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September 21, 1992

JRME 1993, VOLUME 41, NUMBER 4, PAGES 315–327

Carl E. Seashore's tests of musical aptitude, originally published in 1919, were a logical outgrowth of first, centuries of research and thinking on sensory discrimination and specification, and second, applications to psychological research of Charles Darwin's theory of evolution. These two fields came together when English anthropologist Francis Galton (1822–1911) devised tests of sensory perception to test individual mental capacity in the 1870s and 1880s. Galton, who modeled his tests on those devised previously by physicists, included measures of musical perception in his test batteries. He believed that individual differences are quantifiable and that discrete measures of sensory acuity, including musical discrimination, would provide at least an indirect measure of intelligence. Galton influenced American psychologist James Cattell (1860–1944), who in turn influenced Seashore. Because Seashore, like all experimental psychologists of his day, was a sensory psychologist, he produced tests that were criticized from the beginning for being sensory and atomistic. Nevertheless, Seashore's work fired the imaginations and profoundly influenced the work of the first generation of American music education researchers.

Jere T. Humphreys

Precursors of Musical Aptitude Testing: From the Greeks through the Work of Francis Galton

The name usually associated with early musical aptitude testing is Carl Emil Seashore (1866–1949), whose research beginning just before the turn of the twentieth century resulted in the world's first standardized tests of musical aptitude, published in 1919.[1] The most influential music psychologist of his era, Seashore inspired an intense interest in music education research and musical aptitude testing among music education researchers beginning in the 1920s. These facts are recognized by modern music educators, but heretofore, the antecedents of Seashore's prolific, influential research efforts have not been documented.

Seashore's pioneering efforts did not occur in isolation; on the contrary, he built upon the work of a long line of philosophers, physicists, and psychologists with similar goals, beliefs, and methods. This article describes the most important of those antecedents, beginning with early speculation about sensory perception, continuing through the influence of sensory physiology, atomistic chemistry, and

[1] For copies of this article, contact Jere T. Humphreys, School of Music, Arizona State University, Tempe, AZ 85287-0405.

evolutionary theory, and ending with Francis Galton's use in the late nineteenth century of musical discrimination tests to measure individual mental capacity. Seashore's tests have been criticized for being sensory and atomistic; this article demonstrates that, given the heritage on which Seashore built, they hardly could have been otherwise.

Sensation

The first person known to have been interested in sensation was the Greek philosopher Heraclitus (ca. 540 – ca. 475 B.C.), who postulated that thought is derived from the senses. He was followed by Alcmaeon of Croton (ca. 500 B.C. – ?), who developed theories of vision, hearing, smell, and taste, and speculated about the relationship of these senses to the brain. Next came the first person known to have dealt with perception as distinguished from sensation, Empedocies of Akragas (ca. 490 – ca. 430 B.C.), who speculated that sense organs are affected by emanations given off by the perceived objects. Building on Empedocies's work, Democritus (ca. 470 – ca. 370 B.C.) wrote that atoms of the body come into contact with atoms outside the body, resulting in both sensation and perception. Democritus was also probably the first to speculate about the important phenomenon of sensory thresholds.[2]

The next person of note to study sensation and perception was the Greek philosopher Aristotle (384–323 B.C.). Once a devotee of Plato's (428 or 427/348 or 347 B.C.) mode of introspective thinking, Aristotle gradually came to recognize the importance of empirical observation to scientific inquiry. He then proceeded to give direction to his empiricism by identifying the five human senses: vision, audition, smell, taste, and touch. Unlike Plato, who distrusted sensory perception as a means for discovering higher truths, Aristotle believed that knowledge is acquired through the senses, after which it is received by the brain through a part of the human psyche—the faculty of intelligence. Furthermore, he believed that "art is an intellectual activity [that] constitutes one stage in the evolution of thought from sensory perception to wisdom."[3] Aristotle's views about empiricism and sensory perception—including relationships between sensation, perception, and thought—have constituted the mainstream of the field of psychology ever since his time.[4]

