the interwar period, many experiments have highlighted the gap between soundwaves and their perception, thus calling for a distinction between frequency and pitch. But well into the twentieth century, musical pitch was a heuristic notion that crystallized evolving knowledge of the articulation between physical and psychological understandings of sound, thus bridging these two domains of sound knowledge.

That musical pitch was in flux was further attested by linguistic differences. For example, the expression lacks a clear equivalent in French, German, and Italian. In all these languages, the notion has at least two possible translations. While the words "diapason," "Kammerton," and "chorista" respectively referred to the standard in use at a given time or place, it was with the words "ton," "Tonhöhe," and "tono" that the low or high position of sound and its perception were designated. What is more, in the nineteenth century, the

1. Bruce Haynes, "Pitch," in *New Grove Dictionary of Music and Musicians*, ed. Stanley Sadie, 2nd ed. (London: Macmillan, 2001).

French word "diapason" referred not only to abstract standards in use for musical practice and instrument building but also to the instruments that embodied such standards (increasingly, but not only, steel tuning forks), as well as the ambitus of a given voice or instrument (the range of sounds extending from the lowest to the highest note that can be produced).

Beyond historical and geographic linguistic fluctuations, before the general acceptance of electroacoustical procedures for sound measurement in the interwar period and the use of the hertz as a uniform unit from 1960,[2] there was more than one way to quantify and represent pitch. Sound measurements were embedded in diverse cultural contexts. For example, frequency indications were different in France, where the use of single vibrations prevailed, unlike in Germany, Britain, and the United States, where double vibrations predominated. Because tuning procedures relied on temperature, measures also had to be converted between degrees Celsius and Fahrenheit. Adding to the national variety of concepts and units associated with pitch quantification, sound measurements were inseparable from the diverse methods and technologies that scholars used to produce them. At a time when sound metrology was still very much an experimental science, the validity of sound measurements entirely depended on the explanations that accompanied them, detailing the protocols and apparatus that scholars had employed to produce them.

Things got even more complex when it came to measuring musical sounds. Musical pitch is indeed embedded in technologies that embody a variety of systems. As a result, measuring it was an operation that required far more than the mere physical observation of a soundwave. Scholars interested in the measurement of musical pitch also had to mobilize theoretical and historical knowledge about musical scales and temperaments contained in past and present treatises on music. Crucially, nineteenth-century conversations about musical pitch gravitated around the note A, which was the result of practical considerations, rooted in the reality of musical instrument building—A being the note of an open string on a violin. Yet in measuring musical pitch, scholars encountered not only A but also all other notes of the scale. This represented a major epistemological obstacle, given that the relationship between various musical notes was not fixed, neither historically nor at the time. As a result, to compare the results that they obtained from the measurement of various notes, scholars always needed to contextualize them within relevant musical systems.

2. CGPM, *Compte rendu des séances de la 11e conférence générale des poids et mesures* (Paris: Gauthier-Villars, 1961).

Despite the many problems that arose from the creation of pitch data, during the nineteenth century one witnessed the naturalization of musical pitch. This was the product of inherently political projects that took place during the second half of the nineteenth century. After 1850, unifying approaches to musical pitch sought to transcend the local dimension of pitch quantification. The French government made a beginning. In 1859, it created the first nationwide standard pitch value of 870 simple variations, a national point of reference for musical practice and instrument building. In the following decades, musical pitch became the topic of transnational negotiations aimed at establishing a sonic point of reference on a global scale and across different time periods. This, in turn, fueled scholarly discourses that construed musical pitch as a unified phenomenon across time and space and increasingly detached sound measurements from their material and cultural contingencies. In this context, numerical representations of pitch started to gain unprecedented autonomy and a new ability to represent sound without any explicit explanation.

Universal approaches to musical pitch, as can be expected, also created considerable friction, which ultimately opened the door to relativist approaches to sound. This is what I examine in the second part of this essay by turning to the activities of Alexander J. Ellis, one of the central figures in the history of pitch quantification at the end of the nineteenth century. Initially committed to disentangling sound from its specific material and cultural contexts in order to produce unifying knowledge of this phenomenon, Ellis actually ended up unraveling sound's cultural variety as well as the impossibility of reducing it to mere numerical representations. A mathematician and a philologist, Ellis's career predates recent divides between the sciences and the humanities, thus offering a good site to start disentangling the intricate webs of disciplines, concepts, and practices involved in the production of sound knowledge. To measure pitch, Ellis brought together an eclectic network of human and nonhuman actors and corpuses of knowledge that demonstrated the far-reaching implications of sound metrology, far beyond the realm of mathematics and physics.

Ellis not only questioned the validity of purely numerical representations of sound but also created the conditions for a dialogue between the natural sciences and the humanities that resulted in new disciplinary endeavors. To overcome the difficulties arising from measuring sound, he imported methods he had forged for the study of languages into his physical observation of musical sound, eventually paving the way for new, relativist approaches to sound that could be found in a wide range of disciplines, including music history, comparative musicology, and historically informed performance practice. Through his example, and drawing on Lorraine Daston and Elizabeth Lunbeck's definition of scientific observation as an "engine of discovery," this essay argues that universalist approaches to musical pitch ultimately paved the way for relativist approaches to sound, thus showing how pitch quantification created "possibilities for new knowledge in the most unexpected places."[3]

SOUNDS WITHOUT WORDS: A BRIEF ARCHAEOLOGY OF PITCH DATA

In 1834, the German silk manufacturer Johann Heinrich Scheibler introduced a new method to tune pianos in equal temperament and was the first to suggest adopting concert pitch A440 as a point of reference for musical practice in Europe.[4] To stress the need for this standard, Scheibler inserted a short list of measurements he made on tuning forks from Paris, Berlin, and Vienna, which demonstrated the lack of consistency in musical pitch across space (fig. 1). Scheibler's publication is representative of a long tradition of publications on sound quantification, which always link frequency values with a single observer and a particular method and instrument through detailed verbal explanations.

