counter-stereotypic, interventions that highlight this association can produce a lowering of the default stereotype of female = weak. The possibility of such strategies for inducing a shift in automatic stereotypes and the potential to track stereotypes through both behavioral and brain activation measures has the potential, in the future, to inform about stereotype representation, process, content, and mechanisms for social change.

See also: Mental Representation of Persons, Psychology of; Prejudice in Society; Schemas, Frames, and Scripts in Cognitive Psychology; Schemas, Social Psychology of; Small-group Interaction and Gender; Stigma, Social Psychology of

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M. R. Banaji

Stevens, Stanley Smith (1906–73)

S. Smith Stevens (1906–73) was a leading figure in the field of experimental psychology during the middle part of the twentieth century. He is best known for his work in psychophysics and especially for the development of the psychophysical power law, but he also made important contributions to the study of hearing, and to an understanding of measurement theory and its role in psychology. Aside from his many research reports, his most influential publications include the classic *Hearing: its Psychology and Physiology* (1938) co-authored with Hallowell Davis, the *Handbook of Experimental Psychology* (1951), and *Psychophysics: Introduction to its Perceptual, Neural and Social Prospects* (1975) edited by his wife, Geraldine Stevens.

1. Beginnings

To understand fully the significance of any scientist's contribution, it is important to know the context in which it occurred. It is particularly useful to be acquainted both with the scientists who paved the way and with those who followed. Historians of experimental psychology have traced the beginnings of the field to the German scientist Wilhelm Wundt (1832–1920), who established the first laboratory for psychological research in 1879. Although other scientists had made important contributions to the emerging field, it was Wundt who first identified an entire range of questions in psychology amenable to laboratory investigation, and it was to his laboratory in Leipzig that students from many countries came for training in experimental psychology. Stevens, whose distinguished career culminated in his position as Professor of Psychophysics at Harvard University, stands in a direct line of scholarly descent from Wundt as a member of the fourth generation. He was trained by E. G. Boring (1886–1968) at Harvard, who in turn had studied at Cornell with E. B. Titchener (1867–1927), an Englishman who had received his degree in Leipzig from Wundt in 1892. And whereas Wundt may be considered the first to devote himself to Experimental Psychology, it may well be that Stevens was the last. His work marked and contributed to a transition from one era to another in the evolution of scientific psychology and an understanding of that transition makes an interesting story.

Stevens was born on November 4, 1906 in Ogden, Utah, home to the Mormon Church, and, following the customs of that institution, he departed at the age of 17 to spend 3 years as a missionary in Belgium and later in France despite a complete ignorance of the language. It seems likely that this experience contributed to the development of persistence and determination, traits that were to serve him well in his career as a scientist. On his return he entered the University of Utah and, after two years, transferred to Stanford, where he graduated in 1931 having taken such a wide variety of courses that the identification of a major was problematic. He was accepted by the Harvard Medical School but demurred on the grounds that the required payment of a $50 fee and the need to spend the summer taking a course in organic chemistry seemed equally unattractive. But he did decide to study at Harvard, and duly enrolled in the School of Education as the easiest (and most economical) path to Harvard's resources. The transforming experiences there were E. G. Boring's course on perception and service as Boring's unpaid research assistant. By the end of his second year, Stevens had earned a PhD in the Department of Philosophy (from which the Psychology Department emerged a year later). A year studying physiology under Hallowell Davis and another as a research fellow in physics led to appointment in 1936 as an instructor in the Psychology Department, where he remained until his death on January 18, 1973 in Vail, Colorado. By 1946 he achieved the rank of full professor, and in 1962 the University acceded to his request that he be named Professor of Psychophysics in honor of the field founded a century earlier by G. T. Fechner, whose theories, ironically, Stevens worked hard to refute.

