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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 physicians, 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

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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, Empedocles of Agragas (ca. 490 – ca. 430 B.C.), who speculated that sense organs are affected by emanations given off by the perceived objects. Building on Empedocles'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 Maximilian 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 Descartes, 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 physical 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 Quetelet (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 therefore would 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 *Hereditary 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 percentages, 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: