Nature's "Disturbing Influence": Sound and Temperature in the Age of Empire

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> It is not sufficiently realized what havoc a hot day plays with the best-tuned band.
>
> —Hector E. Adkins

"A clothes brush, a dead sparrow, a euphonion mouthpiece, a sprouting potato, and clips used to hold music stands." With this list, the acclaimed maker of brass instruments and acoustician David J. Blaikley (1846–1936) named some of the most incongruous causes for the "faulty intonation" of wind bands that he had come across over the course of his career at Boosey and Co., one of Britain's leading wind instruments manufacturers, between 1859 and 1909.[1] Blaikley continued: "More usually found dead leaves, grass seed, fragments of hay, etc., all of which frequently find their way into instruments used in the open air, are almost equally harmful."[2] Presented at the end of a small booklet composed for the use of British army band players, this heteroclite enumeration epitomized the tension that musical instruments came to crystallize at the end of the nineteenth century. As instrument makers increasingly drew their authority from claims of sonic control and precision, they started construing music's environments as threatening forces. Along with leaves, seeds, and other tangible objects that makers and players could easily handle, Blaikley's booklet identified a far larger, more

The epigraph is from Hector E. Adkins, *Treatise on the Military Band* (London: Boosey and Hawkes, 1931), 312.

[1]David J. Blaikley, *Memorandum on the Pitch Army Bands* (London: Boosey and Hawkes, n.d., 3rd edn., 1910, 1st edn.), 23. Created in 1816, the London-based firm Boosey and Company was first established as a music publisher before starting to manufacture wind instruments in 1851. After buying Distin & Co., a brass and wind manufacturing company, Boosey became one of the leading companies for the manufacture of wind instruments in Britain. See D. J. Blaikley, William C. Smith, and Peter Ward Jones, "Boosey & Hawkes," in *New Grove Dictionary of Music and Musicians*, ed. Stanley Sadie, 2nd edn. (New York: Macmillan, 2000). https://doi.org/10.1093/gmo/9781561592630.article.A2248428

[2]Blaikley, *Memorandum*, 23–24.

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impalpable, "disturbing influence" on sound: temperature.[3]

Entitled *Memorandum on the Pitch of Army Bands*, Blaikley's influential booklet was the first publication to systematically explore the influence of temperature on the pitch of musical instruments. Although musicians and instrument makers had long experienced this phenomenon, it only became an object of scientific knowledge in the second half of the nineteenth century, in the context of efforts to secure sonic uniformity on an international scale.[4] After France created the *diapason normal* in 1859—an A of 870 single vibrations (in modern terms, 435 hertz) envisioned as a musical equivalent to the meter—scholars, musicians, instrument makers, and government representatives across Europe and the United States all became engaged in the enterprise of standardizing pitch.[5] As actors involved in these negotiations soon realized, the influence of temperature on musical pitch was a disrupting force that made their project immensely challenging.

Today, knowledge concerning the relationship between temperature and musical pitch shapes many dimensions of Western musical practice, from the ambient conditions of concert halls, musical instrument manufactures, music shops, and the homes of amateurs to the materiality and design of musical instruments and performers' routines and techniques. But for all the attention that the connections between music, sound, and the environment has received over the last decade, the question of how temperature came to play such a defining role in musical cultures remains unknown. This article lays the foundations for such work by approaching musical instruments as sites of negotiation between acousticians, instrument makers, and players on the one hand, and music's variegated environments on the other. In doing so, it unpacks the silent influence of environmental diversity that continues to haunt Western musical practice. Differentiating my article from previous works on the link between instrument construction and the environment (most of which seldom engage with the acoustic implications of these activities), as well as from examinations of music as a vehicle for environmental discourses, I focus on "raw" sounds to suggest new ways of listening to the interaction between music and the environment.

Since the early modern era, sound had been conceptualized as a phenomenon involving a source of sound, the human ear, and the air between the two; and from the middle of the eighteenth century, scientific and military expeditions fueled observations of the impact of climatic variations on acoustic phenomena that expanded previous ideas of air's inertia.[6] In the context of attempts to unify musical pitch, in the second half of the nineteenth century, a growing number of experiments unraveled another facet of the relation between sound and the environment: the impact of heat

[3] Ibid., 1.

[4] For instance, in 1619, Praetorius warned that fluctuations in temperature might cause the pitch of an organ's pipes to be out of tune. Similarly, a German manual on pianofortes published in 1824 stated that "the strings . . . suffer from heat and cold" and "if a piano were tuned in a room at 16 degrees, and the temperature were to drop overnight to 10 degrees, the bass would already be higher, and vice versa." Michael Praetorius, *Syntagma Musicum II: De Organographia*, Parts III–V, with index, trans. Quentin Faulkner (Lincoln, NE: Zea Books, 2014), 143; Carl Dieudonné and Johann Lorenzo Schiedmayer, *Kurze Anleitung zu einer richtigen Kenntnis und Behandlung der Forte-Pianos* (Stuttgart: G. Hasselbrink, 1824), 46.

[5] On the history of pitch standardization, see Myles Jackson, *Harmonious Triads: Physicists, Musicians, and Instrument Makers in Nineteenth-Century Germany* (Cambridge, MA: MIT Press, 2006), 205–26; and Fanny Gribenski, "Negotiating the Pitch: For a Diplomatic History of *A*, at the Crossroads of Politics, Music, Science and Industry," in *Understanding Musical Diplomacies: Sounds and Voices on the International Stage*, ed. Cécile Prévost and Frédéric Ramel (Basingstoke: Palgrave Macmillan, 2018), 173–92.

[6] For instance, Alexander von Humboldt, traveling on his famous voyage across South and Central America between 1799 and 1804, noted that sound intensity increases at higher elevations where temperatures decrease and the air becomes more rarified; in addition, Captain Parry and Lieutenant Foster tested the validity of the French mathematician and natural philosopher Pierre Simon de Laplace's equation on sound velocity in the Arctic Circle during their stay at Port Bowen, in Australia, in 1824–25. Alexander von Humboldt, "Sur l'Accroissement nocturne de l'intensité du son (Mémoire lu à l'Académie des Sciences le 13 mars 1820)," *Annales de chimie et de physique* 13 (1820): 162–73; and Gerard Moll, "On Captain Parry's and Lieutenant Foster's Experiments on the Velocity of Sound," *Philosophical Transactions of the Royal Society of London* 118 (1828): 97–104.

variations on pitch. As debates over musical standardization developed, the interplay between sound and temperature became an increasingly important issue. These discussions resulted in an understanding of pitch as a scientific object inextricably linked to the climatic conditions of its surrounding environment, whether internal or external. Blaikley was one of the central figures in the development of this new knowledge that transformed musical performance.

Assessing the interaction between pitch and temperature may seem like a decisive step toward the regulation of musical frequencies, but in fact it was the source of countless epistemological and sociopolitical problems. Defining a musical measure in relation to this parameter meant that reformers not only needed to agree on a frequency level, but also to determine a common temperature level at which it should sound. This, in turn, meant identifying the environmental sites in reference to which a musical standard should be fixed. During the initial phase of pitch negotiations, reformers' efforts centered on the production of standard tuning forks in acoustic workshops and laboratories; within this limited context, addressing these questions was relatively easy. But as standardizers soon realized, this did not suffice to secure the dissemination of concert pitch beyond the workshop. They needed to address the problem of pitch's relationship with temperature across music's varied environments, from Italian opera houses to German concert halls and French churches. What is more, attempting to regulate musical frequencies required solutions to further problems, including the interdependencies between ambient air temperature and the breath applied by a wind instrument player, the impact of musical instruments' design on sound velocity, or the differences in materials' responsiveness to heat variations. The reality of musical practice, in other words, confronted standardizers with the multidimensionality of sound's entanglement with temperature, rendering the implementation of a unified pitch difficult to achieve.

Blaikley's research suggests that imperialism made these problems all the more pressing. As he demonstrated through his experiments, similar to his assertions in the first lines of his booklet (quoted at the beginning of this article), pitch variations in wind bands were "more accentuated in India and in extreme climates generally, than among regiments at home."[7] At the end of the nineteenth century, while musical instruments were frequently mobilized as vehicles of colonization in the hands of Western businessmen, missionaries, and militaries, it also became clear how vulnerable they were to local environmental conditions. With the multiplication of exports to the colonies, for instance, European and American piano makers increasingly called attention to the many plagues threatening the physical and symbolic integrity of their products in the tropics, including heat, humidity, and instrument-destroying insects.[8] Instruments thus became sites of constant negotiation between Western ideas of aesthetics, science, and social order on the one hand, and the reality of local conditions on the other. This tension was all the more flagrant in the case of wind instruments used in army bands. Shaping global soundscapes, from theaters of armed conflicts to daily musical entertainment in colonial settings, and imbued with ideas of rationality and precision, these artifacts were the sonic epitomes of imperialism.[9] Yet they were also the most vulnerable to temperature changes and, in addition, the diverse instruments composing wind bands also reacted differently to these variations. Consequently, as Blaikley made apparent, nowhere were the limits of Western ambitions to control sound more audible than in army bands' outdoors performances in the colonies.

7 Blaikley, *Memorandum*, 1.

8 See, for instance, "A Piano Tuner in India: Some Interesting Facts," *Music Trade Review* 18, no. 34 (1894): 35. Daniel Mason's 2006 neo-Victorian novel *The Piano Tuner*, set in India in 1886, nicely captures the questions raised by the circulation of instruments in the colonies. Mason's main character, a piano tuner sent to the Shan States, north of Burma, is a witness to the great impact of tropical climate on Western instruments. See Daniel Mason, *The Piano Tuner* (Basingstoke and Oxford: Picador, 2002), 223.

9 Trevor Herbert and Margaret Sarkissian, "Victorian Bands and Their Dissemination in the Colonies," *Popular Music* (*Core and Periphery: Routes in British Popular Music History 1850–1980*), 16, no. 2 (May 1997): 165–79; Trevor Herbert and Helen Barlow, *Music and the British Military in the Long Nineteenth Century* (Oxford: Oxford University Press, 2013), 240–68; Martin Rempe, "Cultural Brokers in Uniform: The Global Rise of Military Musicians and Their Music," *Itinerario* 41, no. 2 (2017): 327–52.

While Blaikley's *Memorandum* was intended to help secure sonic uniformity within army bands, especially in the colonies, his conclusions found broader applications, including back in Europe and the United States. There, an intensifying search for sonic precision resulted in the cultivation of practices intended to overcome the diversity of environmental conditions. Knowledge of temperature's multifarious influence on sound inspired totalizing approaches to pitch unification that encompassed not only the production of stable tuning devices and musical instruments, but also the regulation of atmospheric conditions within music venues and the policing of musicians' practices. In this way, domesticating nature's "disturbing influence" was a project that reshaped Western musical practice.

In this article, I disentangle the entwined history of pitch standardization and temperature in the age of Empire. First, I examine international negotiations over musical standardization during the second half of the nineteenth century. I show that they provided the conditions for the emergence of a problematic relationship between musical pitch and temperature. Turning to Blaikley's experiments on the influence of extreme temperature variations on army band instruments, I go on to demonstrate that colonialism revealed the limits and extent of Western attempts to control sound on a global scale. Finally, I expose the silent ways in which the new awareness of the connections between sound and the environment continued to inform Western musical practice into the 1940s.

Pitch and Temperature: The Birth of a Scientific Problem

The conceptualization of pitch in relation to temperature was a byproduct of nineteenth-century efforts to unify musical practice. On 16 February 1859, France was the first nation to adopt a national measure for music: an imperial decree imposed the use of the pitch A 435 in all public musical institutions across the country. Reflecting both contemporaries' awareness of the impact of temperature on sound and reformers' high standards of acoustic precision, the decree defined the *diapason normal* in relation to the sound of a tuning fork by a temperature of 15°C, then considered to be "Paris's average temperature."[10]

In the aftermath of the French decision, as negotiations about pitch unification developed in Europe and the United States, the relation between tuning and temperature attracted considerable attention among acousticians. Rudolf Koenig, a Parisian maker of scientific instruments and the world's leading authority on tuning, emphasized the need to control temperature in order to secure sonic precision.[11] He explained that one needed to let tuning forks rest for several weeks after their manufacture or calibration: in the words of Levi K. Fuller, an American organ builder who visited Koenig's workshop as part of his efforts to introduce the *diapason normal* in the United States, "steel will not settle without it has time [*sic*], that is a law of nature, it is something over and beyond the question of temperature–Molecular change."[12] Koenig's knowledge of the relationship between sound and temperature further materialized through the manufacture of tuning forks bearing different pitch values indexed to varied temperature levels (see plate 1). It was also the topic of an article he published in 1880, which influenced the practices of acoustic laboratories across Europe and North America.[13]

[10]"La température moyenne de Paris." This phrase appears in the catalogue of the acclaimed maker Albert Marloye, who coined the term *diapason normal* in 1840, in reference to a device giving a *C* producing 512 vibrations commonly adopted in physics laboratories. *Supplément au Catalogue de Marloye* (Paris: Ducessois, 1840).

[11]David Pantalony, *Altered Sensations: Rudolph Koenig's Acoustical Workshop in Nineteenth-Century Paris* (Dordrecht: Springer, 2009).

[12]Letter from Levi K. Fuller to J. H. Carr, 23 January 1892. University of Vermont Special Collections. Levi K. Fuller's papers. Letters, no 18. "Uniform Pitch."

