Disciplinary Culture:

Artillery, Sound, and Science in Woolwich, 1800–1850

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This article explores connections between science, music, and the military in London in the first decades of the nineteenth century.[1] Rather than look for applications of music or sound in war, it considers some techniques common to these fields, exemplified in practices involving the pendulum as an instrument of regulation. The article begins by exploring the rise of military music in the late eighteenth and early nineteenth centuries, and then compares elements of this musical culture to scientific transformations during

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[1] For broad relations between music and science in this period, see: Myles Jackson, *Harmonious Triads: Physicians, Musicians, and Instrument Makers in Nineteenth-Century Germany* (Cambridge, MA: MIT Press, 2006); Alexandra Hui, *The Psychophysical Ear: Musical Experiments, Experimental Sounds, 1840–1910* (Cambridge, MA: MIT Press, 2012); Emily I. Dolan and John Tresch, "'A Sublime Invasion': Meyerbeer, Balzac, and the Opera Machine," *Opera Quarterly* 27 (2011), 4–31; Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900–1933* (Cambridge, MA: MIT Press, 2004). On science and war in the Napoleonic period, see for example: Simon Werrett, "William Congreve's Rational Rockets," *Notes & Records of the Royal Society* 63 (2009), 35–56; on sound as a weapon, Roland Wittje, "The Electrical Imagination: Sound Analogies, Equivalent Circuits, and the Rise of Electroacoustics, 1863–1939," *Osiris* 28 (2013), 40–63, here 55; Cyrus C. M. Mody, "Conversions: Sound and Sight, Military and Civilian," in *The Oxford Handbook of Sound Studies*, eds. Trevor Pinch and Karin Bijsterveld (Oxford: Oxford University Press, 2012), pp. 224–48. The author wishes to thanks Sarah Hibberd, John Tresch, Sophie Waring, Anna Maerker, and members of the King's College London conference on Music and Science for their helpful comments and suggestions.

the same period. Having established some shared features, it then examines the work of mathematician Olinthus Gregory, whose experiments in standardization and the determination of the velocity of sound bridged the military, musical, and scientific cultures of early nineteenth-century London. Gregory, it is argued, was representative of a community of reform-minded mathematicians and astronomers who sought to introduce greater precision and more mathematics into science. A number of them did this in a military context, where similar values of discipline and precision prevailed. The article concludes by demonstrating how music was not only a resource for these enterprises, but also had the potential to ruin them.

Military music

The military was probably the largest employer of musicians in the first half of the nineteenth century.[2] Music was integral to military action, serving as a means of communication, as inspiration for armies, and as a way to beat time on marches. In the last decades of the eighteenth century, military bands had become a formal part of Europe's armies and they were an increasingly important aspect of the growing culture of parades and inspections in the military of the Napoleonic era. This reflected the broad rise of Britain's

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[2] Trevor Herbert and Helen Barlow, *Music and the British Military in the Long Nineteenth Century* (Oxford: Oxford University Press, 2013), p. 1; on the history of military music, see Henry George Farmer, *The Rise and Development of Military Music* (London: W. Reeves, 1912).

burgeoning fiscal-military state and near doubling of the armed forces during the long eighteenth century.[3]

Given this context, it is clear that military music played an integral role in the disciplinary culture that emerged in Britain during the period. Commentators disagree on the value of 'discipline', however. Foucault famously contrasted a new regime of surveillance and impersonal 'panoptic' control with a form of power based on spectacle in the *ancien régime*.[4] But, more recently, Chris Otter has criticized the terms 'surveillance' and 'spectacle', seeing them as abstractions that are insensitive to historical actors' categories of the period; and I have argued elsewhere that the relationship between sovereign and disciplinary power was more entangled than Foucault proposes.[5] 'Disciplinary culture', the term to be used in this article, entailed both a new emphasis on observation and calculation and a celebration of splendor and display. The military band, at once a highly disciplined body of men and an impressive show of costumes, performance, and sound, might in this sense be taken as an exemplary institution of disciplinary culture. Power operated in the band through the gestures and motions of the bodies of performers and audiences, and via the visceral,

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[3] John Brewer, *The Sinews of Power: War, Money and the English State, 1688–1783* (London; Routledge, 1989), p. 30.

[4] Michel Foucault, *Discipline and Punish, the Birth of the Prison* (1975; London: Penguin, 1991).

[5] Chris Otter, *The Victorian Eye: A Political History of Light and Vision in Britain, 1800–1910* (Chicago: University of Chicago Press, 2008); Simon Werrett, "The Panopticon in the Garden: Samuel Bentham's Inspection House and Noble Theatricality in Eighteenth-Century Russia," *Ab Imperio* 3 (November 2008), 47–70.

emotional experiences that a band of musicians, their appearance and productions, could generate. The band also reminds us that the audible, in addition to the visible, was fundamental to these processes.