2. *Stevens's Psychophysical Power Law*

Scholars familiar with his work quickly could agree in making a list of Stevens's major achievements, but could and do disagree about their relative importance and their lasting value. For some the single most important accomplishment was his discovery of the psychophysical power law that sometimes does and always should carry his name (Stevens 1957). He not only revived a view broached by some in the nineteenth century, but also created a body of evidence that firmly established what is sometimes called the Psychophysical Power Law and sometimes Stevens's Law. It concerns the relation between the strength of some form of energy, such as the sound pressure level of a tone, and the magnitude of the corresponding sensory experience, loudness in this example. It is easily discovered that sensation strength is nonlinearly related to stimulus intensity (two candles do not make a room seem twice as bright as one), but it is harder to say what that relation is. For over a century before Stevens approached the problem, the prevailing view, Fechner's Law, asserted that, as stimulus strength grew geometrically (by constant ratios), sensation strength increased arithmetically. This logarithmic relation had little supporting evidence but remained in many texts for lack of a good alternative. Stevens came to a different conclusion on the basis of data obtained by asking observers who were presented with stimuli varying in intensity to make numerical judgments of their subjective experience. In the case of loudness he found that judged loudness grew as a power function of sound pressure (with an exponent of about 0.6), not as the logarithmic relation predicted by Fechner (Stevens 1961). A similar relation was found to hold between judged brightness and luminance, and eventually, such a relation was found for dozens of other continua. In each case, as the amount or intensity of a stimulus grew by ratio steps, so too did the observer's estimate of his subjective experience of it. Stevens's Law seemed applicable to all intensive perceptual continua.

Equally interesting was the discovery that for each perceptual continuum, there was a distinctive value of the exponent relating numerical judgment to stimulus intensity. In hearing, for example, a huge range of sound pressures was compressed into a much smaller range of loudness, whereas for electric shock applied to the fingertips, a quite small range of currents between detectability and pain was expanded into a larger range of perceived intensities.

Although Stevens originally argued that the method of magnitude estimation provided a 'direct measure' of sensation (see *Sensation and Perception: Direct Scaling*) and that the power law described how energy in the environment was transformed through the relevant sensory apparatus into sensation, critics soon showed this assumption to be untenable. What remained was an empirical principle relating judgment to stimulus intensity.

Stevens went on to show that numerical magnitude estimation was a special case of a more general paradigm, cross-modal matching. If the observer is asked to match loudness, for example, by manipulating the luminance of a light source until its brightness matches the level of the target loudness, the power relation is again the result. And, neatly enough, the exponent of that function is exactly predictable by the exponents identified through magnitude estimation of brightness and loudness alone (Stevens 1969). It is this ability of observers to match perceived magnitudes across many different perceptual attributes, and the discovery that in all cases the result is described by a power function, that are the two pillars on which Stevens's Law rests. Despite the many controversies over its meaning, this simple empirical principle stands securely on a mountain of evidence and must be accommodated by any theory of psychophysics.

3. *Scales of Measurement*

Others attach greater importance to Stevens's ideas about scales of measurement. In a seminal paper (1946) he created a taxonomy of measurement, which identified four classes of scales—nominal, ordinal, interval, and ratio—distinguishing among them on the basis of the operations that leave the form of the scale invariant. Nominal scales assigned numbers that serve only to distinguish one event or class of events from another (the classic example is the set of numbers used to identify each member of a team); any one-to-one substitution is permissible because player identity is preserved. Ordinal scales of measurement permit a rank ordering of measured events (relative hardness of materials, for example) and will remain invariant under monotonic increasing transformations. Interval scales entail a constant unit of measurement and so permit the calculation of differences between any two values (as for the common scales of temperature) and remain invariant under linear transformations. Ratio scales (the bread and butter of physics) also feature constant units of measurement, but in addition allow the expression of two values as a ratio, since a true zero exists; weight is a good example. Such a scale is invariant under a simple multiplicative transformation.

It is harder to assess the impact of this conceptualization of measurement than that of the work on cross-modal matching judgments. The latter was instrumental in creating new bodies of knowledge, especially in the field of sensory psychology, and continues to play an influential role in psychophysical theory and research. But Stevens's four-step hierarchy of measurement scales encountered an assortment of reactions that leaves its present status in some doubt.

Contemporary theorists find the nominal scale of little interest because it imposes no ordering on the measured entities. And several authorities have noted the omission of a log interval scale from what Stevens had proposed as an exhaustive listing. The relevance of this classification to the selection of statistical procedures was hotly debated (e.g., see Binder 1984). Stevens had argued that the type of measurement placed constraints on which statistics can be used, but statisticians were quick to cite seeming exceptions, and the usefulness of Stevens's measurement taxonomy as a guide to the selection of statistical techniques became uncertain.