[13]Rudolf Koenig, "Untersuchungen über die Schwingungen einer Normalstimmgabel," *Annalen der Physik* 9 (1880): 394–417. On Koenig's work on temperature, see Pantalony, *Altered Sensations*, 91–92 and 102–04. At the end of the 1880s, a physicist at the University La Sapienza, which served as Italy's center for the control of tuning forks, led a series of experiments referencing Koenig's 1880 article: Nazzareno Pierpaoli, "Influenza della temperatura sul numero delle vibrazioni d'un corista. Nota 1," *Rendiconti della Reale accademia dei Lincei* 4 (1888): 714–718; "Influenza della temperatura sul numero delle vibrazioni d'un corista. Nota 1," *Rendiconti della Reale accademia dei Lincei* 5 (1889): 265–68. Charles R. Cross, a physicist at MIT, similarly referenced Koenig's 1880 article when

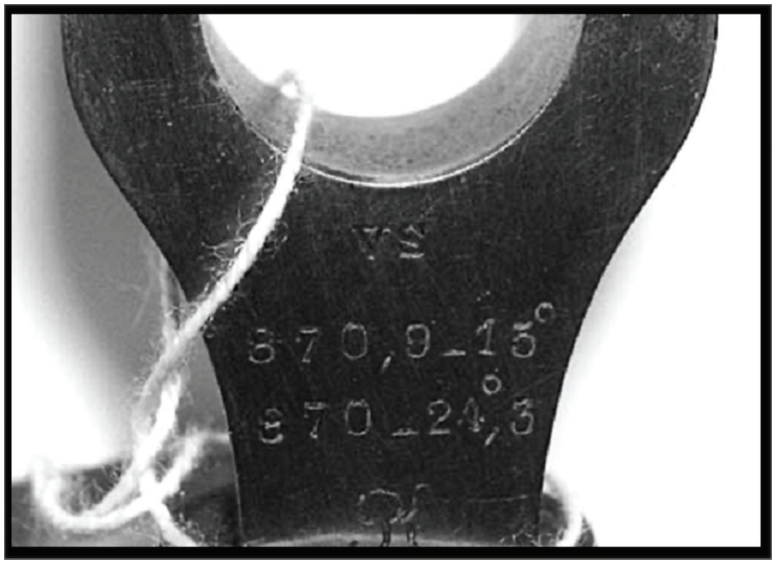


Plate 1: Koenig temperature-adjusted standard fork, la3. Division of Cultural and Community Life, National Museum of American History, Smithsonian Institution, Washington, DC. (Photo by Steven Turner. Reproduced from David Pantalony, *Altered Sensations*, 93.)

While assessing the relationship between tuning forks and temperature was a relatively straightforward process, things were much more complex when it came to musical practice. This became clear amid the conversations that took place in Vienna in 1885 at an international conference dedicated to the problem of pitch unification that attracted delegates from Austria, Italy, Sweden, Germany, and Russia. Drawing on the observation that implementing a reform of musical pitch required much more than securing the manufacture of standard tuning forks, the conference participants started more seriously examining the problem of temperature in relation to musical venues and instruments.

This shift in reformers' horizons created a fresh series of previously unexamined problems. First, determining a temperature standard in relation to musical practice was troublesome due to the variety of ambient conditions characteristic of music venues across Europe. For instance, as the conference's report acknowledged, it was impossible to determine the temperature at which church organs could produce the desired pitch because of ambient variations both between and within churches. As a result, attendees determined that organs' tuning be defined in relation to the specific conditions of their immediate environments.[14] Furthermore, while concert halls and theaters were subject to fewer variations in heat than churches, there were still important differences between them. While the delegates assembled in Vienna chose 24°C as the temperature at which wind instruments could produce the standard, over the coming years, the Italian physicist Pietro Blaserna objected to the choice of 24°C. He argued that "the average temperature in concerts where musical performances are ordinarily held, such as concert halls and theaters, rarely goes above 20 centigrade" since, due to "hygiene and security considerations, one tends more and more to use electric lightening which, as we know, doesn't perceptibly modify a room's temperature."[15] What is more,

reporting on his experiment on musical pitch. Charles R. Cross and William T. Miller, "On the Present Condition of Musical Pitch in Boston and Vicinity," *American Journal of Otology* 2, no. 4 (1880): 249–63.

[14]Kaiserlich-Königliches Ministerium für Cultus und Unterricht, *Beschlüsse und Protokolle der Internationalen Stimmton Conferenz in Wien 1885* (Vienna: Kaiserlich-Königlicher Schulbücher, 1885), 7.

[15]Draft of a letter from Ambroise Thomas, head of the Paris conservatory, to the French ministry of public instruction

Blaserna suggested, picking a single temperature value in reference to the pitch standard was overly simplistic when one took into account the endless variety of musical environments.[16]

The expansion of pitch conversations from the realm of tuning forks, laboratories, and workshops to the more unforgiving world of musical instruments, churches, concert halls, and theaters posed new questions. Crucially, unlike tuning forks, musical instruments were very sensitive to variations in temperature. As Blaserna explained, while a difference of 30°C would change the pitch of a tuning fork of three-quarters of a complete vibration per second, a pipe producing 435 vibrations at 15°C gave 457.7 vibrations at 30°C, which is nearly a semitone higher.[17] In other words, with the inclusion of musical instruments in conversations about pitch unification, temperature became a much larger problem than it was when standardizers' logics revolved only around tuning forks. Blaserna argued that wind instruments posed a particular puzzle by introducing another variable: "the internal warming due to the breath of the wind filled with air, water vapor and nitrogen."[18] The physicist recognized, however, that this was still an "unpredictable factor," and one that rather "complicate[d] the scientifically exact observation" of temperature's impact on pitch, a relationship that was difficult to measure.[19] At this time, acousticians did not yet possess the data necessary to ensure sonic uniformity across musical settings. As they left workshops and laboratories and entered the broad variety of music's environments, they discovered the multidimensionality and even unpredictability of sound's relationship with temperature, which rendered the formation of knowledge about this phenomenon, and the ability to act on it, very troublesome.

Temperature's influence on sound was a major obstacle on the way toward the adoption of an international standard. This became clear when, in 1895, British piano maker and acoustician Alfred Hipkins, who campaigned for the introduction of the *diapason normal* in his country, successfully recommended that Britain adopt A 439 vibrations at 20°C instead of the French A 435 at 15°C as a measure. Hipkins's suggested figure rested on two principles: the impact of heat on the pitch of wind instruments and the choice of 20°C as "the average concert-room" temperature.[20] To produce the sound that France had adopted in 1859 in the conditions characteristic of English concert halls, Hipkins argued, one needed to adopt a different figure, taking into consideration the impact of temperature on pitch. Similarly, in 1917, a percussion maker from Chicago convinced the American Federation of Musicians to change the frequency of the standard adopted by a number of musical associations and instrument makers in the United States from A 435 to A 440. In doing so, Deagan argued, "the American Federation of Musicians has not really changed the pitch at all," but only adapted it to the temperature of theaters and other music venues.[21] As simplistic as the arguments were in regard to the differences between various instruments' responses to heat, they nevertheless attested to the indefectibility of the link between pitch and temperature, which was the source of much disruption in these negotiations.

