Journal of Experimental Psychology:
Learning, Memory, and Cognition
1985, Vol. 11, No. 3, 469–471

0278-7393/85/$00.75

The Contributions of Hermann Ebbinghaus

Bennet B. Murdock, Jr.
University of Toronto, Toronto, Ontario, Canada

The contributions of Ebbinghaus to the study of memory, in order of decreasing importance, are methodological, empirical, and theoretical. The course of subsequent development might have been different had he studied item or associative information rather than serial-order information. His chaining mechanism has been cause for much criticism, but the fault may have been in his conceptualization of associations rather than the chaining hypothesis per se.

In his entertaining and thorough review of Ebbinghaus' contribution to the study of memory, Slamecka (1985) has assessed the scholarly contributions made by Ebbinghaus. Slamecka has considered many of the detailed features of Ebbinghaus' work. I would like to consider the contributions of Ebbinghaus more generally.

It seems to me that the Ebbinghaus contributions to the study of memory can be grouped into three categories: methodological, empirical, and theoretical. They are listed in order of decreasing importance; that is, his methodological contribution comes first and his theoretical contribution comes last. As far as I know, with the exceptions cited by Slamecka, there were really no solid empirical studies of memory before Ebbinghaus. Yet memory has been a topic of great interest from at least the time of Aristotle (384–322 B.C.) to the present. What Ebbinghaus did was to show that memory could be studied experimentally by using the methods of natural science; one could manipulate independent variables, measure dependent variables, and observe lawful relations.

So, by "methodology" I do not mean his invention of the nonsense syllable, the study–test method, or the savings measure in relearning. What I mean by his methodological contribution is the development of techniques to study the changes in memory over time (i.e., forgetting), the development of reliable conditions to study acquisition and learning, and his use of probability theory (or at least the Law of Errors) to account for the variability inherent in all laboratory studies of memory. Today we take all this for granted, but there was no precedent for this in the memory area in 1885. We can perhaps better appreciate the magnitude of his methodological contribution if we read the first chapter of Thorndike's (1911) *Animal Intelligence*, where Thorndike felt he had to justify the experimental study of animal learning.

The empirical contributions of Ebbinghaus are also important, but perhaps less so. His results per se did not lead to any great insights, even though they were novel. Of course, it is very much to his credit that many of his empirical findings are still accepted today, but nobody has ever said that Ebbinghaus was not a diligent and careful experimenter. As I shall mention shortly, he made the mistake of starting with serial learning and used a rather indirect (though very sensitive) measure of memory, but hindsight is always better than foresight.

His theoretical contributions are probably the least of the three, but apparently by design. It is generally acknowledged that a sound empirical basis is a prerequisite to any scientific theorizing, so given that there was no data base at all, his reluctance to engage in theoretical speculation was quite appropriate.

To understand storage and retrieval processes in human memory we have to differentiate between items, associative, and serial-order information (Murdock, 1974). It is too

Preparation of this article was supported by Grant APA146 from the Natural Sciences and Engineering Research Council of Canada.

Requests for reprints should be sent to Bennet B. Murdock, Jr., Department of Psychology, University of Toronto, Toronto, Ontario M5S 1A1, Canada.

bad that Ebbinghaus started with serial-order information (serial learning), because this is the most intractable and least well understood even today. To my knowledge, Müller and Pilzecker (1900) were the first to study associative information; they used paired-associative learning. Still later, Strong (1912, 1913) provided the first experimental study of item recognition in his classic studies of recognition memory. Storage and retrieval of item information is the simplest and best understood of the three; both our experimental results and theoretical understanding today are quite impressive (Murdock, 1980).

If Strong had preceded Ebbinghaus, or if Ebbinghaus had studied recognition memory, the course of our progress over the last 100 years might have been quite different. The simplicity and regularity of Strong's "curve of forgetting" would have been a much better basis on which to construct mathematical formulations and laws of memory than the rather awkward and complex formulation proposed by Ebbinghaus.