In contrast to this collection of numbers, a table presented by the British mathematician and linguist Alexander Ellis several decades later (fig. 2), which is still a key reference for the history of musical pitch today, attests to the emergence of a new approach to sound quantification. Crucially, it is not the work of a single author but rather the fruit of what historians of science Lorraine Daston and Peter Galison have called "collective empiricism" to designate the "collaboration of investigators over time and space" to produce scientific data.[5] The table summarizes the results of an extensive investigation led by Ellis from the late 1860s through 1885, synthesizing the findings of scholars from the sixteenth century to his own time, all across Europe.[6] Assembling measurements performed by different acousticians, whether dead or alive, and using a variety of techniques, with the help

3. Lorraine Daston and Elizabeth Lunbeck, "Introduction: Observation Observed," *Histories of Scientific Observation*, ed. Lorraine Daston and Elizabeth Lunbeck (Chicago: University of Chicago Press, 2011), 7.

4. Heinrich Scheibler, *Der physikalische und musikalische Tonmesser* (Essen: G. D. Bädeker, 1834); Myles W. Jackson, *Harmonious Triads: Physicists, Musicians, and Instrument Makers in Nineteenth-Century Germany* (Cambridge, MA: MIT Press, 2006), 151–81 and 206–7.

5. See Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 26; Lorraine Daston, "Introduction: Third Nature," in *Science in the Archives: Pasts, Presents, Futures*, ed. Lorraine Daston (Chicago: University of Chicago Press, 2017), 1–14.

6. Alexander J. Ellis, "On the Measurement and Settlement of Musical Pitch," *Journal of the Society of Arts* 25, no. 1279 (1877): 664–87, "On the History of Musical Pitch," *Journal of the Royal Society of Arts* 28, nos. 1424 and 1428 (1880): 293–336 and 400–403, and "The History of Musical Pitch in Europe," in Hermann von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Study of Music*, 3rd ed. (London: Longmans, Green, 1895), 493–513. Ellis is a key source for the most important study on musical pitch; see Bruce Haynes, *A History of Performing Pitch: The Story of "A"* (Lanham, MD: Scarecrow Press, 2002).

Berliner, Wiener und Pariser a.

Es wäre wünschenswerth, dass man überall dasselbe a, annähme. Das meinige wäre nicht übel rücksichtlich seiner Höhe, bei welcher der Sänger bestehen kann. Berlin und Wien stehen, nach den Gabeln, die ich als zuverlässig erhielt, viel zu hoch. Paris scheint tiefer gegangen zu sein; wenigstens ist wahrscheinlich, dass *Sarty* (Pag. 60) das Pariser a, führte. Freilich hatte seine Untersuchung das Monochord zur Grundlage, welches auf 10 Vibr. unsicher ist.

Ich habe drei Pariser a, welche dasjenige des Conservatoriums sein sollen, und die alle drei verschieden sind. Ferner zwei von der Opera oder Academie de musique, welche noch unähnlicher sind.

Von *Gand*, luthier du conservatoir de musique (rue croix des petits champs) ist die Gabel Nr. 3, und von *Petitbout*, luthier de l'opera, die Nr. 2. Diese halte ich für die sichersten, weil Jeder seine Sache am besten kennen wird.

Nr. 1. de l'opera, academie de musique, Vibr. 853.5 } 14
„ 2. „ „ „ „ „ „ 867.5

53

Nr. 3. du conservat., des concts. et Italiens, Vbr. 869.9 } 11.5
„ 4. „ „ „ „ „ „ „ 881.4
Dasselbe, älter, „ „ „ „ „ 870.1.

Die einzige, aber zuverlässige Gabel vom a, des Berliner Orchesters, welche ich besitze, hat Vibr. 883.25, und ist also 1½ Vibr. höher als Nr. V. meiner Wiener Gabeln. Diess letzte gab mir der Herr Professor *Blahetka* als zuverlässiges Wiener Orchester-a. Nr. VI. halte ich für einen Auswuchs.

Meine und meiner Freunde Wiener a, haben:

I.	Vibrationen	867.33.
II.	„	872.67.
III.	„	878.30.
IV.	„	880.20.
V.	„	881.74.
VI.	„	889.74.

Ohne Tonmaass kann man kein a, kennen, und ohne ein T a keins nachmachen.

Ich bin überzeugt, dass auch die Berliner a, um 3 bis 4 Vibr. von einander abweichen, und diess reicht hin, um einem Sänger oder einer Sängerin es möglich zu machen, eine Rolle ausführen zu können oder nicht.

Durch Kälte und Wärme steigen und fallen die Flügel um 1½ Vibr. Ich habe mein a, so gemacht, dass es in der Mitte der Grenzen steht, zwischen welchen die Wiener Flügel steigen und fallen.

Figure 1. Johann Heinrich Scheibler, *Der physikalische und musikalische Tonmesser* (1834), 52–53

Outline History of Musical Pitch

A	
370	Ideal lowest, or zero-point.
374	Hospice Comtesse, 1700.
377	Schlick low, 1511; Bodos, 1766.
392	Euler's Clavichord, 1739.
395	R. Smith, 1759; Roman pitch pipes, 172
396	De Caus, 1615; Versailles Chapelle, 178
403	Mersenne Spinet, 1648.
407	Sauveur, 1713.
408	Mattheson, Hamburg, 1762.
409	Pascal Taskin, court tuner, 1783.
415	Dresden chained fork, 1722.
420	Freiberg, 1714; Seville, 1785.
422	Mozart, 1780.
423	Handel, 1751.
424	Praetorius's suitable pitch, 1619; original Philharmonic, 1813.
428	R. Harris, 1696; Opéra Comique, 182
433	Sir George Smart's fork, 1820–26.
435	French Diapason Normal, 1859.
440	Scheibler's Stuttgart Standard, 1834.
442	*Bernhardt Schmidt, low, 1690.
445	Madrid, 1858; San Carlo, Naples, 1857.
446	Broadwood's Medium, 1849; French Opera, 1856; Griesbach's A, 1860
449	=C 531; Griesbach's C 528, 1860.
451	Lille Opera, 1848; British and Belgia Army, 1879.
453	Mean Philharmonic, 1846–54.
455	Highest Philharmonic, 1874; Broadwood, Erard, and (English) Steinway, 1879.
456	Vienna, high, 1859.
457	(American) Steinway, 1879.