By the end of nineteenth century, Western pitch reformers had established an immensely constraining situation for themselves. In their attempt to create sonic uniformity through ever-more precise measurement techniques, they defined standards of pitch as a number of vibrations per second indexed to different levels of temperature. As debates entered the complex worlds of music making, pitch's disruption by the environment became a troubling phenomenon, from both an epistemological and a political point of view. If pitch reforms were already difficult to implement in the European and North American concert halls and theaters for which they had first been envisioned, they were even

and fine arts, Paris, 24 January 1887. AJ/37/81, Archives nationales.

[16]Letter from Pietro Blaserna to Albert Sandoz, Rome, 26 December 1886. Ibid.

[17]Kaiserlich-Königliches Ministerium für Cultus und Unterricht, *Beschlüsse und Protokolle*, 29.

[18]Ibid.

[19]Ibid.

[20]A. J. Hipkins, "The Standard of Musical Pitch," *Journal of the Society of Arts*, 44, no. 2258 (1896): 335–45 (at 342).

[21]J. C. Deagan, "A=440 Pitch Adopted: Pitch versus Temperature," *Musical Quarterly* 4, no. 4 (1918): 587–92, at 588.

more so in the more extreme ambient conditions found in the colonies. Efforts to standardize pitch in imperial contexts provided ever-increasing evidence of nature's disturbing influence on sound and revealed the limits of Western ambitions to tune the world.

Pitch Goes South: The Army, Wind Bands, and the Colonies

Historian of science Deborah Coen has argued that, in accelerating the emergence of a "planetary consciousness," "empires have been experimental sites for exploring ties of interdependence among far-flung humans, nonhumans, and the inorganic world."[22] This section examines the sonic implications of this phenomenon, showing how, like climate science, knowledge of the relations between sound and the environment in the nineteenth century "was inextricably bound to European empire-building."[23] This is what Blaikley's experiments at the turn of the nineteenth century demonstrated. In Vienna, Blaserna had called attention to the complexity of wind instruments' relationship with temperature, leaving many unanswered questions. Europe's overseas military expansion provided the conditions for further investigation of this persistent problem, prompting Blaikley to focus on the behavior of these artifacts under the "extreme" temperature conditions characteristic of army bands' outdoors performances in India.[24] Whereas these ensembles appeared as vehicles of Western power at the turn of the nineteenth century, they were also the vectors of a new awareness of sound's vulnerability to the environment that jeopardized attempts to unify pitch.

Blaikley's research at Boosey and Co. was inflected by a tension between Western attempts to rationalize musical practice and the threat that the variety of environmental conditions posed to this project. Benefiting from the development of wind band practice in Britain during the second half of the nineteenth century, Boosey and Co. owed its success partly to the reorganization of British military bands under the lead of the newly established Kneller Hall Royal Military School of Music.[25] As one of the company's main clients, the school relied heavily on Boosey and Co.'s activities, in particular its effort to standardize military instrumentation; in turn, the school served as an *in vivo* laboratory to test the company's latest technological innovations.[26] Blaikley became Boosey and Co.'s factory manager in 1873, and throughout his career, his work bore the mark of the symbiotic relation between his firm and the military school.[27] He was a regular speaker at the Royal Society of Arts and the Royal Musical Association, and a reader of natural philosophers Hermann von Helmholtz, John Tyndall, and Lord Rayleigh, like many instrument makers of his generation; Blaikley's career unfolded at the crossroads of music, science, and industry.[28]

[22]Deborah Coen, *Climate in Motion: Science, Empire, and the Problem of Scale* (Chicago: University of Chicago Press, 2018), 5.
[23]Coen, *Climate in Motion*, 4.
[24]In 1846, for instance, of the 112 regiments forming Britain's infantry, only 35 regiments were in Britain, with the remaining 78 spread across the country's colonies. See Herbert and Barlow, *Music and the British Military*, 241.

[25]The creation of Kneller Hall Royal Military School of Music in 1857 was intended to lift the standards of British military musical practice. It followed what came to be called the "Scutari incident," in reference to a military parade organized to celebrate the Queen's birthday on 24 May 1854, in Scutari, Turkey. On that occasion, 16,000 army band players performed "God Save the Queen" both in different arrangements and in different keys, calling attention to the pressing need for a reorganization of British military music. Rempe, "Cultural Brokers in Uniform," 334–35.
[26]Jocelyn Howell, *Boosey and Hawkes: The Rise and Fall of a Wind Instrument Manufacturing Empire* (unpublished doctoral thesis, City University of London, 2016, http://openaccess.city.ac.uk/16081/), 29.
[27]Jack Smith, "David James Who? Some Notes on David James Blaikley," *Galpin Society Journal* 56 (2003): 217–23.
[28]On the entanglement of acoustical science and instrument building in the context of industrialization, see Sonja Petersen, "Craftsmen-Turned-Scientists?: The Circulation of Explicit and Working Knowledge in Musical-Instrument Making, 1880–1960," and "Music, Sound and the Laboratory, from 1750 to 1980," ed. Alexandra Hui, Julia Kursell, and Myles Jackson, *Osiris* 28 (2013): 212–23. Blaikley was interested in the history of musical instruments. He collaborated with Alexander J. Ellis and Alfred Hipkins to measure the pitch of ancient artifacts, conducted experiments on antique instruments captured during British military expeditions, and constructed facsimiles of historical Egyptian flutes and Greek auloi. Blaikley, "Afridi Fiddle," *Proceedings of the Musical Association* 25 (1898): 93–95; Thomas Lea Southgate, "On a Pair of Ancient Egyptian Double-Flutes," *Proceedings of the Musical Association* 17 (1890): 13–33; C. F. Abdy Williams, "Ancient Greek Music," *Proceedings of the Musical Association* 24 (1897): 125–44.

Through intensive experimentation, Blaikley expanded previous understandings of sonorous phenomena.[29] Reciprocally, Blaikley's theoretical knowledge of sound fueled his technological innovations.[30]

Pitch standardization was a central concern for Blaikley and other British instrument makers who were eager to take advantage of the commercial opportunities that their nation's territorial expansion created in the last decades of the nineteenth century. In the wake of Britain's considerable expansion, the lack of a national and international standard increasingly appeared as an obstacle, forcing instrument builders to produce artifacts tuned to at least three different standards (the *diapason normal*, its British adaptation A 439, and what was called the "Old Philharmonic Pitch," which served as the army's standard until 1927).[31] Determined to put an end to this situation, Blaikley embarked on a campaign for the standardization of musical pitch.[32] While this represented an effort to unify colonial musical soundscapes, in fact, Blaikley's efforts to introduce a standard pitch in the colonies ultimately undermined broader attempts to unify sound on a global scale. Crucially, the "extreme" climatic conditions found outside Europe magnified the fundamental problem of pitch's entanglement with its variegated environments that had started to emerge in Vienna.