But, for psychologists, his ideas about measurement were, and in some ways continue to be, of great importance. At a time when Stevens was trying to provide support for his newly-created scale of loudness, he felt it important to show that it met the same criteria of legitimacy as did the familiar scales of the more developed sciences. It was a time when the status of psychology as a science was a topic of lively debate, and Stevens was much involved in efforts to identify the critical features of science and the ways in which psychology shared them. During the 1940s and 1950s questions about the nature of science and psychology's place in it were discussed at length, and Stevens's analysis of measurement in general and the ways in which psychologists could use scales of measurement was very influential. The idea that a measurement scale—or, for that matter, any lawful relation—could be expressed in terms of the operations that left it invariant, played an important role in the thinking of his students, and no doubt for scientists in other disciplines as well. The work that Stevens began has now evolved into a mathematical specialty in its own right, yielding results that confirm some of what Stevens intuited, and disconfirming other aspects of his work. (It must be remembered that the ideas he was advancing lent themselves to mathematical formalization, though he himself did not provide it.) That his ideas about measurement have continued to be developed and refined by other scientists today may be the ultimate accolade for his pioneering work in this field (e.g., see Luce and Narens 1999).

4. *Hearing*

If Stevens had never established the psychophysical power law and had left the study of measurement untouched, he would still be known and remembered as a pioneer in the field of psychoacoustics, the scientific study of the perception of sound (e.g., see Scharf 1999). His collaboration with Hallowell Davis in the late 1930s resulted in *Hearing*, a book that for many years was the fundamental source on the subject and has been ranked by some scholars as second only to the work of Helmholtz in its originality and breadth. In addition to his measurements of loudness, he did important work on auditory localization, and on the relation of pitch to intensity. At the behest of the US Army Air Corps he established the Psycho-Acoustic Laboratory at Harvard in 1940 to study the effect of noise on pilot psychomotor efficiency. As its director he was able to attract a group of students and colleagues of extraordinary ability, among them W. R. Garner, K. D. Kryter, J. C. R. Licklider, and G. A. Miller, all of whom made important contributions to psychoacoustics and beyond. It was an interesting aspect of his personality that, despite a rather gruff manner, he functioned as an intellectual magnet, attracting to his laboratory some of the most talented researchers in the world. Not the least of these was G. von Békésy, who spent almost 20 years in Stevens' basement lab and won a Nobel Prize during that period for his early work (in Budapest and Stockholm) on the ear.

Throughout his career there were several periods of intense activity as a laboratory scientist. But in the period before World War II he was also active in the discussion of philosophical questions about the nature of psychology. He was impressed by the work of the physicist P. W. Bridgman on the central role of operationism in science, and argued for its use in defining the concepts of psychology. And for a period he was associated closely with a group of logical and methodological positivists whose ideas about the nature of science seemed especially hospitable to a behaviorist psychology (Stevens 1939). Perhaps one manifestation of this outlook was a reluctance to extend his thinking very far beyond his data. In a period when many experimental psychologists were developing ever more complex theoretical systems, Stevens's own forays into the realm of theory were few and limited in scope. He seemed happiest examining his data (as well as those of others) to see what useful information could be extracted. Much of his time in the laboratory was spent plotting and replotting data in the pursuit of clarity and simplicity, and his research reports were models of both qualities.

5. *Impact on Experimental Psychology*

Two additional characteristics of his work deserve mention. While the majority of his contemporaries were engaged in a search for relevant variables (e.g., does 'meaningfulness' affect ease of remembering?), Stevens's goal was the discovery of functional relations, mathematical descriptions of the association of one factor with another, as epitomized by his psychophysical power law. A corollary of this belief was an attitude toward sampling theory and statistical testing that ranged from indifference to disdain. The object for him was not to see whether 80 dB tones received an average loudness judgment greater than did 60 dB tones (at the 5 percent level of significance), the equivalent of what most of his contemporaries were doing. What was important to Stevens was whether a lawful relation could be seen when data were plotted in a thoughtful way. Large numbers of experimental subjects were not needed to reveal the kind of robust relations he sought; a few colleagues or students recruited in the hallways were enough for most of his purposes.

A landmark publication for research psychologists in the 1950s was the *Handbook of Experimental Psychology* edited by Stevens (1951). It was, as he described it in the preface, 'a technical survey that would systematize, digest, and appraise the mid-century state of experimental psychology.' It was not the first of its kind, but it was the most recent, and thus defined for teachers and students alike the set of shared interests that constituted experimental psychology. It was a time still when one might be expert in one aspect of the field and fairly knowledgeable about many others. Since then the amount of knowledge in psychology has grown at an explosive rate, and now the achievement of competence in one area increasingly restricts knowledge of any other. At the beginning of the twenty-first century, the tent of 'experimental psychology' has few remaining occupants; there are instead cognitive scientists, brain researchers, vision scientists, and a host of others in specialized niches. Just as Stevens's mentor E. G. Boring may have been among the last to teach an all-inclusive account of psychology in a single course, so Stevens may have been among the last to view the phrase 'experimental psychology' as a useful rubric.