Figure 2. Alexander J. Ellis, "On the History of Musical Pitch" (1880), 305

of diverse technologies, Ellis's table reveals how collective empiricism in the sonic field formed the precondition for universal representations of pitch, articulated in numbers. These measurements, like Scheibler's, were originally presented over the course of a book or article that contextualized them through verbal explanations, but Ellis's table disentangles them from the conditions of their production and, thus, from these justifications. In Ellis's table pitch has become a universal phenomenon, observable from Madrid to New York and from 1511 to 1879, one that numbers can represent without the help of words.

To understand the passage from figure 1 to figure 2—to understand, that is, how pitch values hitherto embedded in verbal explanations and local practices and technologies started to form a universal language made of numbers—one must consider movements of reform that arose in the first decades of the nineteenth century. Ellis's table, like other efforts to create pitch data in the second half of the nineteenth century, was indeed the product of international efforts to standardize musical pitch. While the production of pitch data was intended to inform these ongoing debates, it was also shaped by them. In particular, studies on musical pitch echoed the two main concerns of pitch standardizers. First, movements of pitch reform aimed to put an end to spatial divergence in tuning practices. As the world became increasingly interconnected with the development of transportation infrastructures and the signing of economic integration treaties, differences in pitch standards across Europe and the United States were seen as obstacles to the travels of musicians and musical instruments. Second, the determination of a fixed point of reference for musical practice owed much to the rise of historicism in the musical field. Across Europe and the United States, the nineteenth century saw an unprecedented degree of interest in the music from the past, which manifested itself in a cult of such classical composers as Haydn, Mozart, and Beethoven. Fixing pitch was envisioned as a way of freezing time and keeping these composers' legacies alive.

During the second half of the nineteenth century, the production of pitch data bore the marks of this double concern. First of all, universalist considerations clearly shaped the work of the 1859 French inquiry that fixed the value of the *diapason normal*. In its report, the commission expressed a hope that France would lead the concert of nations in the standardization of pitch: "Music is . . . a sort of universal language. All nationalities disappear before musical writing, because a single notation is enough for all people, since the sounds are represented by signs, the same everywhere. . . . Is it not desirable that a uniform and now fixed pitch should add to this intelligent community a supreme link and that an A, always the same, resonating on the whole surface of the universe with the same vibrations, should ease musical relationships and make them even more harmonious?"[7]

7. *Rapport et Arrêtés pour l'établissement en France d'un diapason musical uniforme* (Paris: Imprimerie impériale, 1859), 12.

TABLEAU A.

Tableau des diapasons usités dans les principales villes de France et dans divers pays d'Europe, d'après les types reçus par le ministère d'État.

ORIGINE.		NOMBRE de vibrations par seconde.	DISTANCES au diapason de l'Opéra de Paris, mesurées en vibrations.	DISTANCES au diapason de l'Opéra de Paris, mesurées en fractions de ton moyen.
FRANCE.				
Lille		904	+ 8,0	+ 0,077
Paris	Grand Opéra	896	"	"
Paris	Théâtre Italien	896	"	"
Marseille		894	— 2,0	— 0,019
Bordeaux		886	— 10,0	— 0,096
Toulouse	Théâtre	885	— 11,0	— 0,106
Toulouse	Conservatoire	874	— 22,0	— 0,210
PAYS ÉTRANGERS.				
Bruxelles. (Musique des guides.)		911	+ 15,0	+ 0,144
Londres	N° 3	910,4	+ 14,4	+ 0,138
Londres	N° 2	905	+ 9,0	+ 0,087
Berlin		903,5	+ 7,5	+ 0,072
Saint-Pétersbourg		903	+ 7,0	+ 0,067
Prague		899,5	+ 3,5	+ 0,034
Leipsick		897,5	+ 1,5	+ 0,014
Munich		896,2	+ 0,2	+ 0,002
La Haye		892,3	— 3,7	— 0,035
Pesth		892	— 4,0	— 0,038
Turin, Wurtemberg, Weymar		889,5	— 6,5	— 0,062
Brunswick		887	— 9,0	— 0,086
Gotha		886,5	— 9,5	— 0,091
Stuttgard		886	— 10,0	— 0,096
Dresde		882	— 14,0	— 0,134
Carlsruhe		870	— 26,0	— 0,250
Londres. (N° 1.)		868	— 28,0	— 0,269

Figure 3. "Table of the pitch used in the main French cities and in various European countries, based on the types received by the Ministry of State." Published by the French pitch commission in *Rapport et arrêtés* (1859), 31.

These aspirations guided the commission's work. Its report was grounded in the study of a broad spectrum of tuning forks from across Europe, collected and measured by the commission members over many months (summarized in fig. 3).

By collecting and measuring tuning forks from across Europe, the committee inscribed its inquiry into the framework of a transnational community of musicians. Ten years later, when the Royal Society of Arts charged a committee with examining the issue in Britain, its work was driven by the same universalist spirit. As Ellis reported,

> On the 21st January, 1869, the Society of Arts, through its secretary, applied to the Secretary of State for Foreign Affairs to obtain information respecting the musical pitch used on the Continent, and sent three queries with a list of places from which it was thought desirable to obtain information. The consequence was, a series of reports from the English consuls or ministers, or the Foreign authorities, at Copenhagen, Leipzic, Munich, Dresden, Stuttgart, Vienna, Baden, Berlin, Cologne, Florence, Bologna, Milan, Venice, Stockholm, and Brussels, which were printed in October 1869. These reports were in several instances accompanied by forks.[8]

Ellis's own work on musical pitch drew from this diplomatic initiative. He explains that he started by studying the forks collected by the Society, and then decided to explore the question further:

> The Society of Arts kindly placed at my disposal for examination and measurement the forks thus obtained, including one from St. Petersburg, without any report, and also the two forks made for the Society by the late Mr. J. H. Griesbach. I thought it, therefore, incumbent upon me to make a report to the Society upon these forks, and considered it advisable, in doing so, to take up the whole subject of the measurement and settlement of musical pitch, and to embody in my report such information and results I had already obtained. Such is the origin of the present paper, and the reason why it has been laid before the Society of Arts.[9]

Although he built on previous efforts to objectify and thus "settle" musical pitch, Ellis's own papers extended the scope of investigation very significantly. Whereas the tables created by the French pitch commission of 1858–59 presented a total of forty-six items, there are eighty frequency values in Ellis's initial paper of 1877, and over three hundred in the 1880 article and his 1885 appendix to the first edition of his translation of

8. Ellis, "On the Measurement," 664.
9. Ibid., 664.

Helmholtz's *Sensations of Tone*. His work, in other words, pushed the territorial boundaries of existing studies on musical pitch.