Blaikley's project to introduce a uniform pitch across the British empire resulted in the production of a more complex picture of the relationship between sound and temperature. This is what his first publication on musical pitch revealed in 1891, in which he offered a substantial discussion of temperature, emphasizing that it "plays an important part in the variation of the pitch of wind instruments."[33] Reflecting on the main challenge of wind band practice—namely, securing sonic agreement between different categories of instruments in the open-air—this text drew attention to the important discrepancies between the ways in which heat and cold affected different categories of instruments. As one of the tables presented in this publication shows (see plate 2), Blaikley argued that temperature's influence on pitch was proportional to the size of the instruments. While environmental variations had a limited impact on the pitch of wind bands' smaller components, such as the flute, the oboe, or the clarinet, they had a far greater influence on larger-size instruments, such as the euphonion (today's euphonium) or the bombardon. During a 1904 lecture in front of the Royal Academy of Music, Blaikley projected a diagram illustrating the cacophony that this situation engendered (see plate 3). As the maker concluded in his 1890 "Essay," "It will be evident, from the foregoing data and remarks, that as instruments vary in different degrees with temperature, it is impossible that all the instruments in a band can rise and fall exactly together."[34]

Looking at the problems arising from imperial musical activities further led Blaikley to tackle the "unpredictable factor" to which Blaserna had called attention in Vienna: "the effect of the breath." Although the method by which Blaikley investigated this phenomenon remains unclear, he emphasized how much players, by blowing in their instruments, could reduce the

[29]For example, in 1880, he dismissed misconceptions according to which the material of which an instrument is made had an impact on the quality of tone during a sweeping demonstration based on the comparison between a paper and a copper bugle. David J. Blaikley, "On the Quality of Tone in Wind Instruments," *Proceedings of the Musical Association* 6 (1879): 79–90.

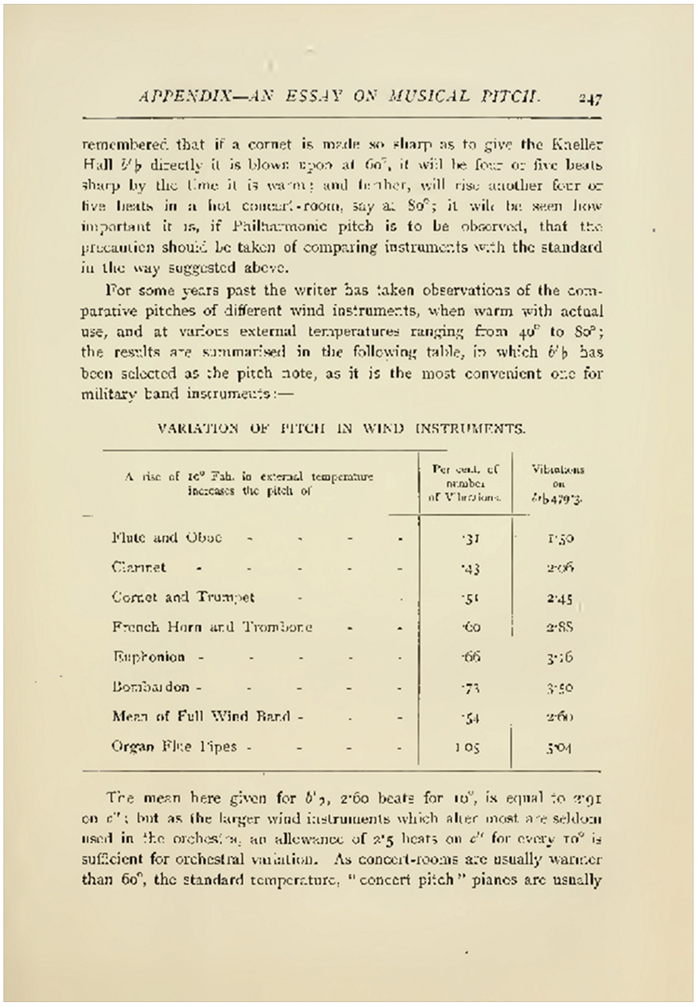
[30]Blaikley's most acclaimed innovation was the three-valve system that afforded greater control over the pitch of brass instruments. See Kelly J. White and Arnold Myers, "Woodwind Instruments of Boosey & Company," *The Galpin Society Journal* 57 (2004): 62–80 and 208–14; Alfred Myers, "Brasswind Innovation and Output of Boosey & Co in the Blaikley Era," *Historic Brass Society Journal* 14 (2000): 391–423; and Howell, *Boosey and Hawkes*.

[31]White and Myers, "Woodwind Instruments of Boosey & Company," 66–67.

[32]Blaikley's involvement in debates on pitch unification dates at least to the late 1870s, when he helped the scholar Alexander Ellis in his research on the history of tuning. Alexander Ellis, "On the History of Musical Pitch," *Journal of the Royal Society of Arts* 28, nos. 1424 and 1428 (1880): 293–336 and 400–03. Attesting to the interest Blaikley took in Ellis's work, in 1880 he issued a *Table Based upon "The History of Musical Pitch" by Alexander J. Ellis* (Boosey & Co., 1880). Blaikley opposed projects to introduce the *diapason normal* in Britain for commercial reasons.

[33]David J. Blaikley, "An Essay on Musical Pitch," in C. R. Day, *A Descriptive Catalogue of the Instruments Recently Exhibited at the Royal Military Exhibition, London, 1890* (London: Eyre and Spottiswoode, 1890), 235–53, 244.

[34]Ibid., 248.



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remembered that if a cornet is made so sharp as to give the Kneller Hall b'♭ directly it is blown upon at 60°, it will be four or five beats sharp by the time it is warm; and further, will rise another four or five beats in a hot concert-room, say at 80°; it will be seen how important it is, if Philharmonic pitch is to be observed, that the precaution should be taken of comparing instruments with the standard in the way suggested above.

For some years past the writer has taken observations of the comparative pitches of different wind instruments, when warm with actual use, and at various external temperatures ranging from 40° to 80°; the results are summarised in the following table, in which b'♭ has been selected as the pitch note, as it is the most convenient one for military band instruments:—

VARIATION OF PITCH IN WIND INSTRUMENTS.

A rise of 10° Fah. in external temperature increases the pitch of	Per cent. of number of Vibrations.	Vibrations on b'♭ 479·3.
Flute and Oboe - - - -	·31	1·50
Clarinet - - - - - -	·43	2·06
Cornet and Trumpet - .	·51	2·45
French Horn and Trombone - -	·60	2·88
Euphonion - - - - - -	·66	3·16
Bombardon - - - - - -	·73	3·50
Mean of Full Wind Band - . -	·54	2·60
Organ Flue Pipes - - - - -	1·05	5·04

The mean here given for b'♭, 2·60 beats for 10°, is equal to 2·91 on c''; but as the larger wind instruments which alter most are seldom used in the orchestra, an allowance of 2·5 beats on c'' for every 10° is sufficient for orchestral variation. As concert-rooms are usually warmer than 60°, the standard temperature, "concert pitch" pianos are usually

Plate 2: Blaikley, "An Essay on Musical Pitch," 247.

impact of environmental conditions on pitch. Crucially, Blaikley showed that while brass instruments were closed circuits in which the breath had a considerable impact on tuning, in contrast, wind instruments were much more vulnerable to the assaults of the environment. Because of the presence of side holes in the bodies of flutes, oboes, and clarinets, breath had a far more limited impact on their pitch.