Given that Ebbinghaus did study the storage and retrieval of serial-order information, what can we say about this contribution? The chaining hypothesis was his associative mechanism, and Slamecka has detailed its fate. I tend to agree with Slamecka's conclusion, but for different reasons. The chaining hypothesis assumes a linking of successive associations, but what is an association? To Ebbinghaus, and to many researchers today, an association is simply a connection or a link between two ideas or concepts. It is the bridge that connects two islands, the road that connects two cities, or the path in a semantic network model that connects two nodes.

Another way to conceptualize associations is from the viewpoint of a distributed memory model, and there associations are quite different. There are a variety of such distributed memory models (e.g., Anderson, 1970; Eich, 1982, 1985; Kohonen, 1977, 1984; Murdock, 1982, 1983; Pike, 1984), but they all have in common the idea that the association between two items is the fusing or blending of two ideas. There is no "link" or "connection" at all. Instead, the two separate items are combined to form a larger unit that has no immediate resemblance to either item alone. Abstractly, we may think of an association as being represented by $\mathbf{f} \cdot \mathbf{g}$ which is to be read as "$\mathbf{f}$ operating on $\mathbf{g}$." The association is the result of this operation.

In such models, chaining refers to the successive association of overlapping pairs. The *chain* is composed of *A–B*, *B–C*, *C–D* associations, but there are no links in this chain. The successive associations are stored in a common memory array, and the serial order is determined by the order of recall. Thus, there is no temporal-to-spatial mapping in the memory store (Milner, 1961), but order information is still preserved.

Chaining models of this sort have been suggested for the storage and retrieval of serial-order information (e.g., Kohonen, 1977; 1984; Murdock, 1983), and they are not necessarily discredited by the negative evidence detailed by Slamecka. There is much evidence that seems to discredit a view of serial learning based on a chain of associations, but perhaps the problem is in the conceptualization of associations not in the concept of chaining.

In conclusion, the chaining notion is not dead; it remains potentially fruitful today. The question is not so much whether chaining is right or wrong but what the mechanism for association is. That is, what is the nature of these associations that are being chained. This conclusion about chaining would not necessarily displease Ebbinghaus, because it is still an associationistic view. What the nature of these associations is, however, is still a question for the future.

References

Anderson, J. A. (1970). Two models for memory organization using interacting traces. *Mathematical Biosciences, 8,* 137–160.

Eich, J. M. (1982). A composite holographic associative recall model. *Psychological Review, 89,* 627–661.

Eich, J. M. (1985). Levels of processing, encoding specificity, elaboration, and CHARM. *Psychological Review, 92,* 1–38.

Kohonen, T. (1977). *Associative memory: A system-theoretical approach.* Berlin: Springer-Verlag.

Kohonen, T. (1984). *Self-organization and associative memory.* Berlin: Springer-Verlag.

Milner, P. M. (1961). A neural mechanism for the immediate recall of sequences. *Kybernetik, 1,* 76–81.

Müller, G. E., & Pilzecker, A. (1900). Experimentelle

Beiträge zur Lehre vom Gedächtnis. *Zeitschrift für Psychologie, 1,* 1–300.

Murdock, B. B., Jr. (1974). *Human memory: Theory and data.* Potomac, MD.: Erlbaum.

Murdock, B. B., Jr. (1980). Short-term recognition memory. In R. S. Nickerson (Ed.), *Attention and performance VIII* (pp. 497–519). Hillsdale, NJ: Erlbaum.

Murdock, B. B., Jr. (1982). A theory for the storage and retrieval of item and associative information. *Psychological Review, 89,* 609–626.

Murdock, B. B., Jr. (1983). A distributed memory model for serial-order information. *Psychological Review, 90,* 316–338.

Pike, R. (1984). Comparison of convolution and matrix distributed memory systems for associative recall and recognition. *Psychological Review, 91,* 281–294.

Slamecka, N. J. (1985). Ebbinghaus: Some associations. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 11,* 414–435.

Strong, E. K., Jr. (1912). The effect of length of series upon recognition memory. *Psychological Review, 19,* 447–462.

Strong, E. K., Jr. (1913). The effect of time-interval upon recognition memory. *Psychological Review, 20,* 339–372.

Thorndike, E. L. (1911). *Animal intelligence.* New York: Macmillan.

Received December 14, 1984 ■