As I have indicated, efforts to regulate musical practice not only aimed to produce a unified space that would enable the circulation of musicians and musical instruments but were also connected to the growing interest in the past. Standardizers indeed looked at history to get a grip on developments in the actual frequency values used for tuning. Fundamental at the start of the negotiations was a shared belief that pitch was rising endlessly (though acousticians and musicologists have challenged that belief more recently).[10] In 1858, the composer Hector Berlioz predicted that "pitch—having risen one tone in a hundred years, or half a tone in half a century—would, if its ascending march continued, go through all the semitones of the scale in six hundred years, and would necessarily be a full octave higher in 2458."[11] This escalation was commonly attributed to the development of instrumental music in the late eighteenth century and a new taste for what were known as "bright sounds," which were associated with higher pitches. The phenomenon was seen as a threat to musical repertoires, especially for voices strained by increasingly high notes. The French imperial decree appointing a pitch commission in 1858, for instance, asserted that "the ever-growing escalation of pitch presents inconveniences from which musical art, composers, artists, and makers alike have to suffer."[12] The establishment of a unified pitch was an answer to this supposed elevation of performing pitches and additionally promised to facilitate the movement of musical works and instruments across different time periods.

In the same way that the standardizers' interest in creating an internationally unified space for communication about pitch inspired transnational inquiries into musical pitch, historicist worries about chronological transformations furthered the production of historical knowledge about pitch. Besides the table representing the distribution of pitch values in Europe (fig. 3), the report produced by the French commission contained a second table that demonstrated its main idea: that musical pitch had been rising dramatically since the late seventeenth century (fig. 4).

With its emphasis on chronology, the table extends previous attempts to capture pitch as a historical phenomenon. The very first diachronic collection of pitch data appeared in a book by Claude Montal (1800–1865), a French piano tuner and maker who grew eager to verify the assumption, common in the 1830s, that pitch was rising in

10. Émile Leipp and Michèle Castellengo, "Du diapason et de sa relativité," *Revue musicale* 294 (1977): 7–10; Haynes, *History of Performing Pitch*.

11. Hector Berlioz, "Le Diapason," *Journal des débats* (September 29, 1858): 1.

12. *Rapport et Arrêtés*, 4. Unless otherwise noted, translations are mine.

TABLEAU B.

Tableau constatant l'élévation progressive du diapason dans divers pays.

NOMS DES OBSERVATEURS.	ANNÉES.	NOMBRE de vibrations.	DISTANCES au diapason actuel de chaque pays en fractions de ton moyen.
PARIS (GRAND OPÉRA).			
Sauveur	1699	808	— 0,845
	1700	808	— 0,845
	1704	810,6	— 0,820
	1713	811,7	— 0,809
Drouet	1810	846	— 0,480
Fischer	1823	862,7	— 0,320
Drouet	1830	871,5	— 0,235
Delezenne	1836 à 1839	882	— 0,134
Lissajous	1858	896	
BERLIN.			
Marpurg	1752	843,75	— 0,574
Wieprecht	1806 à 1814	861	— 0,408
Fischer	1823	874,64	— 0,277
Wieprecht	1830	880	— 0,225
Scheibler	1834	883,25	— 0,194
Wieprecht	1838	903,5	
SAINT-PÉTERSBOURG.			
Sarti	1796	872	— 0,298
Lissajous	1858	903	
TURIN.			
Delezenne	1845	880	— 0,091
Lissajous	1858	889,5	
MILAN.			
Delezenne	1845	893,14	— 0,072
Lissajous	1856	900,6	

Figure 4. "Table showing the progressive elevation of pitches in various countries." Published by the French pitch commission in *Rapport et arrêtés* (1859), 32.

Paris. In the summer of 1835, he collaborated with Charles Cagniard de Latour, the prominent acoustician and inventor of the siren, to measure tuning forks used in the main opera houses of the French capital (the Opéra, the Opéra-Comique, and the Théâtre-Italien) in 1829 and 1835. From his comparison of the figures produced by these measurements, he concluded that pitch was indeed rising in the main theaters of Paris and suggested adopting a standard pitch.[13]

The gesture was replicated two decades later by Charles Delezenne (1776–1866), a member of the Société des sciences, de l'agriculture et des arts in Lille. In the late 1840s and early 1850s, Delezenne measured the pitch of the Lille orchestra, and his repeated observations enabled him, like Montal, to tackle the question of pitch escalation.[14] But Delezenne, perhaps painfully aware of his own peripheral position and that of his city of Lille, also accompanied his data with measurements produced by other French and German acousticians in a chronologically organized table (fig. 5).

A rather modest collection of thirty rows of figures, the physicist's list of pitch data nevertheless performs an important reconfiguration, by extracting sound quantification from its technological and epistemological contexts. The physicist's table presents both his own measurements and measurements made by other acousticians. And although he offers some explanations about the way he performed his own measurements, he silences the voices of those who made measurements before him. Where Montal chose tuning forks as his historical tokens, Delezenne refers to the works of Joseph Sauveur (1653–1716), Scheibler, and other scholars as historical sources.[15] From being observers of physical phenomena, these authors become the collective documenters of a historical process. Delezenne's table constructs pitch as a unified and universal phenomenon. It does not simply store pitch data but embodies one of the central ideas of pitch negotiations: pitch is rising over time.