From the Greek period through the end of the nineteenth century, much of the history of psychology can be traced through the search for increasingly specific information about the psychological senses. Boethius (ca. 480 – 524 A.D.), in his enormously influential *De Institutione Musica* (The Principles of Music), questioned "the exact nature of [the] senses," as well as "the actual property of ... objects sensed." He concluded that "the answers to these questions are not so obvious." He went on to state that

> sight is present in all mortals. But whether we see by images coming to the eye or by rays sent out from the eye to the object seen, this problem is in doubt to the learned, although the common man is not conscious of doubt. ... The same thing can be said of the other senses, especially concerning aural perception.[5]

Boethius may have been the first to advocate scientific study of musical perception:

> The power of the mind ought to be directed toward fully understanding by knowledge what is inherent in us through nature. Thus just as erudite scholars are not satisfied by merely seeing colors and forms without also investigating their properties, so musicians should not be satisfied by merely finding pleasure in music without knowing by what musical proportions these sounds are put together.[6]

After the Middle Ages, during which little progress was made in this field, came the Renaissance and its great enthusiasm for studying natural and human phenomena. John Locke (1632–1704) led the way in sensory research by differentiating between primary and secondary qualities of sensation.[7] He was followed by Isaac Newton (1642–1727), who divided the spectrum into colors,[8] and Charles Bell (1774–1842), François Magendie (1783–1855), and Johannes Peter Müller (1801–1858), all of whom studied relationships between nerves and sensation.[9] Other important research was done on touch by Ernst Heinrich Weber (1795–1878) and Maximillan Ruppert Franz von Frey (1852–1932), and on vision and audition by Hermann Ludwig Ferdinand von Helmholtz (1821–1894).[10] In addition to these and other sensory specification studies came attempts to measure sensation and perception. Among the most important early measurement studies were by Pierre Bouguer (1698–1758), who studied perception of lights of different intensities.[11]

Studies designed to measure musical perception occurred relatively early. One of the most important early musical studies was by Charles Eduard Joseph Delezenne (1776–1866), who in 1827 measured the least discernable differences in musical pitch by musically trained and untrained subjects.[12] Other studies of musical perception were conducted by physicists on musical consonance as early as 1799, on timbre by 1830, and on upper and lower thresholds of the hearing of tones as early as 1831.[13]

Sensory measurement took a giant leap forward in 1834, when Ernst Weber identified what appeared to be a scientific, naturally occurring law on which such measurements could be based. He proposed that the "just noticeable difference" between stimuli that vary—weights, sights, sounds, and the like—occurs in constant ratio to the magnitude of the stimuli being compared, and that the size of the smallest perceivable difference between stimuli is determined in part by the original intensities of the stimuli, not just by the absolute difference between them. Weber's theory drew little attention until Gustav Theodor Fechner (1801–1887) elaborated on it in 1860, developing a complicated formula for determining relationships between stimuli and sensations. Fechner dubbed the principle "Weber's law."[14]

Although Weber's law was the source of considerable controversy in psychology and was later found not always applicable, it provided a strong impetus for the fusion of philosophical speculation and physiological research on sensation in the middle of the nineteenth century. The result was the emergence and growth of the related fields of experimental psychology and psychophysics.[15] For the remainder of the century, experimental research on sensory perception, including musical perception, constituted the mainstream of psychology.

The Theory of Evolution

At about the time Weber's law gave physicists a theoretical basis for measuring sensory perception, another theory changed the course of psychology even more radically: In 1859, Charles Robert Darwin (1809–1882) published a theory of evolution in his work *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*.[16] Darwin suggested that variations between individual members of a given species function within the evolutionary process to isolate certain "optimal configurations" by which a given species

can be perpetuated. In short, the theories of natural selection, survival of the fittest, and evolution are based in part upon the premise that individuals differ from each other.[17]

Before Darwin's theory was published, scientists had searched not for individual differences, but for natural laws that govern all living things. Physicists like Delezenne, Weber, Fechner, and Helmholtz, and other scientists like Wilhelm Wundt (1832–1920), the most influential psychologist of the nineteenth century, did not think in terms of variations in human attributes and capabilities. Rather, they sought to identify and quantify aspects of the body and behavior common to people in general.