Military music provided a soundtrack to this disciplinary culture. In the 1780s, Samuel Bentham (brother of Jeremy) designed the first panopticon, Foucault's favorite instantiation of discipline, not as a prison but as a spectacle for the Empress Catherine the Great. Martial music was part of the performance. Mary Bentham wrote of her late husband's stay in Russia that, "He was strict in enforcing discipline, yet by his gentleness and regard for the welfare of all ranks soon made himself universally beloved. Passionately fond of music himself, he wrote to England for a complete set of military musical instruments and for an expert *drummer*."[6] This he did while contemplating how to control the drunken English workmen he was using to run his patron's estate in White Russia. His solution, alongside the drums whose distinctive sound had long made them a tool to regulate marching soldiers, was the panopticon.[7]

Bentham himself was a military man: he was awarded the rank of colonel of Russia's Black Sea fleet and served as inspector general of the Navy's works in Portsmouth after his return to England in the 1790s.[8] During his lifetime, both discipline and display were increasingly seen as critical to an

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[6] Mary S. Bentham, *The Life of Brigadier-general Sir Samuel Bentham* (London: Longmans, 1862), p. 79.

[7] Werrett, "The Panopticon in the Garden."

[8] On Bentham's work as inspector, see William J. Ashworth, "System of Terror: Samuel Bentham, Accountability and Dockyard Reform during the Napoleonic Wars," *Social History* 23 (1998), 63–79.

effective military: aspirations were expressed in a growing regime of inspections and parades that combined the political spectacle of assembled power with micro-techniques of control over soldiers' bodies. The Duke of Wellington explained how soldiers "should never be exempt from observation and free from controul."[9] Regiments instigated regular inspections of troops to enforce precision, accuracy, and attention. As one manual put it: "No mistake or inaccuracy, however trifling, can possibly escape the instructor's notice if he is at all attentive."[10] The slightest infraction prompted punishment, often involving the kinds of spectacular violence typical of sovereign power. Discipline also took the form of demands that soldiers keep uniforms and accoutrements in perfect order. Routinized micro-techniques of polishing, mending, and cleaning controlled soldiers' bodies, although not without resistance: for some, the new discipline led to alcoholism and desertion.[11]

Military music was constantly in the service of this new disciplinary culture. In a role that had a very long history, fifes, trumpets, and tenor or side drums communicated movements on the battlefield, their shrill sounds heard above the din of artillery and gunfire.[12] Niccolò Machiavelli stated in the *Art of*

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[9] Wellington, quoted in Scott Hughes Myerly, *British Military Spectacle: From the Napoleonic Wars through the Crimea* (Cambridge, MA: Harvard University Press, 1996), p. 72.

[10] Lt. John Sinnott, *A Manual of Light Infantry and Other Duties; Originally Compiled for the use of the Non-Commissioned Officers of the Forty-seventh or Lancashire Regiment*, 2nd edn (London: Parker, Furnivall and Parker, 1851), p. 111; quoted in Myerly, *British Military Spectacle*, 75.

[11] Myerly, *British Military Spectacle*, p. 73.

[12] Jon Sumida, "Martial Music," in Robert Cowley and Geoffrey Parker, eds., *The Reader's Companion to Military History* (New York: Houghton Mifflin, 2001), pp. 314–15, here p. 315.

War that “the drum commands all things in battle, proclaiming the commands of the officer to his troops.”[13] Music also served an emotional role, evoking the passions. Edward Gibbon wrote of martial music that “the mechanical operation of sounds, by quickening the circulation of the blood and spirits, will act on the human machine more forcibly than the eloquence of reason and honour.”[14] Finally, music regulated marching soldiers: a drum-major, as Bentham no doubt knew, “must scrupulously observe the ordered times of march, whether ordinary or quick, and use no tunes but such as are particularly adopted to such times of march.”[15]

Woolwich and the music of the Arsenal

The artillery had used fifes and drums since the mid-sixteenth century, but military music was only institutionalized as part of disciplinary culture in the late 1700s. British officers stationed in Prussia copied Prussian practice to create formal “bands of musick” attached to their regiments. The bands played during marches, served on the battlefield, and provided concerts that added pomp to the regiment. They introduced new instruments, such as serpents, bassoons, horns, and hautboys—which impressed Charles Burney with “a very good effect.”[16] An exemplary location for these new regimental

[13] Henry George Farmer, *Memoirs of the Royal Artillery Band: Its Origin, History and Progress: An Account of the Rise of Military Music in England* (London and New York: Boosey, 1904), p. 14.

[14] Edward Gibbon, *The History of the Decline and Fall of the Roman Empire*, ed. J. B. Bury, 7 vols. (1896–1900; Cambridge: Cambridge University Press, 2013), vol. 7, p. 190.

[15] *Standing Orders … 56th Regiment*, quoted in Myerly, *British Military Spectacle*, p. 74.

[16] Charles Burney in 1773; quoted in Herbert and Barlow, *Music and the British Military*, p. 36.

bands was Woolwich Warren, or the Royal Arsenal as it became known from 1805: it was the headquarters of the Royal Artillery and the hub of ordnance production and supply of the British Empire. The arsenal produced gunpowder weapons and cannon, and housed barracks for the artillery regiment.[17]

The official Royal Artillery Band was formed in Minden in 1762, during the Seven Years War. The first eight musicians were Prussian, replaced by Britons after 1764. Frederick the Great's Prussian bands were the model.[18] By 1802 the band had twenty-one performers playing bassoons, bassett horns, oboes, clarionets, trumpets, and flutes. From 1805 to 1810, Colonel Charles A. Quist (1732–1821) took charge, inaugurating popular concerts in the Royal Artillery Officers' Mess every winter. This was the scene illustrated by George Scharf in 1826, "At the Marine Officers Mess Room, at Woolwich, during Dinner" (see plate 1).[19] The soldiers, who wore a white and later blue uniform with yellow braids and silk epaulettes on the shoulders, played a variety of instruments: here the flute, clarinet, French horn, keyed bugles, bassoon, serpent, and trombone.[20]

[**insert near here** – Plate 1: George Scharf, "At the Marine Officers Mess Room, at Woolwich, during Dinner," 1826 (British Museum)]

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[17] O.F.G. Hogg, *The Royal Arsenal: Its Background, Origin, and Subsequent History*, 2 vols. (London: Oxford University Press, 1963). The Warren was established in the 1690s.