In the growing debates over pitch standardization, Delezenne's data were often referred to, but in a form that increasingly detached them from the specific contexts of their production. Thus, when his table was reprinted in the instrument makers' union journal *Le Luth français* in 1856 (fig. 6), it was shorn of its two last columns. Crucial elements of Delezenne's methodological choices, such as the fact that he used a C string as a measuring tool, simply disappeared.[16]

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13. Claude Montal, *L'Art d'accorder soi-même son piano, d'après une méthode sure, simple et facile, déduite des principes exacts de l'acoustique et de l'harmonie* (Paris: J. Meissonnier, 1836), 33.

14. Charles Delezenne, *Note sur le ton des orchestres et des orgues* (Lille: Privately published, 1854).

15. Friedrich Wilhem Marpurg (1718–1795), Giuseppe Sarti (1729–1802), and Ernst Gottfried Fischer (1754–1831).

16. This black-boxed the transposition of his results into A values, an operation that was far from self-evident in the production of pitch data, given the variety of musical scales in use at the time (see above).

(15)

Dates.	Observateurs.	Noms des lieux ou des personnes.	Oscillations du la.	Oscillations de l'ut du violoncelle.	Numéros d'ordre
1752	Marpurg.	Berlin.	843,75	125,00	1
		Très-vieux diapason.	845,29	125,23	2
1823	Ficher.	Théâtre italien.	848,34	125,68	3
1834	Scheibler.	Ancien. M. Petitbout.	853,50	126,44	4
1823	Ficher.	Feydeau.	855,22	126,69	5
		M. Cohen.	857,41	127,02	6
1823	Fischer.	Grand-Opéra	862,68	127,80	7
		Vieux diapason.	865,70	128,25	8
1834	Scheibler.	Vienne Minimum.	866,00	128,29	9
1834	Scheibler.	Opéra, M. Petitbout.	867,50	128,52	10
1834	Scheibler.	Conservatoire. M. Gand.	869,90	128,87	11
1834	Scheibler.	M. Gand.	870,10	128,90	12
1796	Sarti.	Saint-Pétersbourg.	872,00	129,18	13
1845		Florence.	873,40	129,39	14
1823	Fischer.	Berlin, Théâtre.	874,64	129,57	15
1845		Turin.	879,88	130,32	16
1834		Stuttgard. Congrès.	880,00	130,37	17
		Opéra. M. Pleyel.	880,94	130,51	18
1834	Scheibler.	Vienne. M. Blahetka.	881,40	130,58	19
		Opéra. M. Leibner.	882,05	130,67	20
1834	Scheibler.	Berlin. De 1.re source.	883,25	130,85	21
1834	Scheibler.	Vienne. M. Streicher.	886,00	131,26	22
1834	Scheibler.	Paris. M. Wolfel.	886,50	131,33	23
		Marquis d'Aligre.	887,00	131,41	24
1834	Scheibler.	Vienne. Maximum.	890,00	131,85	25
1845		Vienne. Conservatoire.	890,88	131,98	26
		Pianos de M. Pleyel.	892,00	131,15	27
1845		Milan.	893,14	132,31	28
1851		Lille. Festival.	893,54	132,37	29
1848 et 54		Lille. Théâtre.	901,00	133,48	30

Figure 5. Charles Delezenne, "Note sur le ton des orchestres et des orgues" (1854), 15

In the 1880s, Ellis's work once again expanded the ambit of studies on the history of musical pitch. Comprised of dozens, then hundreds, of frequency values, his impressive tables covered a *longue durée* from the sixteenth century to his present. As debates over pitch standardization intensified, musical pitch, hitherto a local phenomenon, was recast

MOUVEMENT ASCENSIONNEL DU TON DES ORCHESTRES,

DEPUIS 1752 JUSQU'EN 1854,

Par M. Delezenne.

Dates.	Observateurs.	Noms des lieux ou des personnes.	Oscillations du *la*.
1752	Marpurg.	Berlin (1).	843,75
		Très-vieux diapason (2).	845,29
1823	Fischer.	Théâtre italien.	848,34
1834	Scheibler.	Ancien. M. Petitbout.	853,50
1823	Ficher.	Feydeau.	855,22
		M. Cohen (3).	857,41
1823	Fischer.	Grand-Opéra.	862,68
		Vieux diapason.	865,70
1834	Scheibler.	Vienne. Minimum.	866,00
1834	Scheibler.	Opéra, M. Petitbout.	867,50
1834	Scheibler.	Conservatoire. M. Gand.	869,90
1834	Scheibler.	M. Gand.	870,10
1796	Sarti.	Saint-Pétersbourg.	872,00
1845		Florence.	873,40
1823	Fischer.	Berlin, Théâtre.	874,64
1845		Turin.	879,88
1834		Stuttgard. Congrès (4).	880,00
		Opéra. M. Pleyel.	880,94
1834	Scheibler.	Vienne. M. Blaetka.	881,40
		Opéra. M. Leibner.	882,05
1834	Scheibler.	Berlin. De 1re source.	883,25
1834	Scheibler.	Vienne. M. Streicher.	886,00

Figure 6. "Ascending movement of orchestra pitches, from 1752 to 1854," "Société des fabricants de pianos. Procès-verbal de la séance du 9 juin 1856. Présidence de M. Savart," *Le Luth français* 1, no. 2 (June 20, 1856): 2.

as a universal object. As I explore in the next section, however, the constitution of large collections of pitch data that accompanied this transformation also created "frictions,"[17] which eventually revealed the limitations of numbers in representing musical pitch.

17. See Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA: MIT Press, 2010), xvii.

BACK TO WORDS: FROM COMPARISON TO SONIC RELATIVISM

Throughout the nineteenth century, tracking the differences in pitch across space and time was a collective task that fostered the constitution of transnational and interdisciplinary networks of natural philosophers, music antiquarians, collectors, and instrument makers. The emergence of collective empiricism revealed cultural differences in ways of measuring and conceptualizing pitch that necessitated many operations of translation. In addition to sonic technologies and measurements, the members of this community traded words, a phenomenon that, itself, attested to their cultivation of a "hybrid hermeneutics."[18] Ellis's activities are illustrative of this phenomenon. Just like scholars from the natural sciences, Ellis mixed empirical observation with the reading of texts. To begin with, his work relied heavily on scholarly sociability and, thus, on letter correspondence. In his first paper on musical pitch, Ellis gives a list of 107 "helpers" who sent him useful information for his inquiry. Second, all the operations he uses—whether selecting which carrier of pitch, such as historical tuning forks or organ pipes, to be measured or interpreting existing written data—apply historical knowledge contained in ancient treatises or modern historical studies. While universalist and historicist approaches increasingly detached pitch values from verbal explanations of the conditions of their production, nonetheless texts paradoxically began to play a new role in the making of pitch data.