The implications of Blaikley's imperial framing of the question of pitch standardization become clear in a passage where the instrument maker confesses his dismay at addressing environmental conditions in these contexts. As he writes: "The manufacturer may be expected to make [instruments] so that they stand well together at a medium temperature; but the adjustment necessary to ensure a good *ensemble* at extreme temperatures must be left to the judgement and experience of the players."[35] What Blaikley's careful observation of the impact of temperature on the pitch of wind instruments ultimately revealed was the limits of Western ambitions to regulate sound frequencies on a global scale. Whereas the army band seemed, and to some extent was, an ideal vehicle for the implementation of pitch reforms because of its tradition of discipline and standardization, due to its dissemination across and

[35]Ibid.

January 13, 1905. *JOURNAL OF THE SOCIETY OF ARTS.* 181

tone of the instrument, gives a distinct colouring, to which is due the sense of unity of quality, and also of individuality, running through the whole compass of the instrument.

We may take an illustration from another organ of sense than the ear—the eye. We may see a landscape with its distinctive greens, browns, purples, and other colours under ordinary light, and yet the general effect may be greatly modified either by a grey sky, or by the rays of a setting sun. So with sound. We may have groups or a succession of very distinct wave-forms, but these are capable of modification by the introduction of another wave-form which shall be common to all.

This view which I put forward tentatively does not apply only to the flute, for analogous conditions are to be found in brass and other wind instruments.

The attempt to summarise the chief points in the developments of wind instruments leads to the following conclusions as regards the different classes.

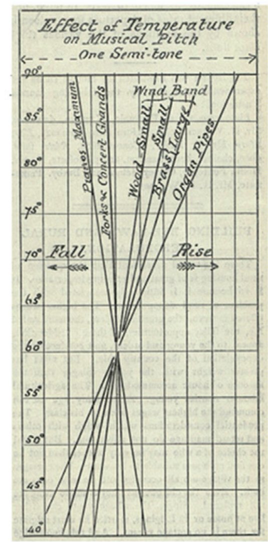
Brass Instruments.—The direct action of the lips as applied to the most simple horns has been maintained throughout all improvements and modifications.

Reed Instruments. — Reeds enclosed in chambers, and therefore not under the direct control of the lips, have passed away so far as artistic music is concerned.

Flutes.—A similar result is to be observed. The air-reed issuing from a mechanically formed slit, as in the recorders and other beaked flutes, has passed away.

We find, then, that all attempts to improve upon the wonderfully sensitive action of the lips by mechanical means have disappeared, but the work which lies fairly within the province of design and mechanism, that is to say, the determination of the proportions of a tube to give particular intervals and tone-quality, and the instantaneous regulation of its length in accordance with the requirements of the musical scale, so that it shall be suited in every way for response to the impulse of the lips, has been very marked during the last century.

Temperature is one natural condition which has an effect, in greater or less degree, upon all instruments; and although the full consideration of its influence would take more time than is at our disposal, a brief reference to it will not be out of place. Change of temperature affects the pitch of all instruments, and if all groups were influenced in the same direction and to the same extent, the result, in practical music, would be small, for all instruments would rise or fall together. The effect of heat upon metals being to expand them, a tuning fork is rather longer when warm than when cold, and is consequently flatter in pitch. If the expansion of the metal were the only effect of heat upon a brass



instrument, the same result would follow; but another influence is at work, producing five or six times the effect in the contrary direction. This influence is the greater velocity of sound in warm than in cold air. The change of pitch corresponding to this increased velocity is equal to a rise of a quarter of a tone between 47° and 73° Fah., a very ordinary range of temperature. This change is exhibited to its full extent in organ flue-pipes: the reed pipes

Plate 3: "Cantor Lectures: Musical Wind Instruments. By D. J. Blaikley. Lecture IV. Delivered December 19, 1904." *Journal of the Society of Arts*, vol. 53, no. 2721, 181. This diagram was reproduced in the *Memorandum*.

vulnerability to the globe's varied environments, it fundamentally undermined the project to control sound frequencies across the world.[36] While standards of pitch were envisioned as colonizing tools, Europe's colonial and imperial contexts intensified the epistemological problems that reformers had started to identify at the turn of the century. And if Western efforts to standardize pitch partly reshaped global soundscapes, the diffusion of pitch reforms through an increased variety of environments in turn renewed the ways in which standardizers conceived of the unification process.

[36]In 1918 the United States Army and Navy introduced pitch and temperature specifications according to which all instruments "must give A-435 at 59°F, and A-440 at 71° or 72°." Commenting on this strategy, the piano tuner D. A. MacDonald, from the Chicago-based and flourishing firm Lyon & Hailey, mocked this approach, referring to Blaikley to remind his audience that "If one instrument could be made to do this—and I do not consider this possible—the others could not comply with this requirement." "The Finished Piano and the Tuner," in Acoustic Department, American Steel & Wire Company, *Piano Tone Building: Proceedings of the Piano Technicians Conference. Chicago 1916, 1917, 1918. New York 1919* (New York: American Steel & Wire Company, 1919 [Chicago Technician Conference of 3 April 1918]), 180.

"Like a green-house": From Pitch to the Standardization of Musical Environments

Blaikley's research had far-reaching implications that continued to impact Western performance practice into the first decades of the twentieth century. In particular, the notion of standardizing the climatic conditions of musical environments, instead of expecting instrumentalists to adapt to various conditions, has remained a particularly prominent solution. Since the beginning of the twentieth century, acousticians' attempts to solve the problem of climate's impact on musical pitch have informed many dimensions of musical performance, from the definition of concert pitch to the regulation of musical sites' ambient conditions and the control of musicians' practices. In revealing how difficult it is to control pitch due to the multidimensional influence of temperature on sound, Blaikley's work eventually refashioned twentieth-century approaches to musical performance in Europe and the United States. In doing so, his work also points to how imperialism not only transformed colonial soundscapes, but also shaped Western musical practice from the outside in.

In 1858, at the time when the French commission was discussing the question of pitch unification, Hector Berlioz made a suggestion that revealed the potentially broad implications that the desire to control pitch could have on musical performance. Already in 1858, the composer suggested materializing the *diapason normal* through an organ pipe installed in every opera's foyer. To ensure the agreement between the pitch of this pipe and that of the orchestra, the composer recommended that wind instruments remain, "during the intervals of theatrical performances and concerts, locked in the foyer where this pipe is, and this foyer will be like a green-house, constantly kept at the average temperature of a theater filled with an audience."[37] As unrealistic and authoritarian as Berlioz's proposal may have sounded in the mid-nineteenth century, in the decades that followed, amid growing evidence of the impact of temperature and other atmospheric conditions on musical pitch, environmental control started to become a reality. As a matter of fact, Berlioz's image of the green-house aptly captures the standards of contemporary musical performance, according to which sonic uniformity requires extensive environmental regulation.