[18] Farmer, *Memoirs of the Royal Artillery Band*, p. 34.

[19] W.Y. Carman, "George Scharf: Military Artist," *Journal of the Society for Army Historical Research* 44 (1966), 84–7.

[20] On uniforms, see Farmer, *Memoirs of the Royal Artillery Band*, p. 70–1.

The military band was integral to the soundscape of Woolwich, a town to the southeast of London that did not become part of the metropolitan area until the mid-nineteenth century. The Royal Artillery Band played throughout the summer on the parade ground in front of the Artillery Barracks. According to one guide:

> The mind of the stranger is lost in admiration, if it is his first visit to Woolwich, the ear is instantaneously charmed and electrified with the most delightful sounds—the band of the Royal Artillery, in their handsome and graceful costume, has commenced, and the melodious and powerful tones of forty instruments, in the able hands of those who use them, rivet him to the spot. The only motion he can make is to keep time with his head or his heel, all other ideas having vanished like a fleeting dream.[21]

Music aroused emotions in soldiers while it charmed and electrified listeners, both were effectively disciplined in their rhythmic behavior, and both were compared by contemporaries to machines.[22] In order to establish precision in marching, drum majors were instructed to use a pendulum or plummet of a prescribed length whose swing could set the tempo of the music and synchronize it with the marching body perfectly. The army regulations of 1811 explained:

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[21] John Grant, *A Guide to Woolwich* (London: [Grant], 1841), p. 19.

[22] Myerly, *British Military Spectacle*, p. 72.

> The Music and the Drums and Fifes, when playing or beating for Military Purposes … should be attentive not to deviate in the most trifling degree from the Time which will allow … the exact number of steps prescribed by His Majesty's Regulations, and the Music … should be practiced … with the Plummet, until the exact prescribed Cadence has been required.[23]

The body had to defer to the machine. A drum-major was "not to be allowed to trust … his own ear … but at all times to have a plummet," that is a pendulum, to keep time.[24] Such precision allowed calculation: regulations expected a soldier to take 75 paces of 30 inches each in one minute, that is, at the "ordinary step." The quick step and wheeling march were faster. From this, the speed of movement of an army was calculated, as was the distance it might be expected to travel in an hour, typically about four miles at the normal marching pace.[25]

Post-revolutionary changes in the sciences

Disciplinary culture was also becoming increasingly evident in the sciences. Eighteenth-century science had promoted a natural historical practice of careful, qualitative observation, and attracted public spectators through the senses. But in the context of the French Revolution appeals to mass

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[23] *General Regulations and Orders for the Army* (12 August 1811), p. 93; quoted in Herbert and Barlow, *Music and the British Military*, p. 21.

[24] Quoted in Myerly, *British Military Spectacle*, p. 74.

[25] Herbert and Barlow, *Music and the British Military*, pp. 22–3.

audiences were politicized: a different style of science emerged, stressing precision measurement that by definition could not take place in public spaces before audiences because this would interfere with the process.[26] William Ashworth describes the culture of science in Britain in the 1820s and 30s as operating a "calculating ideology," combining discipline, precision, mathematics, and liberal economic values.[27] For example, members of the new Astronomical Society, founded in 1820, promoted rigorous, self-disciplined positional astronomy to replace the more qualitative, natural historical cosmology characteristic of the eighteenth century.[28] Astronomy was thus transformed from speculation to a practice with stringent values of self-negation, punctuality, and precision—values that were exerted through micro-techniques of observation, recording, and calculation that astronomers were obliged to practice. Proponents of this style of science championed an efficiency achieved through standardization, measurement, and accountancy, the sorts of qualities that were reflected in the close ties of some members—such as Francis Baily and Benjamin Gompertz—to the City of London and the world of finance. Ultimately nature, men, and instruments could all be reduced to calculation: a well-ordered machine, manageable and measurable.

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[26] Lissa Roberts, "The Death of the Sensuous Chemist," *Studies in History and Philosophy of Science* 26 (1995), 503–29; Simon Schaffer, "Natural Philosophy and Public Spectacle in the Eighteenth Century," *History of Science* 21 (1983), 1–43.

[27] William J. Ashworth, "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy," *British Journal for the History of Science* 27 (1994), 409–41.

[28] Ashworth, "Calculating Eye," 410–15; on the Astronomical Society, see also J.L.E. Turner and H.H. Turner, eds., *The History of the Royal Astronomical Society* (London: Royal Astronomical Society, 1923).