In the following paragraphs, I examine the broader ramifications that the emergence of this hybrid hermeneutics had for the history of knowledge, showing how it contributed to new disciplinary endeavors, from psycho-physiology, to comparative musicology, to ethnomusicology, to performance practice studies. As the most thoroughgoing attempt to capture pitch across time and space, Ellis's work sheds useful light on the tensions triggered by universalist approaches to musical pitch drawing on collective empiricism, as well as on their implications. On the one hand, his studies marked the summit of large-scale nineteenth-century pitch quantification; on the other, they point to the inability of universalist representations to pin down a phenomenon characterized by great historical and geographic diversity. In an effort to address the difficulties produced by empirical approaches to pitch across diverse cultural contexts, Ellis introduced comparative perspectives that lastingly shaped research on sound. Emphasizing the conventional nature of pitch determination, and using verbalization as the vehicle of a new knowledge that bridged art, the sciences, and the humanities, he laid the foundations of new disciplines that addressed the specificities of sonic cultures—if only to expand the domination of Western sound knowledge over geographic and historical "others."

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18. Lorraine Daston, "The Sciences of the Archive," *Osiris* 27 (2012): 156–87.

To disentangle this complex history of knowledge on pitch, one has to go back to the early days of Ellis's career. Importantly, his interest in pitch resulted from previous work on language. Born to a wealthy family, Ellis studied mathematics and philology at Cambridge; his financial independence then allowed him to pursue research as he pleased. Throughout the 1840s and 1850s, Ellis worked to improve society by opening up access to literacy for the British working class. On the premise that English orthography hampered the acquisition of literacy by inaccurately reflecting the language's pronunciation, he designed several phonotypic alphabets. Over time, Ellis significantly extended the scope of his studies, from the British Isles to Britain's colonies, and from present to earlier forms of pronunciation. Throughout his work on language, Ellis showed his faith in empirical experimentation as a basis for knowledge and an ability to build active scholarly networks to feed comparative approaches, contacting researchers in Britain, Continental Europe, and North America.[19] Shaw's preface to the bestselling *Pygmalion* describes him as one of the greatest authorities in the field of phonetics in the 1870s, and Alexander Graham Bell's autobiography similarly presents him as a "distinguished linguist and philologist."[20]

The study of language was Ellis's entry door into sonic matters.[21] Keen to understand the production of vowel sounds, Ellis discovered the work of the German physicist Hermann von Helmholtz, which familiarized him with questions of tonometry and prompted him to translate Helmholtz's eminent study *On the Sensations of Tone*.[22] Ellis's work on language also shaped his approach to pitch as a phenomenon. Just as he documented the historical and geographical diversity of pronunciation through intensive empirical work, he was keen to capture pitch across as many contexts as possible. And just as he had with language, Ellis approached pitch with a great interest in comparison.[23]

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19. Jonathan P. J. Stock, "Alexander J. Ellis and His Place in the History of Ethnomusicology," *Ethnomusicology* 51, no 2 (2007): 311, 314.

20. George Bernard Shaw, preface to *Pygmalion* (New York: Penguin, 2003), 3–4; Alexander G. Bell, entry for February 6, 1879, "Autobiography of A. G. Bell," 3–4, Alexander Graham Bell Family Papers, Library of Congress, quoted in Stock, "Alexander J. Ellis," 315.

21. One of his first books analyzed spoken sounds as the basis for phonetic alphabets: Alexander Ellis, *The Alphabet of Nature* (London: Bagster & Sons, 1845). See Julia Kursell, "Alexander Ellis's Translation of Helmholtz's *Sensations of Tone*," *Isis* 109, no. 2 (2018): 339–45.

22. Hermann von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Study of Music*, trans. Alexander Ellis, 3rd ed. (London: Longmans, Green, 1895), 23–24.

23. Ellis's interest in sound also resulted from his acquaintance with Charles Wheatstone and his concertinas: James Q. Davies, "Instruments of Empire," in *Sound Knowledge: Music and Science in London, 1789–1851*, ed. J. Q. Davies and Ellen Lockhart (Chicago: University of Chicago Press, 2017), 145–74.

Applying the methods he had developed for the study of language eventually led Ellis to bring in new contexts for the study of pitch. To begin with, he conceived of sound primarily as a sensation, and placed physical approaches to pitch on a physiological and psycho-acoustical basis. Significantly, Ellis's first independent contribution to the study of musical pitch is titled "On the Sensitiveness of the Ear to Pitch and Change in Pitch in Music" and discusses recent experiments by the physiologist William Preyer (1841–1897).[24] In this paper, as well as in subsequent publications, Ellis presents at length the various methods used for sound quantification, and turns from objects to subjects in order to compare the different experiences produced by different ways of observing pitch.

Ellis's interest in comparison also led him to embed pitch data in specific historical contexts. Due to the variety of tunings and temperaments in use across time—from just intonation to Pythagorean, meantone, and equal temperaments—it was necessary to learn about musical systems in order to accurately interpret and calibrate data. How, for instance, could records of measurements for different musical notes—A, B, C—be compared without knowing the specific organization of the scale to which they belonged?

In all his publications on the topic, Ellis demonstrates that the production of pitch data requires much more than measuring instruments or the hunt for numbers in the books of long dead acousticians. Rather, it calls for theoretical knowledge of music, which the scholar can glean from the publications of early modern theorists or their modern commentators. Similarly, Ellis emphasizes that carriers of pitch are inextricable from particular territories, time periods, and musical practices. Whether tuning forks, organ pipes, or other musical instruments, Ellis gives his readers detailed explanations of the material components of past sonic cultures.