After Darwin, a new type of investigator appeared, scientists who based their research on the theory of evolution. They, too, sought to quantify body part sizes and certain aspects of human behavior, but, unlike the traditionalists, those influenced by evolutionary theory attempted to identify differences between people rather than commonalities among them. They reasoned that the concept of variation within a given species implies quantity for everything governed by the natural selection process. They reasoned further that anything with quantity is susceptible to measurement. Accordingly, they, like their colleagues who continued to search for natural laws governing commonalities, began to measure height, weight, arm length, head size, and other parts of the human anatomy.

Francis Galton's Mental Testing Research

After physical measurement came attempts to measure simple behavioral and psychical differences, and it was at this stage that musical perception testing took the turn that eventually led to musical aptitude testing. The first person to apply Darwin's principles to the study of human characteristics other than relatively straightforward physical dimensions was Darwin's half cousin, English anthropologist Francis Galton (1822–1911).[18] It was he who first experimented with testing mental ability.[19]

Galton was an innovator, but he did hold certain conventional beliefs, one of which was in the veracity of faculty psychology, the leading nineteenth-century psychological theory. Faculty psychologists believed that the mind is composed of separate compartments, or faculties, each of which operates more or less independently.[20] The sensory faculties were thought to correspond roughly to specific faculties of the brain.

Another influence on Galton came from the field of atomistic chemistry, a field then enjoying considerable success and prestige due to the recent discovery of chemical elements. With Wilhelm Wundt leading the way, "elementalism" became the watchword of psychology, as he, Galton, and others began to search for and measure specific elements of consciousness. Given the centrality of sensation in the history of psychological thinking up to that time, as well as the dominance of faculty psychology, it is not surprising that Wundt and Galton turned first to the psychological senses, which to them constituted the elements of the mind.[21]

Still another view of Galton's, this one dating back to Aristotle, was that all knowledge is obtained through the five senses. Galton began to deviate from conventionalism, however, when he hypothesized that a measure of sensory acuity would provide a crude measure of a person's level of intelligence. This erroneous belief, which for a time was held widely, was one of the fundamental premises that helped launch the mental testing movement.

Finally, Galton made an even larger leap when he hypothesized that mental ability is normally, or randomly, distributed within a given population. Galton's inspiration for this hypothesis came from the work of Belgian astronomer, mathematician, and statistician Adolphe Quetelét (1796–1874), who had calculated earlier in the century that the measurements of certain body parts and other phenomena form normal distribution curves.[22] Because the theory of evolution assumes random, or chance, selection, and because it was becoming clear by then that at least some physical characteristics are normally distributed, Galton assumed that mental phenomena are distributed normally as well:

> There is no bodily or mental attribute ... which cannot be ... consolidated into an ogive [distribution curve] with a smooth outline, and thenceforward be treated in discussion as a single object.[23]

Later, he wrote that he had

> applied this same law [normal distribution curve representing height] to mental faculties, working it backwards in order to obtain a scale of ability.[24]

For all these reasons, when Galton set out to study mental ability by measuring individual differences in psychological functions, he devised a series of tests designed to measure sensory discrimination ability, which he believed would prove to be distributed normally. Others were already studying sensory discrimination, principally German physicists led by Helmholtz and German psychologists led by Wundt, but Galton's tests differed from those of the German investigators in that they were designed to identify differences between individuals rather than traits common to all people. Furthermore, Galton's tests, unlike the German tests, were designed to be administered quickly and easily to large numbers of people. The main difference between the Galton and German tests, however, was the purpose for which they were to be used: Galton contended that tests of sensory discrimination would be "indicative of judgment and thus of intelligence,"[25] two traits that he believed varied considerably among individuals.