In the first decades of the twentieth century, knowledge of the interplay between sound and environment started to fuel approaches to the standardization of performance spaces as a means of pitch unification that revealed both a reversal and a considerable extension of the problem of the relationship of pitch unity to temperature. Rather than fixing musical pitch in relation to temperature, as acousticians had previously attempted, they now sought to stabilize concert pitch by controlling musical environments. This reconfiguration of acousticians' focus was initially manifested in the reconceptualization of concert pitch as an "absolute" standard at the end of the interwar period. In May 1938, the British Standards Institution (BSI) held a meeting with Britain's authorities on pitch matters to gather their thoughts on the problem of musical standardization. This event served as preparation for an upcoming international conference during which France, Britain, Italy, Holland, and Germany adopted concert pitch A 440 as the international tuning frequency.[38] Temperature was at the center of conversations, which largely drew on Blaikley's findings. Not only did some participants know about Blaikley's *Memorandum*, but two attendees familiar with the maker's experiments were present: Major Adkins, bandmaster at Kneller Hall, representing the interests of the army, and Arthur J. Blaikley, David J. Blaikley's son and Boosey and Hawkes's factory manager.[39]

As these debates revealed, Blaikley's conclusions created a dilemma. In light of the instrument maker's findings about temperature's impact on musical pitch, some actors were convinced that it only made sense to produce a

[37]Hector Berlioz, "Feuilleton du Journal des Débats du 29 septembre 1858, Le Diapason," *Journal des Débats*, 29 September 1858, 2.

[38]Gribenski, "Negotiating the Pitch."

[39]In 1937 Arthur Blaikley sent his father's *Memorandum* to the BBC engineer R. C. Thatcher. Letter from Arthur Blaikley to R. C. Thatcher, 1 November 1937. BBC Written Archives Center, E2/437/1, "Foreign Gen. Normal Pitch. Standardization. 1937–1940."

relative definition of the standard. This is what Major Adkins claimed, supporting his position by giving the example of a military band playing in Australia in 1934. "Anticipating the temperatures which would be met with there," the bandmaster recalled, "he had the percussion instruments tuned very nearly to high pitch, and the wind instruments to flat pitch."[40] In other words, in that case, it was through the *lack* of initial agreement between musical instruments' pitch that Adkins had managed to secure a harmonious performance of the band at high temperature. Blaikley shared Adkins's views, arguing "that any standard adopted should be associated with temperature."[41] Other delegates, however, considered that Blaikley's conclusions made it all the more urgent to adopt an absolute definition of the standard. The acoustician Edward Gick Richardson, for example, was "strongly of the opinion that the pitch . . . should not be allowed to vary with temperature."[42] As he explained in a 1940 article, Richardson was convinced that "the change of pitch of wind instruments with atmospheric conditions is a thing which has always militated against the adoption of universal pitch."[43] In other words, to succeed and secure the world's sonic integration and unity, one must close the door to the confusing variety that environmental diversity introduced in conversations about musical standardization.

Richardson's opinion ultimately prevailed, not only in Britain, but also on an international level.[44] In May 1939, when France, Italy, Britain, Holland, and Germany met in London and signed an agreement regarding concert pitch 440, they defined the standard as an absolute number of cycles per second. Despite the definitive nature of this decision, it was clear that it did not hold up under the truly environmentally diverse conditions of the colonies, as Richardson emphasized "the difficulties that will beset a military band playing in the open air." Given that "the outdoor temperature in India, for example, may reach 120°F," the physicist declared that "if open-air performances are given by a band in different parts of the world, they will have to provide themselves with special instruments for the tropics, if they are to keep to the international standard" (though he surmised that "probably they will not consider the expense worth while").[45]

The creation of "absolutist" definitions of musical pitch and the corresponding rejection of environmental diversity attested to standardizers' desire to focus the conversation on Europe's premier musical sites and their relatively temperate climates.[46] This, in turn, paved the way for the cultivation of practices aimed at controlling ambient conditions within these sites, a concern that remained paramount into the middle of the twentieth century. Since the mid-nineteenth century, architects had drawn on a combination of acoustical and hygienist concerns to connect considerations about sound propagation with concerns about building ventilation. For example, in 1853, J. Baxter Upham, the driving force behind the construction of Boston Music Hall, outlined how in "a room containing a crowded auditory, artificially lighted and warmed in the usual manner, the air becomes rapidly loaded with the products of respiration and combustion, and, too often, by the addition of coal gas from the furnace flues."[47]

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[40]British Standards Institution, Technical Committee B/26, Acoustics, "Report of proceedings at a conference on international agreement on concert pitch held under the auspices of the British Standards Institution at Broadcasting House [on May 20, 1938]," 2185/JB/71/4a, Surrey History Centre, Broadwood Piano Manufacture.

[41]British Standards Institution, "Report of Proceedings," 9.

[42]British Standards Institution, "Report of Proceedings," 10.

[43]Edward Gick Richardson, "The International Standard of Musical Pitch," *Journal of the Royal Society of Arts* 88, no. 4570 (20 September 1940): 851–64, at 855.

[44]Resolutions adopted by ISA Subcommittee 43/3b at a meeting held in Broadcasting House, London, on Thursday, 11 May and Friday, 12 May 1939. Knudsen papers, coll. no 1153m box 25, folder 4, UCLA Special Collections.

[45]Richardson, "The International Standard of Musical Pitch," 856.

[46]This is what the piano maker Whelpdale, from Bluthner & Co, made clear during a meeting organized at the BSI, when he demanded that "something . . . be done to standardize pitch for concert use, regardless of whether the Army bands could fall into line." The preoccupation of the BSI discussions, he continued, "was really with the idea of arriving at a pitch which could be used at what might be called high-class concerts." British Standards Institution. Technical Committee B/26, Acoustics, "Report of proceedings at a conference on international agreement on concert pitch held under the auspices of the British Standards Institution at Broadcasting House [on May 20, 1938]," 2185/JB/71/4a, Surrey History Centre, Broadwood Piano Manufacture.

[47]J. Baxter Upham, *Acoustic Architecture of the Construction of Buildings with Reference to Sound and the*

While considerations about the entanglement of sound propagation and atmospheric conditions continued to shape architectural acoustics during the first decades of the twentieth century, awareness of temperature's influence on tuning started fueling additional calls for music buildings' environmental control. In particular, it was clear that pitch unification demanded the stabilization of ambient conditions within these spaces. The BSI's 1939 publication on concert pitch A 440, which served as Britain's norm for the regulation of musical frequencies, declared that "in view of the dependence of the pitch of nearly all musical instruments on temperature . . . the increasing employment of 'air conditioning' for concert halls is an important factor."[48] After the war, at a time when international negotiations over concert pitch resumed, it was similarly through the generalization of "manufactured weather" in musical venues that nations hoped to implement concert pitch A 440 worldwide.[49] For example, the Australian Broadcasting Company proposed that "concert venues should be air-conditioned to maintain 'a constant temperature equal to the standard workshop temperature at which wind instruments are manufactured,'"[50] while West Germany's Physical Institute drew attention to "the degree of dependency of musical pitch on factors such as temperature, degree of humidity, carbon dioxide contents of the air, etc."[51]