Ellis's initial ambition of providing a systematic approach to the history of pitch appears somewhat contradicted by his attention to historical specificities. Below his tables that present collections of measurements, Ellis inserts very detailed explanations of every single number, a gesture that tends to decompose universalism into relativism. Figure 7 is a striking example of this extensive verbal embedment. This entry is dedicated to A422.5, which Ellis also referred to as "Handel's pitch." At a time when Handel was the national hero of English music, this meant that this pitch was one of the most authoritative examples of Ellis's history of musical pitch. Reflecting the significance of this standard, the entry comprises over eighty lines of explanation on the various owners of the tuning fork embodying the tone, and the historical and cultural significance of this

24. Alexander J. Ellis, "On the Sensitiveness of the Ear to Pitch and Change in Pitch in Music," *Proceedings of the Musical Association* 3 (November 6, 1876): 1–32; William T. Preyer, *Über die Grenzen der Tonwahrnehmung* (Jena: Hermann Dufft, 1876); Alexander J. Ellis, "Notes of Observations on Musical Beats," *Proceedings of the Royal Society of London* 30, no. 200–205 (1880): 522.

(1) A **422·5**, MC 505·4 [JC 507, EC 502·4], S 2·30. (Ellis.) 1751, England, from a copy made by myself (and compared with the original some months afterwards, when it was found perfectly exact) of Handel's fork. The box containing it bears this inscription :—"This Pitchfork was the property of the Immortal Handel, and left by him at the Foundling Hospital, when the Messiah was performed in 1751. Ancient Concert, whole tone higher; Abbey, half-tone higher; Temple and St. Paul's organs exactly with this pitch. Presented to Rd. Clarke by J. Brownlow, the Dep. Sec., 1835. Invented by M. Shore, Serj. Trumpeter, time of H. Purcell." This fork was bought by Rev. G. T. Driffield, rector of Bow, near London, at the sale of the effects of Mr. Clarke, and by his permission I took and compared the copy. The fork is probably far superior to any made by John Shore, who (and not Mathias Shore, as the inscription implies) was the inventor of the Tuning-fork, see Art. 10 above. This fork probably represents the exact pitch of the organ built by Messrs. Glynn and Parker (see (2) A 424·3), which was presented by Handel to the Foundling Hospital, and opened by him "on the 1st of May, 1750, when the concourse of persons was so great that the performance was repeated fifteen days afterwards. Upon one of these occasions the audience was conveyed in no less than 800 coaches and chairs" ("John Brownlow's History and Objects of the Foundling Hospital," third edition, London, 1865, p. 78). This fork was received by the secretary, John Brownlow, from his predecessor, who was in office from 1795 to 1849, and Mr. Brownlow in a letter to Mr. Driffield, dated May 21, 1848, says, that "in an unguarded moment" he gave it to Mr. Clarke. He did not remember the story of Handel's leaving it in the orchestra, and imagined that that might be "apocryphal." Mr. John Reid, a partner in Messrs. Broadwood's house, writing to Mr. Driffield on June 13, 1859, says that that house had once possession of Handel's fork, and they do not know how it came out of their possession. Handel was a friend of Tchudi, the founder of the house. Richard Clarke, to whom the fork was given, died Oct. 5, 1856, aged 76½, and his effects were sold by auction, May 2, 1857, when Mr. Driffield bought both this fork and A 419·9. I am indebted to Mr. E. J. Hopkins, of the Temple organ, for furnishing me with a MS. note made by Mr. Leffler (d. 1819), organist of St. Katherine's, then by the Tower, with Mr. W. Russell, then organist of the Foundling, which describes the great peculiarity of this organ. It had the usual 12 keys to the octave, but a means of altering the notes sounded by four of them. There was a slider with three rests above the draw stops on each side. When the sliders were at the central rest, the 12 notes were the usual 12 of the meantone temperament, E *flat*, B *flat*, F, C, G, D, A, E, B,

Figure 7. Ellis, "On the History of Musical Pitch" (1880), 320

particular frequency. It illustrates how Ellis moved from the "settlement" to the unsettling of pitch by drawing a complex picture of diverse sonic pasts.

Ellis's interest in pitch's cultural variety led him not only to conduct a systematic survey of past European tuning practices but also to go beyond the history of Western musical practice and embrace non-Western sounds. Along with John Hipkins, a piano maker who shared Ellis's interest in the history of musical pitch, the scholar performed measurements on several musical artifacts from China, Japan, and North Africa.[25] This work, in turn, allowed him to produce new knowledge of the musical systems in use in these various contexts, which he presented in an 1885 paper titled "On the Musical Scales of Various Nations."[26] As in his research on the history of pitch, Ellis did not rely solely on his own observations to trace this geographic diversity; he also used scholarly writings and an extensive correspondence with experts on different musical traditions to generate his data. For instance, Ellis initially only categorized the sounds produced by Chinese instruments at an 1884 exhibition in London as undecipherable, but was later able to make sense of them with the help of the first survey in English of music in China, published by a customs employee.[27]

This endeavor with musical pitch beyond Europe and the United States had far-reaching implications from the point of view of the history of knowledge. While most nineteenth-century music scholars considered the structure of the diatonic scale as universal, Ellis, drawing on his measurements on the pitch of non-Western musical instruments, adopted the relativist stance that scales were "just various."[28] These views found great resonance especially in the German-speaking world, where they inspired scholars in the emerging field of comparative musicology. Carl Stumpf immediately translated "On the Scales of Various Nations" into German in the prestigious *Vierteljahrsschrift für Musikwissenschaft*, in 1886,[29] and Erich M. von Hornbostel called Ellis the "true founder of comparative scientific musicology."[30] Ellis's influence over this community has secured him the status of a founding figure of ethnomusicology up to this day.[31]

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25. Harry Liebersohn, *Music and the New Global Culture: From the Great Exhibitions to the Jazz Age* (Chicago: University of Chicago Press, 2019), 91–121. I warmly thank Harry Liebersohn for sharing this text with me before its publication.

26. Alexander J. Ellis, "On the Musical Scales of Various Nations," *Journal of the Society of Arts* 33, no. 1688 (1885): 485–527.

27. Liebersohn, *Music and the New Global Culture*, 104–7.

28. Ibid., 121.

29. Carl Stumpf, "Alexander J. Ellis: On the Musical Scales of Various Nations," *Vierteljahrsschrift für Musikwissenschaft* 2 (1886): 511–524.