Galton's concept of variation in mental ability differed radically from the prevailing view of human mental ability. Wundt, for example, believed that deviations from the average result from error—not measurement error but human error, representing deficiencies in the deviating individuals. Wundt and others therefore tended to dismiss variations between individuals. Conversely, Galton sought to identify and measure individual differences, which he considered to be naturally occurring phenomena.

To determine differences in mental ability, Galton sought to " 'sample' a man with reasonable completeness," to "measure *absolutely* where ... possible, otherwise *relatively* ..., the quality of each selected faculty" [emphasis in original]. The next step was to

> estimate the combined effect of these separately measured faculties in any given proportion, and ultimately to ascertain the degree with which the measurement of sample faculties in youth justifies a prophecy of future success in life....[26]

Galton, who previously had studied instances of genius within families, was convinced as early as 1865 of the

> pressing necessity of obtaining a multitude of exact measurements relating to every measurable faculty of body or mind, for two generations at least, on which to theorize.[27]

After 1869, when he outlined his basic tenets on human genius and its tendency to run in families in his first book, *Hereditary Genius: An Inquiry into Its Laws and Consequences*, Galton began to conduct experiments on human variability. He was beginning to conclude by then that his anthropometric research was superficial and provided little information about the mind, his real interest. For that reason, he turned increasingly to psychometrics, or mental measurement.[28]

One of his first attempts at psychometrics came in the 1870s, when he asked a number of elementary and secondary schools to make certain measurements of their students.[29] When this effort failed, he began to conduct some crude experiments on his own.

Galton's Musical Discrimination Research

Studies of musical discrimination were among Galton's first psychometric experiments. As early as 1876, he worked on a brass whistle (the "Galton whistle") capable of producing variable pitches, which he used to test the perception of upper limits of pitches by different people and animals.[30] Among his findings were that there is "a remarkable falling off in the power of hearing high notes as age advanced," and that cats are superior to most other animals in high-frequency pitch perception. His attempts to measure the hearing of insects failed.[31] Galton was not the first to make those kinds of measurements relating to music, but he seems to have been the first to use them specifically to identify differences in ability between individuals.

In 1882, Galton wrote an article in which he recommended the establishment of anthropometric laboratories, partly to conduct intelligence testing. In this famous article, the first publication ever to suggest intelligence testing in anything like its modern form, Galton advocated the testing of sensory discrimination ability, among other things. He acknowledged the vast body of extant research on sensory discrimination, but said that "the work remaining to be done is to select out of extant instruments those that are sufficiently inexpensive and quick in manipulation to be appropriately placed in an anthropometric laboratory...."[32] Within the realm of sensory discrimination, Galton specified in this article only "the more important measurements": those of sight, sound, touch, and muscular sense. For sound, he suggested measuring "keenness" of hearing, "the appreciation of different grades of loudness," and the perception of "different notes."[33]

One year after the publication of this article, Galton published his landmark book, *Inquiries into Human Faculty and Development*, now regarded by some historians of psychology as the beginning of both the scientific study of individual psychology and of mental testing.[34] In this book, Galton described his experiments on human variability conducted during the previous fourteen years, since the publication of his *Heredity Genius* in 1869. Among the experiments described were those on musical discrimination.