Just as Berlioz had suggested in 1859, acousticians in the first decades of the twentieth century not only requested the regulation of room temperature and other atmospheric conditions, but also musicians' awareness of such problems and their effect on their instruments. As early as the Vienna conference in 1885, delegates drew on musicians' observations that the oboe's pitch tended to rise with temperature in recommending that it give the A to the orchestra "when it is completely warmed up."[52] Providing new evidence of this phenomenon, Blaikley similarly recommended that instruments be tuned and played "not when they are first taken up, but when they are fairly warmed up with playing."[53] For this reason, delegates at the 1939 BSI conference in London agreed to "[abandon] the oboe as arbiter of pitch."[54] They resolved to more broadly examine "the practical procedures to be adopted in order to take into account the fact that the frequency of certain musical instruments . . . particularly wind instruments, varies very appreciably."[55] During and after World War II, Germany, Norway, Britain, Australia, and other countries started to develop electroacoustic tone generators to replace the oboe across a wide array of musical sites, from recording studios and concert halls to dance halls, movie theaters, and schools.[56] Further research is needed to analyze the impact of these programs across a broad spectrum of social, musical, and professional contexts, from factories and conservatories to open-air performance sites. Such work would unveil the silent fight of acousticians, instrument makers, music teachers, and performers with and against environmental diversity, and reveal the myriad ways in which their efforts continue to resonate across contemporary music cultures.

Best Musical Effect (New Haven, CT: R. L. Hamlen, 1853), 35 and 40.

48 British Standards Institution, *British Standard Concert Pitch* (London: British Standards Institution, 1939), 7. See also: "The temperature troubles are likely to be overcome when the adoption of air-conditioning becomes general and the temperature of concert halls is not allowed to vary more than a degree or two." Richardson, "The International Standard of Musical Pitch," 855.

49 Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America* (Cambridge, MA: MIT Press, 2002), 222.

50 Simon Andrew Purtell, *Tuning the Antipodes: Battles for Performing Pitch in Melbourne* (Melbourne: University of Melbourne, Lyrebird Press, 2016), 158.

51 ISO Technical Committee 43 Acoustics. German Proposal Concerning the Standardization of Musical Pitch, 25 October 1953. BBC Written Archives Center, E2/437/2. "Foreign General. Normal Pitch. Standardization. 1941–1953."

52 Kaiserlich-Königliches Ministerium für Cultus und Unterricht, *Beschlüsse und Protokolle*, 30.

53 Blaikley, *Memorandum*, 11.

54 Richardson, "The International Standard of Musical Pitch," 856.

55 "Resolutions adopted by ISA Subcommittee 43/3b."

56 Hans-Joachim von Braunmühl and O. Schubert, "Ein neuer elektroakustischer Stimmtongeber für 440 Hz," *Akustische Zeitschrift* 6 (1941): 299–303; BSI CM (ACM) 2267. Technical Committee ACM/7–Musical Pitch, reply from the Norwegian Standards Association Concerning Implementation of the Decisions of the 1939 Conference on Concert Pitch, BBC Written Archives Center, R54/21/3, "Technical Gen. Personal: BSI. Standard Pitch. 1948–1950"; and Purtell, *Tuning the Antipodes*, 157.

Conclusion

In 1859 Berlioz called for strict regulations aimed at securing the adoption of the *diapason normal*, from environmental control to punishing merchants who sold out-of-tune pianos. Opposing what he saw as both a politically problematic and an unrealistic proposition, the musicologist Adrien de La Fage responded to Berlioz that same year by imagining what other absurd measures could come next: "One will then have to punish cold, which elevates the sound of metallic strings, humidity, which stretches gut strings, and heat, which causes wind instruments to raise. All temperatures will have to adopt this official A, without being able to pretend that they ignore the law."[57] While La Fage depicted climate as an ungovernable force shaping musical practice, later generations of acousticians attempted to hold climate accountable for pitch variations. As a result, pitch became a measure of the relation between humans and their environments, with musical instruments serving as the terrain of their negotiation. If this was a lost battle for pitch reformers, who failed to overcome the impact of temperature on pitch in "extreme climates," climate and temperature nevertheless exerted considerable influence on musical performance, triggering the regulation of all dimensions of Western musical environments.

While instruments have attracted some attention in the field of ecomusicology as the products of problematic processes of extraction and large-scale supply chains, little has been written about their actual use in musical performance as sites of negotiation with the environment. The history of sound, inasmuch as it articulates the variegated materiality of air, offers a rich site to investigate the connections between humans and the climate.[58] As this article demonstrates, acoustics have long played a key role in shaping the terms of these relations, calling for historical studies at the intersection of musicology and history of science that will unpack the epistemologies that have shaped humans' musical interactions with their environments.

Abstract.
Today, knowledge concerning the relationship between temperature and musical pitch shapes many dimensions of Western musical practice, from the ambient conditions of performance sites to the design of musical instruments, and performers' routines and techniques. But the history of how temperature came to play such a defining role in musical cultures remains unexamined. This article lays the foundations for such work by approaching musical instruments as sites of negotiation between acousticians, instrument makers, and players on the one hand, and music's variegated environments on the other. First, the article shows that the conceptualization of pitch in relation to temperature was a by-product of nineteenth-century international negotiations over musical standardization. These debates reveal that, while assessing the relation between pitch and temperature may seem like a decisive step toward the regulation of musical frequencies, in fact it was the source of countless epistemological and sociopolitical problems. Next, the article turns to David J. Blaikley, a British maker of wind instruments, whose experiments on the influence of extreme temperature variations on army-band instruments revealed the limits of Western attempts to control sound on a global scale, including in colonial contexts. Finally, I trace the implications of this new awareness of the interplay between sound and the environment to expose the silent ways in which that awareness continued to inform Western musical practice into the 1940s and beyond. Keywords: musical practice, musical instruments, acoustics, environmental conditions, imperialism

[57] "On devra par suite punir aussi le froid qui élève le son des cordes métalliques, l'humidité qui tend les cordes de boyau, et la chaleur qui fait monter les instruments à vent. Toutes les températures seront tenues d'adopter le *la* officiel, sans pouvoir prétexter à l'ignorance de la loi." Adrien de La Fage, *De l'Unité tonique et de la fixation d'un diapason universel* (Paris: Dentu, 1859), 133.

[58] Sound artist Robert Hamlin Jackson's installation of a piano in the Chihuahua desert surrounding Marfa, in Texas, demonstrates that musical instruments are rich sites for sounding the relationship between humans and the environment. Showing the rapid alterations of the instrument in this outdoor setting—the surface of the key is uneven; the varnish of the wood is gone—this installation entitled *MarfA440* demonstrates man's inability to control nature. It is above all through the repeated sounds of an out-of-tune A_3 that the artist draws attention to the failure of capitalist attempts "to standardize the world around us" while "it is always slipping away, being pulled back into a relationship that is more direct and material." https://vimeo.com/340631608. I thank Jamie Allen for bringing this project to my attention.