Ashworth roots the discipline that characterized early nineteenth-century science in business and French systems of institutional administration, but it was also closely allied to the military. As he himself notes, astronomical practice reflected the principles espoused by Samuel Bentham, who introduced to dockyard management in Portsmouth a rigorous system of surveillance and accountancy, much to the consternation of the artisan shipbuilders who worked there.[29]

The champions of calculation also found a common cause in the plight of mathematician Charles Hutton, dismissed as foreign secretary of the Royal Society in 1784.[30] Hutton's dismissal was viewed by his allies as the result of an outdated culture of cronyism and patronage surrounding the Society's President, the natural historian Joseph Banks. Hutton was an instructor in mathematics at Woolwich's Royal Military Academy, and—in contrast to Banks—a proponent of calculation supported by such figures as Nevil Maskelyne, the astronomer royal, at the Board of Longitude.[31] Hutton was an early member of the Astronomical Society alongside several other military men, including Major Thomas Colby of the Royal Engineers, who served as Vice-President; Major-General John Rowley, also of the Royal Engineers; and

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[29] Ashworth, "Calculating Eye," 435–6.

[30] John L. Heilbron, "A Mathematicians' Mutiny, with Morals," in *World Changes: Thomas Kuhn and the Nature of Science*, ed. P. Horwich (Cambridge, MA: MIT Press, 1993), pp. 81–129; David Phillip Miller, "Between Hostile Camps: Sir Humphry Davy's Presidency of the Royal Society of London, 1820–1827," *British Journal for the History of Science* 16 (1983), 1–47.

[31] W. Johnson, "Charles Hutton, 1737–1823: the Prototypical Woolwich Professor of Mathematics," *Journal of Mechanical Working Technology* 18 (1989), 195–230.

Captain Francis Beaufort of the Royal Navy, who served on the Council.[32] David Phillip Miller has accurately characterized these men as belonging to a distinct community of mathematical practitioners connected to the military, one that also included Samuel Hunter Christie and Peter Barlow, both mathematicians and physicists associated with the Royal Military Academy at Woolwich, and James Ivory, who taught at Sandhurst. Miller notes how these men combined the teaching of astronomy, mathematics, and surveying to military cadets, with the pursuit of research for the Board of Ordnance and the Admiralty. Many of them published dictionaries and mathematical textbooks and used their leisure time to undertake investigations in the physical sciences.[33]

Woolwich and the science of sound

These conditions made possible a variety of relationships between music, science, and disciplinary culture in the first decades of the nineteenth century. The astronomer William Herschel provides a good example of the ways in which music and science came together through a qualitative, natural historical, and experiential approach associated with the Royal Society under Banks. In contrast, the Woolwich mathematician Olinthus Gregory, one of the astronomers who celebrated the “calculating eye,” valued mathematics, precision, and an approach to music that reduced it to the physics of sound.

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[32] Anon, “Astronomical Society,” *Annals of Philosophy, or Magazine of Chemistry* [ed. Thomas Thomson], 5 (Jan to Jun 1815), 308–9.

[33] David Philip Miller, “The Revival of the Physical Sciences in Britain, 1815–1840,” *Osiris* 2 (1986), 107–34, here 108.

Herschel famously practiced both science and music. His father Isaac was a military bandsman, who trained in the Prussian service under a conductor named Päbush before being engaged as an hautboy player in the Foot-Guards regiment of Hanover.[34] William joined the Hanover Guards as a musician at the age of fourteen, playing the hautboy and violin. In 1756, his appointment took him to an encampment in southern England, where he learned English. However he was soon disillusioned by the life of a regimental bandsman: as he later put it, "the continual marches were very harrassing."[35] Becoming domiciled in England, Herschel sought work as a professional musician but, again in his own words, "London was so overstocked with musicians that we had but little chance of any great success." Consequently, Herschel moved to Bath, where his musical and philosophical interests gradually gave way to astronomy. Before this move, however, he accepted a place in a small regimental band quartered at Richmond, Yorkshire, where he "composed military music on purpose to show off our instruments."[36]

The significance of Herschel's musical career to his astronomy has already been noted. Emily Winterburn has recently shown how learning the violin gave Herschel a lesson in the acquisition of expertise through "long intense periods of repetitive practice."[37] This skill was then, at least arguably,

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[34] William Herschel, "Memorandums from which an historical account of my life may be drawn," in *The Scientific Papers of Sir William Herschel*, vol. 1, ed. John Louis Emil Dreyer (Cambridge: Cambridge University Press, 2013), p. xiv.

[35] Ibid., p. xvi.

[36] Ibid., p. xvii.

[37] Emily Winterburn, "Philomaths, Herschel, and the myth of the self-taught man," *Notes and Records: The Royal Society Journal of the History of Science* 68 (2014), 207–26, here 208.

important to Herschel's astronomical discoveries, which depended on using a large refracting telescope whose mirror he needed to spend many hundreds of hours polishing. What is more, his music teacher introduced him to the study of French, philosophy, ethics, logic, and metaphysics, thus allowing him to represent himself as an independent learner, despite relying on a network of expert support. As if in further demonstration, Herschel's first philosophical work was a *Treatise on Music*, which remained unpublished. Here he argued against reducing music to mathematical rules, claiming instead that experience offered the best way to appreciate music.