Galton believed he was measuring intellectual ability, at least indirectly, with his pitch perception and other sensory tests:

> The only information that reaches us concerning outward events appears to pass through the avenue of our senses, and the more perceptive the senses are of difference, the larger is the field upon which judgment and intelligence can act.[35]

He also noted that "the discriminative faculty of idiots is curiously low," and that

> the trials I have as yet made on the sensitivity of different persons confirms the reasonable expectation that it would on the whole be highest among the intellectually ablest....[36]

As for music, he speculated, after mentioning the principle of just noticeable differences, that although people might possess equal ability to hear very loud and very soft sounds, "they may differ as to the number of intermediate grades of sensation." He suggested that musicians do not necessarily have more ability than others to hear loud and soft sounds, but he implied that they should be able to discriminate more finely within their ranges.[37]

The year after Galton's *Inquiries* was published, he established an anthropometric laboratory as part of the International Health Exhibition that opened in London in 1884. At this laboratory Galton and his associates measured exhibition attendees, charging them a "threepenny fee" for the privilege. When the health exhibition closed in 1885, he moved his laboratory into the Science Galleries at the South Kensington Museum in London.[38] Altogether, Galton made seventeen measurements on each of 9,337 people, who ranged in age from five to eighty years.[39]

Probably the most important result of Galton's anthropometric laboratory was his development of the rudiments of statistical correlation, which he devised to determine the "relation between two variables partly dependent on a common set of influences."[40] In addition to that significant accomplishment, Galton published some of the data collected at his anthropometric laboratory, including results of his tests of strength of pull, standing and sitting height, arm span, weight, breathing capacity, strength of squeeze, swiftness of blow, and keenness of sight.[41] He was able to make only one generalization about human variability from the data, and that was an incorrect one: that women are inferior to men in sensory ability (except for the sense of touch), as well as in the nonsensory abilities measured. He attributed these discrepancies to differences in inherited abilities.[42]

Galton's musical discrimination measurements included those of keenness of hearing and highest audible pitch. The only published information on the results of these measurements concerns the perception of highest audible tones. The tones were produced by a set of five whistles ranging in pitch from 10,000 to 50,000 cycles per second (Hz). Galton's table of results includes data from males age twenty-three to twenty-six years (n = 206) and forty to fifty years (n = 317), and females age twenty-three to twenty-six years (n = 176) and forty to fifty years (n = 284). Males surpassed females in the ability to hear high notes in both age categories. (Virtually all subjects could hear the 10,000-Hz tone.) Galton barely refrained from declaring his data normally distributed:

> The results fall into a very fair curve; however, it would be hardly justifiable to give percentiles, because the values on which the curve is based are wide apart [20, 30, 40, and 50 thousand Hz]. I therefore limit myself to giving a table of percentages for the convenience of comparison.[43]

It is clear that Galton thought of his musical discrimination tests in relation to mental aptitude and not musical aptitude per se. He may have been the first, however, to propose the need for musical aptitude tests:

> It is perfectly conceivable that the Artistic Faculty in any person might be somehow measured, and its amount determined, just as we may measure Strength, the power of Discrimination of Tints, or the tenacity of Memory.... It is reasonable to expect that the Scheme [distribution] of the Artistic Faculty would be approximately Normal in its proportions, ... [and] that the same law of inheritance might hold good in the Artistic Faculty that was found to hold good both in Stature and in Eye colour.[44]

Although Galton did not experiment with sensory perception in music in relation to musical aptitude, he attempted to deal with aptitude indirectly.[45] In the early 1880s, he offered prizes to families for providing him with family records, which he compiled into a collection titled "Records of Family Faculties." To compile data on the artistic faculty, one of the many faculties he studied, he simply asked adult subjects from some 150 families whether they considered themselves artistic. He defined artistic persons as those "especially fond of music and drawing," but he conceded that his list of artistic persons "no doubt includes many who are artistic in a very moderate degree."[46]

Galton found, among 894 subjects, that 28 percent were artistic males and 33 percent were artistic females, a difference he attributed not to heredity, as he did with sex differences in sensory discrimination, but to the inclusion of more music and drawing in girls' education. He did admit that although men and women probably "differ little in their artistic capacity, ... such difference as there is in adult life is somewhat in favour of women."[47]