6. *Conclusion*

Stevens can be seen as a transitional figure in the evolution of psychological science, yet much of what he did continues to influence the way it is practiced today. His lasting contributions to the fields of psychoacoustics and psychophysics have been discussed here. But, in addition, he created a roadmap for much of modern sensory neurophysiology and for those who theorize in that area. Many of the phenomena for which today's brain researchers seek explanations were established by Stevens or by others using the methods he developed. Were he alive today, it seems likely that he would embrace the new technology and would be developing ingenious techniques for exploring the neural aspects of sensory events. Although an account of his influence remains an unfinished story, at the least he will be remembered as one who brought new and powerful ideas to the study of psychophysics, leaving it a field reinvigorated and evolving as a subject of great intrinsic interest and many useful applications (e.g., see Baird 1997, Norwich 1993, Stevens 1966).

See also: Audition and Hearing; Experimentation in Psychology, History of; Galton, Sir Francis (1822–1911); Helmholtz, Hermann Ludwig Ferdinand von (1821–94); Lashley, Karl Spencer (1890–1958); Psychology: Historical and Cultural Perspectives; Psychology: Overview; Psychophysics; Wundt, Wilhelm Maximilian (1832–1920)

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R. Teghtsoonian

Stigler, George Joseph (1911–91)

1. Personal History

George Stigler, one of the great economists of all time, with a gift for writing matched among modern economists only by John Maynard Keynes, was born January 17, 1911 in Renton, Washington, a suburb of Seattle, the only child of Joseph and Elisabeth Stigler. His parents had separately migrated to the United States at the end of the nineteenth century, his father from Bavaria, his mother from what was then Austria-Hungary. Stigler went to public schools in Seattle, and then to the University of Washington, receiving a BA in 1931. Although he says that he had 'no thought of an academic career' when he graduated from college, he applied for and was awarded a fellowship at Northwestern University for graduate study in the business school, receiving an MBA in 1932 (Stigler 1988, p.15). More important, at Northwestern he developed an interest in economics as an object of study in its own right and decided on an academic career. After one further year of graduate study at the University of Washington, he moved to the University of Chicago where he found the intense intellectual atmosphere he sought. Chicago became his intellectual home for the rest of his life, as a student from 1933 to 1936, a faculty member from 1958 to his death in 1991, and a leading member of, and contributor to, the 'Chicago School' throughout. He received his PhD in 1938, with a thesis, now a classic, on the history of neoclassical theories of production and distribution (Stigler 1941).

At Chicago, Stigler was particularly influenced by Frank H. Knight, under whom he wrote his dissertation, Jacob Viner, who taught economic theory and international economics, John U. Nef, economic historian, and their younger colleague, Henry Simons, who became a close personal friend and whose *A Positive Program for Laissez Faire* greatly influenced many of Stigler's contemporaries.

'At least as important to me,' Stigler writes (1988, pp. 23–5), 'as the faculty were the remarkable students I met at Chicago,' and goes on to list W. Allen Wallis, Milton Friedman, Kenneth Boulding, and Robert Shone from Britain, Sune Carlson from Sweden, Paul Samuelson, and Albert G. Hart—all of whom subsequently had distinguished careers.

In 1936, Stigler was appointed an assistant professor at Iowa State College (now University), and shortly thereafter was married to Margaret Mack. The Stiglers had three sons: Stephen, a professor of statistics at the University of Chicago, David, a lawyer in private practice, and Joseph, a businessman. Mrs. Stigler died in 1970, tragically without any advance warning. George never remarried.

In 1938, Stigler accepted an appointment at the University of Minnesota, going on leave in 1942 to work first at the National Bureau of Economic Research and then at the Statistical Research Group of Columbia University, where he joined a group directed by W. Allen Wallis that was engaged in war research on behalf of the armed services. When the war ended in 1945, George returned to the University of Minnesota, but remained only one year, leaving in 1946 to accept a professorship at Brown University, where he also remained only one year before moving to Columbia University in 1947 and then, in 1958, to the University of Chicago where he remained the rest of his life. At Chicago, he became an editor of the *Journal of Political Economy*, established the Industrial Organization Workshop, which achieved recognition as the key testing ground for contributions to the field of industrial organization, and in 1977 founded the Center for the Study of Economy and the State, serving as its director until his death in Chicago on December 1, 1991.

Stigler served as President of the American Economic Association in 1964, and of the History of

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