Herschel's distaste for mathematics and approval of experience probably sat well with a person already mentioned: one of the key figures in British science of his generation, Joseph Banks. Banks was a botanist, and botany, as Simon Schaffer has shown, was a valuable resource for Herschel's astronomy, which amounted to a "natural history of the heavens."[38] Herschel identified a variety of nebulous fields in the heavens, which he imagined as snapshots in the life of stellar forms, akin to growing plants. And Banks, like Herschel, had a great taste for music. As a young man traveling on Captain Cook's first voyage he had been fascinated by bands and music played in the Pacific islands.[39] He noted in later life that he was "an attendant on plays,

See also John Tresch and Emily I. Dolan, "Toward a New Organology: Instruments of Music and Science," *Osiris* 28/1: Music, Sound and the Laboratory from 1750–1980 (2013), 278–98, here 289–90.

[38] Simon Schaffer, "Herschel in Bedlam: Natural History and Stellar Astronomy," *British Journal for the History of Science* 13 (1980), 211–39.

[39] Joseph Banks, *Journal of the Right Hon. Sir Joseph Banks Bart., K.B., P.R.S.: During Captain Cook's First Voyage in HMS Endeavour in 1768–71 to Terra Del Fuego, Otahite,*

operas, concerts, masquerades, etc. until prevented by infirmities."[40] Banks was also the enemy of those mathematical practitioners who championed a different kind of science in the early decades of the nineteenth century; and their approach to music was, it seems, equally distinct. Just as the mathematical reformers rejected the cosmological and qualitative dimensions of astronomy in favor of a more disciplined, quantitative approach, so they had little time for music as an art and experience, preferring to explore the science of sound. Charles Babbage, for example, wrote that "my love of music is not great;" he only attended concerts "for the pleasure of the society."[41]

Exemplary among the reformers and enemies of Banks was Olinthus Gregory, whose career as a mathematician and astronomer began through the patronage of Hutton. After trying out careers in journalism and bookselling in Cambridge, Gregory became a teacher of mathematics; in 1801 he wrote *A Treatise of Astronomy*, a volume dedicated to Hutton, whom he evidently admired deeply throughout his life (he even named his own son Charles Hutton Gregory). In December 1802 Hutton secured for Gregory the position of second mathematical master at the Woolwich Royal Military Academy; from this base Gregory published several successful works on astronomy and mechanics, also editing Hutton's works and writing his biography. As a mathematical expert operating outside the Royal Society, Gregory belonged firmly to the camp of natural philosophers who opposed the regime of Banks

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New Zealand, Australia, the Dutch East Indies, Etc. (1896; Cambridge: Cambridge University Press, 2011), p. 99.

[40] Banks, *Journal of the Right Hon. Sir Joseph Banks*, 262.

[41] Charles Babbage, *Passages from the Life of a Philosopher* (London: Longman, 1864), p. 427.

and championed a calculating style of science. Banks had no time for Gregory, scoffing that his work was "blundering" in a letter to a friend.[42] Gregory, for his part, published a biting critique of Banks in 1820 and, along with Babbage, Millington, William Herschel's son John, was a founding member of the Astronomical Society.[43]

Gregory's work followed the new demand for disciplined surveillance that marked out the scientific reformers with whom he worked. His early treatise on astronomy proposed that the discipline demand accuracy and precision in "diligent and judicious observation."[44] In a *Treatise on Mechanics*, he railed against the idea that natural philosophy might be practiced without a knowledge of mathematics, something he felt had led to a decline of mathematics in Britain.[45] But Gregory was also interested in music, albeit only insofar as it was subject to his own mathematical calculations. The pleasures

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[42] "Kater sets out with his Pendulums on Wednesday he will proceed to Shetland & from hence to Norway on his return he will visit.… The discovery ships sailed on 5 May. While at Shetland they made a few pendulum observations which are consonant with the theory & differ intirely from the Blundering Result obtained by Olynthus Gregory;" Joseph Banks to Charles Blagden (19 June 1819). Royal Society, London. BLA.B.73; also referenced as CB/1/1/156.

[43] On Gregory, see Anon., "Memoir of Olinthus Gregory … professor of mathematics, Royal Military Academy, Woolwich," *Imperial Magazine* 5 (1823), 777–92; [Olinthus Gregory], "A review of some leading points in the official character and proceedings of the late president of the Royal Society," *London and Edinburgh Philosophical Magazine* 56 (1820), 161–74, 241–57.

[44] Olinthus Gregory, *A Treatise on Astronomy* (London: G. Kearsley, 1802), p. viii.

[45] Olinthus Gregory, *A Treatise on Mechanics*, 2 vols. (London: F.C. and J. Rivington et al., 1815), vol. 1, preface.

of music seemed to be something foreign to him, even while the knowledge it afforded was fascinating. In his first publication, a textbook of *Lessons, Astronomical and Philosophical for the Amusement and Instruction of British Youth* (1793), Gregory explained that:

> Of the philosophy of sounds, *Music* is undoubtedly the essential and most refined part; and we find that persons in general are exceedingly fond of musical sounds, being thereby affected with the most agreeable and ravishing sensations. It is my province in this place to give no more of the science of *Music* than what relates to the production of musical sounds, and indeed of *sounds in general*.[46]