Conclusions

The most important discoveries and insights leading to Carl Seashore's early attempts to measure musical aptitude were the centuries of speculation and research on sensory perception and Darwin's theory of evolution, both of which led to Francis Galton's pioneering work in mental testing. Galton's work was especially influential on later music testing. His concept of individual differences, his strong belief in inherited abilities, and his discovery of statistical regression and correlation all became cornerstones of the mental testing movement from which Seashore drew his inspiration and methods. Galton built on centuries of speculation and research on sensory perception, applied Weber's law, used the new techniques of experimental psychology, adapted new discoveries in chemistry, and, most important, fused all these things with the theory of evolution to identify individual differences and develop tests to examine these differences. In music, he speculated about and gathered data on aptitude, measured individual sensory perception, and suggested the feasibility of measuring musical aptitude directly. Galton's methods of measuring both mental and artistic ability were crude, and he was mistaken about many things, but, for better or worse, one segment of the mental testing movement followed his course for many years.

In the 1890s, when Galton turned his attention to other matters, the United States became dominant in the mental testing movement. The movement was led by James McKeen Cattell (1860–1944), who had studied with Galton in the 1880s. Cattell continued Galton's work, including experiments on musical discrimination, coined the term "mental test," and for a generation led the American mental testing movement of which Seashore and other important American psychologists were part. Under Cattell's leadership, the mental testing movement soon came to have powerful political, social, and educational implications, especially in the United States.

Fewer than ten years after Galton closed his anthropometric laboratory in London, Seashore began laboratory experiments that led to the publication of his tests of musical aptitude. It is no wonder that Seashore's work strongly reflects the centuries of psychological research on sensation, one of the "three great topics" that led to modern scientific psychology.[48] Because the two other "great topics" were learning and motivation, neither of which became popular until after the turn of the century, Seashore, like all experimental psychologists trained in the nineteenth century, was a sensory psychologist. It is also not surprising that Seashore was influenced strongly by Francis Galton, the scientific genius who founded mental testing only a short time before Seashore began work on his tests of musical aptitude, tests that fired the imaginations of the first full generation of American music education researchers.[49]

NOTES

1. Carl E. Seashore, Don Lewis, and Joseph G. Saetveit, *Seashore Measures of Musical Talents* (New York: The Psychological Corporation, 1919).
2. Zusne, *Names in the History of Psychology: A Biographical Sourcebook* (Washington, DC: Hemisphere Publishing Co., 1975), 1–4.
3. Michael L. Mark, *Source Readings in Music Education History* (New York: Schirmer Books, 1982), 35.
4. Zusne, *Names*, 7–8; and Renford Bambrough, *The Philosophy of Aristotle* (New York: The New American Library, 1963), 230.
5. Boethius (Anicius Manilus Torquatus Severinus), *De Institutione Musica*, Book I; excerpts quoted in Mark, *Source Readings*, 64.
6. *Ibid.*, 68.
7. John Locke, *An Essay Concerning Humane Understanding: In Four Book* (London, 1690), Book II, Chapter 8; excerpts quoted in Richard J. Herrnstein and Edwin G. Boring, eds. *A Source Book in the History of Psychology* (Cambridge, MA: Harvard University Press, 1965), 14–17. For more information on the history of sensory specification and measurement see *ibid.*, 1–88.
8. Isaac Newton, two-part paper delivered to the Royal Society of London on December 9 and 16, 1675; published in Thomas Birch, *History of the Royal Society of London* (London, 1757), III, 262–63; excerpts quoted in Herrnstein and Boring, *Source Book*, 7–8.
9. Charles Bell, *Idea of a New Anatomy of the Brain: Submitted for the Observation of His Friends* (London: Privately printed, 1811), 21–24, 28–29, 34–37; François Magendie, "Expériences sur les fonctions des racines des nerfs rachidiens," *Journal de Physiologie Expérimentale et Pathologique* 2 (1822): 276–79, and "Expériences sur les fonctions des racines des nerfs qui naissent de la moëlle épinière," *ibid.*, 366–71; and Johannes Müller, *Handbuch der Physiologie des Menschen*, Book V (Coblenz, 1838), Introduction; excerpts quoted in Herrnstein and Boring, *Source Book*, 17–33.
10. E. H. Weber, "Der Tastsinn und das Gemeingefühl," in Rudolph Wagner, ed. *Handwürterbuch der Physiologie* (Brunswick, 1846), vol. III, part 2, 481–588; Max von Frey, *Vorlesungen über Physiologie* (Berlin: Springer, 1904), 308-26; H. L. F. von Helmholtz, *Die Lehre von den Tonempfindungen* (Brunswick, 1863); and H. L. F. von Helmholtz, *Handbuch der Physiologischen Optik*, vol. II (Leipzig, 1860); excerpts quoted in Herrnstein and Boring, *Source Book*, 34–58.
11. Pierre Bouguer, *Traité d'Optique sur la Gradation de la Lumière*, Book I (Paris, 1760); excerpts quoted in Herrnstein and Boring, *Source Book*, 60–62.
12. C. E. J. Delezenne, "Sur les valeurs numériques des notes de la gamme," *Recueil des Travaux de la Société des Sciences, de l'Agriculture et des Arts de Lille (1827): 4–6;* excerpts quoted in Herrnstein and Boring, 61–64. Perhaps the first study on pitch perception thresholds was conducted in 1700: Joseph Sauveur, "Des intervales des sons, et son appli-

