EBBINGHAUS, HERMANN

Hermann Ebbinghaus (1850–1909) was the founder of the experimental psychology of memory. He laid the foundation for the scientific study of memory in a monograph entitled *Über das Gedächtnis* (1885). The little book, whose appearance belies its impact, was translated into English in 1913 under the title *Memory: A Contribution to Experimental Psychology.*

Life

Ebbinghaus was born on January 23, 1850, at Barmen, near Bonn, Germany. His father was a well-to-do merchant. As the University of Bonn he studied languages and philosophy. He served in the army during the Franco-Prussian War of 1870–1871, and upon returning to the university completed his doctoral dissertation in 1873. Ebbinghaus then spent some five years traveling in France and England. He began his research on memory at Berlin in 1878, spending over a year on the initial set of experiments. Upon completing these studies he became a private lecturer at the University of Berlin in 1880, and continued his studies of memory. He repeated many of the original experiments from 1879/1880 in 1883/1884 and added new ones. He published the report on both series in his 1885 monograph.

Ebbinghaus's life after he published his epoch-making study was active and productive. He was appointed a professor at the University of Berlin in 1886, remaining there until 1894, when he moved to the University of Breslau. He stayed at Breslau for eleven years and then accepted an ap-

Figure 1. Hermann Ebbinghaus.

pointment at the University of Halle. Over the years he became known as a prominent and respected member of the new scientific discipline of experimental psychology. A major source of his renown lay in his textbook of general psychology, *Grundzüge der Psychologie* (1897). It went through many subsequent revisions and editions, and became the most widely read psychology text in Germany. Because of his administrative responsibilities and the time spent in writing and revising his textbook, Ebbinghaus did relatively little original research, and what he did was not comparable in impact with his 1885 monograph. He died of pneumonia at Halle on February 26, 1909.

Ebbinghaus's Approach to Memory

Before Ebbinghaus, the study of memory consisted of philosophical "armchair speculation" concerning remembering and forgetting in everyday life, and clinical observations of patients with memory disorders. The philosophical approach of the day is beautifully reflected in William JAMES's *Principles of Psychology* (1890). The clinical approach is well illustrated by the work of Théodule RIBOT. Both lines of thought produced many insights into the nature and workings of normal and impaired memory. However, there were also curious gaps; not surprisingly, the contemporary thinkers were unaware of many of them. There was, for instance, the widely held view that memory could not be studied by strict scientific methods. Although methods of science had been applied to the "lower" mental processes, such as sensation and perception, under the general rubric of psychophysics, the "higher" mental processes such as memory were regarded as being beyond the pale of such methods. Another, tacit, idea was that remembering and forgetting occur in an all-or-none fashion: A person either does or does not remember a fact, a thought, a name, and the like. The possibility that nonrecoverable mental contents could exist at different levels of strength was discussed neither by philosophers nor by students of memory pathology.

Ebbinghaus's work changed all that. In his now-classic monograph he introduced the general approach to the study and measurement of learning and memory by psychological means, outlined the appropriate methodology, and reported a number of experiments illustrating the power of his methods. All of this was highly original.

The general strategy that Ebbinghaus adopted can be summarized in terms of three simple principles for the scientific study of mental processes that are not directly observable. These principles are as valid today as they were when Ebbinghaus first made use of them. First, it is necessary to find a way of converting the unobservable mental processes into observable behavior. Second, it is necessary to be able to measure this observable behavior reliably. Third, it is necessary that the behavior thus quantified by shown to vary systematically with other variables and experimental conditions.

The unobservable mental processes that Ebbinghaus wanted to study and measure were *associations* between ideas. Like almost all of his contemporaries, he assumed that memory reflects the existence of associations between ideas. He also thought that learning consists in the acquisition of associations, whereas forgetting reflects their loss. Ebbinghaus decided that the study of the acquisition and loss of associations would be best undertaken in a situation in which the associations to be learned were initially nonexistent. To that end he invented the nonsense syllable as a basic idea unit to be used in experiments on memory. A nonsense syllable is a meaningless single syllable consisting of two consonants separated by a vowel or a diphthong. When he composed a number of randomly chosen syllables into a series—the "lesson" to be learned and remembered—no associations existed between and among the members of the series. Learning the series therefore would involve the formation and strengthening of associations. The process could be captured by observing and measuring some behavior that could be assumed to be closely correlated with changes in the associations.

Methods and Results

In all his experiments Ebbinghaus was his sole subject. In numerous different studies, in which he varied the conditions of learning and retention, he would learn and then test himself with a large number of different series of syllables. He would learn a given series by first reading and then repeating the sequence of syllables aloud to the beating

of a metronome, at the rate of two and a half syllables per second, until he could produce the series faultlessly. The amount of effort required to master the series provided measures of both original learning and subsequent retention (or forgetting, the opposite of retention). Ebbinghaus adopted the number of readings, or the amount of time required for the learning of the series, as the *measure of learning*. Some time later he would *relearn* the same series, using the same method of reading and repeating the syllables. The comparison of initial learning and relearning scores provided a measure of *savings*. Ebbinghaus took savings to represent a measure of retention of the original learning.