Music should, in other words, be subjected to rational principles. In a long footnote Gregory scoffed at musical tradition as outdated and inefficient. Passing a calculating eye over the way music was written down, he proposed "the substitution of proper characters to denote the different kinds and velocities of *musical time*, instead of those vague indefinite ones, which are now in use." He went on to argue that the use of time signatures such as 3/2 and Italian terms such as *Adagio* and *Allegro* were "of very little avail in ascertaining with precision the point the musician wishes to discover." Instead music should indicate the "absolute rate" of performance, "based on the

[46] Olinthus Gregory, *Lessons, Astronomical and Philosophical for the Amusement and Instruction of British Youth* [1793], 6th edn, "much enlarged and improved" (London: B.J. Holdsworth, 1824), p. 98.

length of a pendulum which would make one complete vibration in the time that part of a bar called a beat was performing”. He continued:

> Thus, for instance, suppose I set a tune in triple time, and wish to have each bar performed in a second and a half, the character I must make use of is 3/10; for from this it might be concluded, that there were three beats in a bar, and each of these beats must be performed in the time a pendulum, ten inches long, made one vibration.[47]

Gregory’s demands were part of a larger debate in Continental Europe in the early nineteenth century about the values of precision for science and music. As Myles Jackson has shown, musicians in Germany argued over the value of chronometers and timepieces for regulating the tempo of music, an argument resolved with the invention of Dietrich Nikolaus Winkel and Johann Nepomuk Mälzel’s metronome, a practical and inexpensive device that quickly took off after Mälzel patented it in 1815.[48]

The metronome turned the pendulum into a standard regulating device for music, and also came to be used in a variety of medical and experimental settings in the nineteenth century. Indeed, it emerged from a period in which the pendulum became the focus for intersections of music, science, and the

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[47] Gregory, *Lessons, Astronomical and Philosophical*, pp. 98–9.

[48] Myles W. Jackson, “From Scientific Instruments to Musical Instruments: The Tuning Fork, the Metronome and the Siren,” in *The Oxford Handbook of Sound Studies*, eds. Trevor Pinch and Karin Bijsterveld (Oxford: Oxford University Press, 2012), pp. 201–23, here 209–12; on debates over precision in science, see M. Norton Wise, ed., *The Values of Precision* (Princeton: Princeton University Press, 1995).

military. Gregory's proposal to regulate tempo with a pendulum followed what was no doubt a familiar sight for him at Woolwich—the use of the pendulum by the drum-major to regulate marching music. The body, musical instruments, and the scientific instrument should all work together in synchronization to generate the required result. The same triangulation characterized military surveying and astronomical observation at this time. As Miller notes, from about 1815 experiments with the pendulum to measure the figure of the earth became a major concern of mathematical practitioners and scientific servicemen such as Henry Kater, Edward Sabine, James Ivory, and Francis Baily.[49] In 1817, Kater, who had served in the trigonometrical survey of India before joining the Royal Military College, High Wycombe, invented a reversible pendulum allowing precise measures of the seconds pendulum, which served as a basis for the British standard yard and was used on geodetic surveys for a century.[50] More accurate surveys of the country in turn enhanced military communications and navigation. Such standardization served the liberal economy: elites and free market proponents supported national standards to replace the local weights and measures that traditionally benefitted local communities.[51]

Gregory participated in debates about standards and promoted the pendulum as an ideal instrument for determining the standard of length. His

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[49] Miller, "Revival of the Physical Sciences," 119–27.

[50] Gordon Jones, "The Scientific Publications of Henry Kater," *Centaurus* 11 (1965), 152–89.

[51] On standards in this period, see Julian Hoppit, "Reforming Britain's Weights and Measures, 1660–1824," *English Historical Review* 108 (1993), 82–104; Aashish Velkar, *Markets and Measurements in Nineteenth-Century Britain* (Cambridge: Cambridge University Press, 2012).

demands for precision in music should be understood as part of this broader conversation. He lambasted the diverse, variable standards current in England as typifying "an absolute disregard of scientific, or … rational principles."[52] Seeking more scientific alternatives, Gregory rejected the French idea carried through by Jean-Baptiste Delambre and Pierre Mechain that a "natural" standard of length might be based on a fraction of the length of a degree of a meridian in a given latitude, the basis of the meter, since the measurement of the meridian arc must be liable to error. Instead, he proposed the standard should be sought "from the length of a pendulum that shall vibrate in a given interval, in a given latitude."[53] Proposing the use of cylindrical pendulums to increase accuracy, he recommended the production of a standard foot agreeing with the scale made by Bird for the Trigonometrical Survey run by General William Roy. To be rational, the standard foot should be divided into ten, not twelve, inches. Rods should be made to bear the standard, and here Gregory again brought together music and precision measurement. To adjust the length of the rods, Gregory proposed the use of a "micrometer screw, such as is described in Lord Stanhope's account of his monochord."[54] The politician and inventor Charles Stanhope had designed the monochord for tuning musical instruments in 1805 to demonstrate "the beating that arises when sounds made by two

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[52] Olinthus Gregory, "Weights and Measures," *British Review and London Critical Journal* 9 (1817), 159–83, here 160.

[53] Ibid., 167.