cation à tous les systèmes et à tous les instruments de musique," *Hist. Acad. Sci. Paris* (1701): 299–366; cited in Edwin G. Boring, *Sensation and Perception in the History of Experimental Psychology* (New York: Appleton-Century-Crofts, Inc., 1942), 339.

13. Ernst Florens Friedrich Chladni, "Ueber die wahre Ursache des Consonirens und Dissonirens," *Allgemeine musikalische Zeitung* (1800/1801): 337, 353; and R. Willis, "On the Vowel Sounds, and on Reed Organ-Pipes," *Cambridge Philosophical Society 3* (1830): 231–68; cited in David Medford Butler, "An Historical Investigation and Bibliography of Nineteenth Century Music Psychology Literature," vol. I (Ph.D. diss., Ohio State University, 1973), 62, 65. F. Savart, "Sur la perception des sons graves," *Annales de Chimie et de Physique* 47 (1831): 69–74; cited in Boring, *Sensation and Perception*, 333.
14. Herrnstein and Boring, *Source Book*, 64–75.
15. *Ibid.*, 60; and Edwin G. Boring, *A History of Experimental Psychology*. 2nd ed. (New York: Appleton Century-Crofts, 1950), 158.
16. Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (London: Dent, 1859).
17. Herbert Spencer, not Darwin, coined the term "survival of the fittest," although it is compatible with the latter's theory; likewise, Darwin's was by no means the first theory of evolution, only the first reasonably coherent and documented one.
18. German biologist August Welsmann (1834–1914) and Austrian monk Gregor Mendel (1822–1884) were Galton's Darwinian counterparts in the worlds of animal and plant research, respectively.
19. Achievement testing of various types has an extremely long history, and attempts had been made before Galton's day to identify "mental defectives." Nevertheless, the mental testing (psychometrics) movement in psychology was set in motion by Galton's efforts to test mental aptitude.
20. Jere T. Humphreys, "The Child-Study Movement and Public School Music Education," *Journal of Research in Music Education* 33 (Summer 1985): 80.
21. The influence of the discovery of chemical elements on the emerging field of psychology is represented vividly in a book published in 1896 by the well-known psychologist Edward Titchener (1867–1927), in which he listed the "known" sensory elements, along with blank spaces for those yet undiscovered; Edward Bradford Titchener, *An Outline of Psychology* (New York: Macmillan 1897; reprint of the first edition, 1896), 66–67. Titchener was probably influenced by a table drawn up in 1869 by the Russian chemist Dmitri Mendelyeev (1834–1907), which included a list of all known chemical elements, along with gaps from which the existence of other elements was eventually inferred.
22. For more information about Quetelét, see Frank H. Hankins, *Adolphe Quetelét as Statistician* (New York: AMS Press, 1968; reprint of the first edition, New York: Columbia University Press, 1908).
23. Francis Galton, *Inquiries into Human Faculty and Development* (London: Macmillan, 1883), 52.
24. Francis Galton, *Hereditary Genius: An Inquiry into Its Laws and Consequences* (London: Julian Friedmann Publishers, 1978; reprint of the 1869 first edition and preface to the 1892 second edition), xi–xii.
25. Boring, *A History*, 487.
26. Franics Galton, *Memories of My Life*, 2nd ed. (London: Methuen & Co., 1908), 267.
27. *Ibid.*, 244.
28. Karl Pearson, *The Life, Letters and Labours of Francis Galton*, vol. II. (Cambridge, England: Cambridge University Press, 1924), 211. Anthropometrics ("man measurements"), the measurement of human physiological features, was one of the immediate forerunners of psychometrics, the measurement of mental abilities and achievement.
29. Galton, *Memories*, 244.

30. Pearson, *The Life*, vol. II, 212.
31. Galton, *Inquiries*, 26, 39–40.
32. Francis Galton, "The Anthropometric Laboratory," *The Fortnightly Review* 31 (March 1882): 336.
33. *Ibid.*
34. Kathryn W. Linden and James D. Linden, *Guidance Monograph Series*, Series III, "Testing." Shelley C. Stone and Bruce Shertzer, eds. (Boston: Houghton Mifflin Co., 1968), 7.
35. Galton, *Inquiries*, 27.
36. *Ibid.*, 28–29.
37. *Ibid.*, 27–28.
38. Galton, *Memories*, 245–47.
39. Francis Galton, "On the Anthropometric Laboratory at the late International Health Exhibition," *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 14 (1885): 206, 213, 216.
40. Galton, *Inquiries*, 27. Galton's discovery of the fundamental principles of statistical regression also contributed heavily to the mental testing movement.
41. Francis Galton, "Tables of Observations," *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 18 (October 1889): 420–30. These tables include statistics for twenty-three- to twenty-six-year-old male subjects only. For more information about Galton's anthropometric laboratory findings, see Francis Galton, "Retrospect of Work Done at My Anthropometric Laboratory at South Kensington," *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 22 (1892): 33.
42. Francis Galton, *Natural Inheritance* (London: Macmillan, 1889), 199–201. Darwin, too, believed in the superiority of male sensory and locomotive abilities; see Charles Darwin, *The Descent of Man and Selection in Relation to Sex*, 2nd ed. (New York: American Publishers Corporation, 1874), 225.
43. Francis Galton, "Some Results of the Anthropometric Laboratory," *The Journal of the Anthropological Institute of Great Britain and Ireland* 14 (1885): 286. Although Galton claimed superiority for males over females on this particular "faculty," chi-square comparisons computed from Galton's data by the present author indicate no statistically significant percentage differences between sexes on any frequency (20, 30, 40, or 50 thousand Hz) for subjects ranging in age from 23–26 or those 40–50 years of age. (The eight χ values with 1 degree of freedom each range from 0.00 to 1.8, all $p \geq .05$).
44. Galton considered musical ability part of the "artistic faculty"; *Inquiries*, 158–59.
45. Typically, nineteenth-century research on musical aptitude, conducted primarily in Germany, dealt not with musical aptitude in the general population, but with abilities of major composers and with relationships between musical ability and various abnormalities; Butler, "An Historical Investigation," 79.
46. Galton, *Natural Inheritance*, 154.
47. *Ibid.*, 156.
48. Herrnstein and Boring, *Source Book*, 1.
49. Jere T. Humphreys, "Applications of Science: The Age of Standardization and Efficiency in Music Education," *The Bulletin of Historical Research in Music Education* 9 (January 1988): 19–21.

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July 2, 1992