30. Erich M. von Hornbostel, "Über die Tonleitern verschiedener Völker," *Sammelbände für vergleichende Musikwissenschaft* 1 (1922): 3, quoted in Stock, "Alexander J. Ellis," 308. On the history of comparative musicology in Germany, see especially Alexander Rehding, "The Quest for the Origins of Music in Germany Circa 1900," *Journal of the American Musicological Society* 53 (2000/2): 345–385; Eric Ames, "The Sound of Evolution," *Modernism/Modernity* 10 (2003/2): 297–325; and David Trippett's annotations in Carl Stumpf, *The Origins of Music*, trans. and ed. David Trippett (Oxford University Press, 2012).

31. See, e.g., Stock, "Alexander J. Ellis," 308. Daniel Walden, however, has proposed a critical re-examination of Ellis's work, too often regarded as genuinely relativist when it was actually infused with colonialist prejudices; see "Alexander John Ellis: Pitch Fundamentalist," presented at the Annual Meeting

Ellis's conclusions about non-Western musical systems themselves had further ramifications that continue to shape musical research. His relativist approach to the Western scale indeed ultimately led him to question the adequacy of Western musical notation as a way of capturing the sounds of other musics. In view of the challenges he had faced when trying to record the sounds of foreign musicians, and earlier when notating the English alphabet, Ellis proposed a new way of representing pitch that would account for the limitations of the Western notation system when confronted with other musical traditions. Ellis indeed suggested employing the "cent" to capture the scales of other nations. This interval corresponded to the subdivision of the semitone—the smallest interval used in European musical systems at the time, corresponding to the gap between a white and a black key on the piano—into a hundred parts. Just as the International Phonetic Alphabet draws on Ellis's contribution to linguistics and phonetics, the cent system is still used by ethnomusicologists today.[32]

Moving freely between the sciences and the humanities—from phonetics and linguistics to physics, physiology, history and comparative musicology—Ellis's career allows us to trace the intricate genealogy of knowledge on pitch in the modern era. Thanks to his financial security, Ellis was able to pass from one field to the next and thereby to durably transform some of their practices.

FROM KNOWLEDGE TO MUSICAL PRACTICE: LISTENING TO THE HISTORY OF PITCH DATA

In Ellis's day, creating a unified measure for musical practice and instrument building was the priority. Consequently, music circles did not pay much attention to his studies, assuming perhaps that this matter was not of their concern. That changed with the rise of what musicologists have called "historically informed performance."[33] Eager to offer an apparently authentic interpretation of the musical past based on the findings of musical philology, performers representative of this movement took good note of Ellis's explanations about the centrality of the standard A422.5, presented in figure 7, which he called "European mean pitch for two centuries."[34] The use of the pitch A tuned to 415 hertz, long employed as the standard for the performance of early music, was the

of the American Musicological Society, San Antonio, TX, November 2018. Liebersohn offers a more nuanced view, reading Ellis's career as exemplifying the making of musical "global" cultures in London; see *Music and the New Global Culture*, 91–121.

32. Kursell, "Alexander Ellis's Translation"; Stock, "Alexander J. Ellis," 341.

33. This notion, broadly used in musicology since his publication, was first used by John Butt, *Playing with Music: The Historical Approach to Musical Performance* (Cambridge: Cambridge University Press, 2002).

34. Ellis, "On the History of Musical Pitch," 305.

materialization of Ellis's claim, though adapted to the technological reality of musical performance. Tuned just a semitone lower than 440, it allowed for mathematically easy transpositions to keyboard and other instruments tuned to A440.[35]

If Ellis's work molded the early music revivalists' unified approach to tuning, it fed more differentiated approaches to pitch in the field of performance practice studies, a subfield of musicology dedicated to documenting historical musical performance in order to revive it. In 1968, the American musicologist Arthur Mendel introduced Ellis as a founding figure of this research trend by reissuing his last history of pitch with a substantial commentary.[36] Mendel saw several problems in Ellis's work—the high level of precision in Ellis's data failed to represent either the limits of the human ear or the reality of musical practices, and his selection of evidence was acoustically reliable but historically irrelevant.[37] Nevertheless, he acknowledged the path that Ellis had opened up. The early music revivalists' reception of Ellis's concept of "European mean pitch" was simplistic, Mendel claimed; the scholar's work offered a much more complex picture of the history of pitch. Warning that one should not simply rely on Ellis's collections of numbers but should also read the words that surrounded them, Mendel insisted that Ellis's evidence pointed to not one but many different pitches for the practice of early music.

Today, the sonic diversity highlighted by scholars in the field of performance practice studies is shaping musicians' tuning strategies, unsettling the very standardization process that triggered the production of pitch data. In performing the knowledge borne across pitch negotiations, musicians remind us of disciplinary exchanges and the role of soft "sonic skills" in the making of pitch data.[38] Commercial, political, and artistic concerns were the conditions for the emergence of a new sonic collective empiricism, which constructed pitch as a universal phenomenon. But pitch quantification was an engine of discovery: it yielded surprising results that challenged the very premises of this new regime of observation and paved the way for future academic disciplines and artistic

35. See, e.g., one of the central figures of the early music revival, Barthold Kuijken, in *The Notation Is Not the Music: Reflections on Early Music Practice and Performance* (Bloomington: Indiana University Press, 2013), 19–26. The pitches 415 and 440 are a semitone apart in equal temperament.

36. Alexander J. Ellis and Arthur Mendel, *Studies in the History of Musical Pitch* (Amsterdam: Frits Knuf, 1968).

37. Whereas Ellis considered that there was "no more accurate means of preserving pitch" than tuning forks, because their material makes them such a sustainable sound object, Mendel argued that they were of little use to historians since they were detached from any specific musical context; see Ellis, "On the History of Musical Pitch," 297.

38. See Karin Bijsterveld, *Sonic Skills: Listening for Knowledge in Science, Medicine and Engineering* (London: Palgrave Macmillan, 2019).

practices to address the specificity of sonic and musical cultures—and thus further expand the empire of contemporary Western epistemologies of sound.

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