[54] Ibid., 177.

strings are not exactly in unison."[55] A micrometer screw with fifty threads to an inch could be used to adjust the length of these strings, a level of accuracy that Gregory now applied to his standard measure. Musical and scientific precision thus served one another in Gregory's work, in which the pendulum replaced tradition and experience as the guide for standards of measurement and standards of music.[56]

A third set of experiments by Gregory demonstrates further the nature of these links between mathematics, music, and the military. In October 1823 Gregory reported on a series of experiments at Woolwich to determine the velocity of sound.[57] This had been estimated many times before, but Gregory argued that previous measures were imprecise and failed to take account of a number of variables—to which he would attend. These included temperature, air pressure, humidity, and wind speed. At Woolwich, Gregory thus set out to measure the velocity of sound in relation to temperature and wind speed, and to consider whether direct or reflected sounds traveled at different speeds. His experiments depended on military expertise and labor. He first had muskets fired near the Royal Artillery Barracks and timed the interval between the flash

[55] Michael Kassler, "Stanhope's Novel Musical Instruments," in *The Music Trade in Georgian England*, ed. Kassler (Farnham: Ashgate, 2011), pp. 433–50, here 440.

[56] On the broader context of developing British standards, see A.D.C. Simpson, "The Pendulum as the British Length Standard: A Nineteenth-Century Legal Aberration," in *Making Instruments Count*, ed. R.G.W. Anderson, J.A. Bennett, and W.F. Ryan (Aldershot: Variorum, 1993), pp. 174–90.

[57] Olinthus Gregory, "An Account of some Experiments made in order to determine Velocity with which Sound in transmitted in the Atmosphere," *Transactions of the Cambridge Philosophical Society* 2 (1827), 119–38, here 133.

and the report from a location on the Arsenal's mortar range, some distance away. Subsequent experiments used six-pounder cannon fired on Shooter's Hill with the permission of Royal Artillery Garrison Commandant General Ramsey. Observing stations were set up at Charlton, Blackheath, and Eltham. The flash of the guns was observed with a theodolite telescope, and the sergeant-major who fired the guns was ordered to use a watch to time firings every two minutes. From these and other experiments made around the Woolwich area, Gregory concluded that the velocity of sound was 1100 feet per second at 33 degrees Fahrenheit, the freezing point of water, and that it increased and decreased by a regular proportion as the temperature of the air changed. He also argued that wind affected the intensity and velocity of sound. Since direct and reflected sound traveled with equal velocity, he further concluded that echoes might be reliably used to measure distances.

Consequences and resistance

Gregory's work exemplified a scientific approach to music, which had shifted from sociable concert-going and an emotive appreciation of experience and tradition to a "rational" science of sound based on mathematics, measurement, and discipline. The shift reflected a changing economy and a growing emphasis on disciplinary culture in the military, for which martial music, regulated by a more scientific chronometry, was an important resource. But if the intentions of mathematical reformers were to underwrite new regimes of standards, epistemic, economic, and military practices, their efforts were not without resistance.

Historians have long highlighted the tremendous social unrest and labor activism that grew up in opposition to new calculating regimes in the early nineteenth century. Contra Foucault, Michel de Certeau called attention to practices such as wandering in the streets: “tricky and stubborn procedures that elude discipline,” they did not necessarily have any purpose or agency and were thus disruptive of disciplined action.[58] The mathematical reformers, men such as Babbage and Gregory, also faced resistance to their practices, and music played a role here, even while it offered them resources. Babbage would famously decry the nuisance of street music in his autobiography published in the 1860s.[59] Indeed, Babbage waged a campaign, joined by many, to banish or at least control the musicians, often foreigners, playing barrel organs and other instruments on the streets of London. These he claimed disrupted the intellectual labors of men of science and scholarship such as himself.

Babbage applied exactly the principles of the “calculating eye” to the problem of street music. He worked out the number of different “instruments of torture” used to make noise in London streets, and the number of “encouragers of street music,” and then how much intellectual labor had been lost from their interruptions, comparing the sum total to income tax:

[58] Michel de Certeau, *The Practice of Everyday Life* (Berkeley, CA: University of California Press, 2011), p. 96.

[59] See, for example, John M. Picker, *Victorian Soundscapes* (Oxford: Oxford University Press, 2003), pp. 41–81.

> On a careful retrospect of the last dozen years of my life, I have arrived at the conclusion that … one-fourth part of my working power has been destroyed by the nuisance against which I have protested. Twenty-five per cent is rather too large an additional income-tax upon the brain of the intellectual workers of this country, to be levied by permission of the Government, and squandered upon its most worthless classes.[60]

He next explored the irritation caused by street music in much the same abstracted way as Gregory reduced music to a science of sound. Like Gregory's studies of the velocity of sound, Babbage considered how the noise of street music changed its effect according to varying conditions.

> The effect of a *uniform* and *continuous* sound, in … disturbing intellectual pursuits, is almost insensible…. It is the change from quietness to noise, or from one kind of noise to another, which instantly distracts the attention.… The injurious effect of noisy interruptions … also varies with the nature of the investigations upon which we are engaged. If they are of a kind requiring but a very small amount of intellectual effort … they will be little felt. If, on the other hand, those subjects are of such a character as to require the highest efforts of the thinker, then their examination is interrupted by the slightest change in the surrounding circumstances.[61]

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[60] Babbage, *Passages from the Life of a Philosopher*, p. 345.

[61] Ibid., p. 346.

Babbage concluded that there was a direct proportion between the intellectual effort involved in a task and the degree of painful effect produced: even the "least intellectual" mind would still suffer if it were stretching to perform some task.