Using these methods of measurement of memory, Ebbinghaus investigated a number of basic phenomena of learning and retention. The results of his experiments, concerning things such as the relation between the length of the series and the difficulty of learning it, the effects of the original overlearning of a series on its subsequent relearning, the advantages of distributed over massed practice, and the shape of the forgetting curve, turned out to be highly regular and lawful. The underlying relations are in fact orderly, and Ebbinghaus exercised meticulous care in carrying out his experiments. Among other things, he went to the trouble of performing numerous replications of individual experiments. The resulting regularity and lawfulness of his findings greatly impressed other scientists.

In one particularly ingenious set of experiments Ebbinghaus measured and compared three kinds of associations: forward associations, backward associations, and remote associations. In order to measure remote associations he would initially learn a series of syllables in a particular order, and subsequently relearn various series systematically *derived* from the original one. In these derived series the originally learned syllables were separated by a certain number of other syllables. For instance, if the original series is symbolized by A B C D E F . . . (. . . designating other syllables), then the derived series "skipping one syllable" would consist of A C E . . . B D F . . . , and the derived series "skipping two syllables" would consist of A D . . . B E . . . C F. . . . Ebbinghaus found that the savings in learning these derived series varied regularly with the remoteness of the members of the derived series from one another in the originally learned series. These data suggested that in the course of learning a series of syllables, associations are formed not only between immediately adjacent syllables but also among remote ones, the strength of the remote associations between any two members of a series varying with the degree of their remoteness in the original series.

Influence

Ebbinghaus's work proved to be highly influential for a number of reasons. Despite the pioneering nature of his work, he did just about everything right by the standards of science. He replaced philosophical discussions about memory and its phenomena with tightly controlled experimental demonstrations of how memory could be measured, and how memory performance could be found to be related to and determined by various independent variables. He discussed the sources of error and the problems of unreliability of measurement. He explained and demonstrated how one could measure fine gradations in mental processes that until then were thought to be scientifically intractable. He showed how the "higher" mental processes seemed to obey the same general kinds of laws that governed the "lower" processes. He explicitly and forcefully pointed out the intimate connection that exists between learning and memory, a realization that guides the study of memory. Like many other novel ideas introduced by Ebbinghaus, the connection between learning and memory is terribly obvious in our day, but it had been overlooked by most thinkers before Ebbinghaus. Ebbinghaus's adoption of the basic study/test paradigm in which a subject learns some previously unknown material and is subsequently tested for retention of the material contrasted sharply with the then current philosophical practice of discussing problems and phenomena of memory from the vantage point of *existing* associations.

Three particular features of Ebbinghaus's ground-breaking work that are most frequently mentioned in textbooks—his invention of the nonsense syllable, his serial learning task, and his adoption of the savings method as a measure of strength of associations—have had little direct influence on succeeding generations of memory researchers, who even shortly after 1885 rapidly adopted other methods and techniques of studying and measuring memory. Nonsense syllables turned out to vary greatly in meaningfulness, and thus lost the advan-

tage of homogeneity. The serial learning task did not allow independent manipulation or assessment of stimulus and response functions in learning and retention. And the originally ingenious savings method was replaced with more direct methods of measuring retention and forgetting.

Ebbinghaus's most important single achievement consisted in his highly convincing demonstration that it is possible to reliably measure aspects of complex mental processes that are not directly observable. Next to that, it was his general orientation and approach, and his attitude and spirit in the matter of applying the methods of science to the study of the human mind, that were embraced by succeeding generations of psychology students interested in learning and memory.

Ebbinghaus's pioneering role in the founding of the field of research on human learning and memory is universally acknowledged. Just about everyone agrees that *Über das Gedächtnis* represented a truly remarkable achievement of a great scientist, one that has left an indelible stamp on the study of one of the most fascinating problems of the human brain/mind.

(See also ASSOCIATIONISM.)

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Endel Tulving

ECOLOGICAL MEMORY

See Natural Settings, Memory in

EIDETIC IMAGERY

Nothing captures better the popular belief in "photographic memory" than the term *eidetic imagery,* although the latter hardly supports the exaggerated claims made for the former capacity. Photographic memory is the general claim that people can "still see in front of them" things that were experienced in the past. Eidetic imagery, on the other hand, is more closely tied to objective experimental criteria.

A generation of German investigations of eidetic imagery in the early years of the century (see Woodworth, 1938, p. 45) was largely ignored at midcentury when American psychology was dominated by theoretical behaviorism and had, at best, no use for the concept of imagery. The silence was broken in 1964 by publication of a paper by R. N. Haber and R. B. Haber (see also later summaries in Haber, 1979, and accompanying commentaries). Their report launched modern research on eidetic imagery and largely sustained conclusions from the continental work of a generation earlier.

Haber and Haber (1964) studied 150 elementary-school children in a standardized testing situation. The children were shown a set of four coherent pictures for 30 seconds apiece and interviewed immediately after each as to what they "saw" on a blank easel in the same location as the picture had been. Eight measures were collected, such as whether they saw an image, how long it lasted, whether the image description used positive coloration (rather than complementary colors, as in afterimages), whether it was described in the present tense, and so on. Although over half the children (84/150) reported at least some kind of imagery for the presented picture, there was considerable variability in scores on these eight measures. In particular, a group of twelve children was easily distinguished from the other seventy-two who had indicated some imagery. These twelve children were discontinuous with their classmates in the presence of positive coloration, duration of the images, use of the present tense to describe images, and visual scanning (of the