Babbage's campaign is well known, but it would be wrong to think of it purely in terms of discipline and resistance. After all, the very idea of resistance—in this case to activities and events that disrupted the progress of what was thought to be a rational process—was a product of disputes such as these, and it cannot simply be used to analyze them. The idea of "resistance" to progress, by analogy with physical processes, emerged at just this time. To take a famous military example, the Prussian Carl von Clausewitz spoke in 1832 of "friction" on the battlefield, caused when unexpected events and difficulties slowed and disturbed offensive strategies as they unfolded.[62] Babbage expressed a similar idea in the intellectual realm, describing street music as a disruption to the scholar's attention and thinking that was best expressed in terms of the time, money, and productive output that was lost as a result. What he did not discuss were the emotions that street music aroused—which were arguably more pertinent to an explanation of the detrimental effects of music on "the calculating eye."

For reformers such as Babbage, the legitimacy of the enterprise depended on its lack of emotion, a lack that underwrote the credit and authority of mathematics and standards. A science divested of the personal and emotional would come to be associated with objectivity, another new

[62] Carl von Clausewitz, *On War*, eds. and trans., Michael Howard and Peter Paret (Princeton: Princeton University Press, 1989).

notion of this period.[63] Yet street music evoked precisely those passionate emotions in the men of science. Already in 1825 an article in the *Literary Chronicle* lamented the insufferable noise of the city, with its street-criers, fire-engines, coaches, and porters. The article complained particularly of street musicians:

> since London abounds with men who must *think*, and women who must *feel*, we must confess that it … strikes us as a very serious evil, that the … sounds of our mighty metropolis should be swollen into such discordant chorus … by the innumerable performers on barrel-organs, dulcimers, Pandean-pipes, &c. which … pour all the miseries of their melodies … upon the … wretched inhabitants of those regions.[64]

Gregory, Babbage, and the mathematical reformers' desire that music be reduced to its science, freed from "ravishing" emotions, was scuppered by the nuisance of street music. The author went on to single out the intellectual activities, particularly mathematics, that were ruined by the noise.

> All conversation is forbidden, all power of thought destroyed.… We are well acquainted with a mathematician who removed lately out of an open street into a court, for the sole purpose of avoiding this species of

[63] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone, 2007).

[64] "B.," "Street Music," *The Literary Chronicle* (14 May 1825), 315–16, here 315.

> interruption to his studies, but, to his great horror, on the second day of his abode there, found a harp-player.[65]

Misery and horror characterized the experience of the mathematician subjected to street music, and this might be its real danger to the men of science, provoking emotional reactions that threatened the whole enterprise of the calculating eye. Hence perhaps the strange, strenuous effort to deny that men had any emotions at all, "London abounds with men who must *think*, and women who must *feel.*" And hence the reduction of music from a passionate experience to an emotionless accountancy.

Conclusion

Gregory's experiments and Babbage's anger belonged to a period when men of science increasingly claimed jurisdiction over practices they sought to represent as unthinking labors in need of intellectual oversight. People who practiced crafts or who depended on intelligent skill and experience to make a living would, they believed, have to decide between opposing this turn to "rational principles" and embracing it. This is why Gregory's experiments on the velocity of sound were presented in the *Harmonicon* as a subject "highly interesting to really scientific musicians."[66] A Lecturer in natural philosophy at Guy's Hospital, William Mullinger Higgins, insisted in his book *The Philosophy of Sound and History of Music* that musicians needed education in Gregory's

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[65] Ibid., 315.

[66] "On the Velocity of Sound," *The Harmonicon, A Journal of Music* (25 January 1825), 3.

experiments because, “a knowledge of music should be based upon its philosophical principles.”[67]

The rise of a division of labor between those who reasoned and those who practiced is normally said to reflect the changing economy of machines and manufactures in the early nineteenth century, while the style of science of the reforming members of the Royal Astronomical Society has been linked to business and accounting practices of the era. This article has argued that the military provided an equally important context for the rise in values of precision, calculation, and discipline, and the application of rational principles. The ideal soldier should be a machine, moving to the beat of a drum regulated by a pendulum. Music played a role in regulating this machine and became an integral part of British regimental life. Disciplinary culture was also manifest in the sciences of this period, as reformers developed an alternative to the old Banksian natural historical style of science by creating a mathematical physics founded on accurate measurement and precision instrumentation. Figures such as Olinthus Gregory marked a new way of bringing science, music, and the military together. Gregory sought to apply mathematical calculation to music and the sciences. The pendulum constituted an instrument that joined together music, science, and the military, offering a means to regulate motion and observation in astronomy, surveying, the standardization of weights and measures, and music; and as a means to regulate marching bands and tempo in musical notation. All these projects converged on Woolwich Arsenal, an experimental space where new scientific

[67] William Mullinger Higgins, *The Philosophy of Sound and History of Music* (London: W.S. Orr and co., 1838), pp. 1–2.

and musical regimes emerged. Music was a resource for the exact science promoted at the Arsenal, but it could also threaten it. The "calculating eye" secured authority by presenting science as objective, freed of emotions, but the insistence that men of science were society's exclusive thinkers was ruined by infuriating street musicians and the torturous blasts of bagpipes and hurdy-gurdies. Ultimately, as any Royal Artillery bandmaster knew very well, music's ability to evoke emotions was powerful indeed.