JOHN G. SEAMON, Editor

HUMAN MEMORY

CONTEMPORARY READINGS

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Edited by
JOHN G. SEAMON
Wesleyan University

New York • Oxford
OXFORD UNIVERSITY PRESS
1980

Library of Congress Cataloging in Publication Data
Main entry under title:
Human memory: Contemporary readings.
Includes index.
1. Memory. I. Seamon, John G.
BF371.R34 153.1'5 79-28335
ISBN 0-19-502738-8 ISBN 0-19-502739-6 pbk.

Printed in the United States of America

To my mother and father

PREFACE

More than a few years have passed since a book of readings dealing with research on human memory has appeared. Since the earlier collections by Kausler (*Readings in Verbal Learning,* Wiley, 1966) and Slamecka (*Human Learning and Memory: Selected Readings,* Oxford, 1967), the psychology of memory has changed in profound ways. Cognitive processes have superseded verbal learning as psychologists have turned their attention to issues such as understanding and the representation of knowledge. For this reason, a new collection of readings reflecting current contributions to memory seems appropriate. No attempt has been made to reproduce the classic papers already available in the Kausler and Slamecka collections; this would be not only wasteful, but antithetical to the present purpose.

The function of this book is to serve as supplementary reading for advanced undergraduate and graduate courses in learning, memory, and cognition. While the size limit of twenty-five articles makes this collection more modest than its predecessors, it may be comfortably used in a single semester course. The division of the book into seven parts is based on the belief that the topics covered include those normally covered in cognitively oriented courses (e.g., Historical Background, Transient Memories, Attention and Memory, Mental Imagery, and Remembering and Understanding) as well as a few that typically, but undeservedly, receive scant coverage (e.g., Developmental and Cultural Factors, and Memory Pathology). Overall, empirical and theoretical presentations are balanced, and selection, from those publishers who permitted reproduction, was based on the criterion of increased understanding of each topic. Obviously, in any collection, it is not possible to include all of those articles that meet this criterion.

It is fitting, in closing, that appreciation be expressed to all of the authors who granted permission to reproduce their scholarship, to their publishers, and to Marcus Boggs and the staff at Oxford University Press for continued support and assistance. To each I say thank you.

Middletown, Conn.
April 1980

J. G. S.

CONTENTS

HUMAN MEMORY

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HISTORICAL BACKGROUND AND A CURRENT PERSPECTIVE

Before beginning a book of memory research, it is a good idea to have some notion of the historical antecedents for the current endeavors. For this reason we start this collection of current research with a paper that is different from those that follow. Article 1 by Murray provides a review of the literature on memory and cognition as performed in the nineteenth century when psychology separated itself from philosophy and began as an empirical science.

Murray notes that the early literature on memory and cognition fell into three broad classes. There were investigations of a medical or physiological nature, which examined memory pathologies such as anterograde or retrograde amnesia. There were studies involving educational and developmental issues, such as those dealing with intelligence and cognitive abilities in children. And there were philosophical discussions on topics such as the nature of the memory trace and its consolidation over time. Many of these topics, as shown by the rest of the papers, are still pursued today. The study of brief memory images, for example, begun by Baxt (1871) and continued by Sperling (1960), is considered in Part II, *Transient Memories*. Debate on the representational basis for the memory trace is presented in Part IV, *Mental Imagery*. And current work on amnesia and consolidation processes is covered in Part VII, *Memory Pathology: The Amnesic Syndrome*. Although many of the topics remain the same, progress has been made in gaining a greater appreciation and (in some cases) understanding of the problems under study.

Aside from a historical overview, what is needed to organize memory research is a grand theoretical framework that shows how memory relates to other aspects of cognitive functioning. Psychology is still years away from this framework, and perhaps, because of the complexity of the issues involved, such a goal is unattainable. But still, schemata are helpful, even on a lesser scale. One such schema, developed by Atkinson and Shiffrin (1968), holds that the memory system is composed of memory structures and control

processes. Memory structures are those parts of the system that are permanent. These structures include the sensory memory system, short-term storage, and long-term storage. Control processes, on the other hand, are the means by which information in memory may be acted upon. Mental rehearsal, for example, is a control process that can be used to maintain information in short-term storage so as to prevent forgetting.

Article 2 by Shiffrin and Schneider provides a revision of the earlier model of Atkinson and Shiffrin. While space limitations have permitted only that portion of their paper dealing with the general theory to be presented, the entire paper, as well as a companion article (Schneider & Shiffrin, 1977), may be read for profit. Following work by Shiffrin (1976), the memory structures are viewed as unified, since stimulation from the sensory memory system is thought to activate its permanent representation in long-term storage. This activation of information in long-term storage represents short-term storage. Where long-term storage is seen as a permanent and passive repository of all the things we know, short-term storage is the temporarily activated portion of the larger body. Two types of processes used to interact with information in memory receive considerable attention in this paper. Automatic processes, which require extensive practice to develop and are subsequently difficult to suppress or alter, are activated in response to a particular stimulus and make no attentional demands on the person. Controlled processes, in sharp contrast, make sizable demands upon attention, but can be manipulated by the person and are available to consciousness.

In light of the historical background provided by the Murray paper and the current perspective given by the Shiffrin and Schneider paper, the papers that follow provide an indication of what has been accomplished and what remains to be done.

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RESEARCH ON HUMAN MEMORY IN THE NINETEENTH CENTURY

D. J. MURRAY
QUEEN'S UNIVERSITY

The experimental study of memory is customarily held to date from Ebbinghaus's monograph *Über das Gedächtnis* (1885). Nevertheless, there was, prior to that date, a large literature on memory in general. For instance, Burnham's selective bibliography (1888–89) contains over 200 items: and if writings on "mnemotechnics" be included, the number of references is much higher (Young, 1961). Most of this literature can be classified under three headings: philosophical discussions concerning memory and associations; physiological-medical reports on cases of amnesia, aphasia, and other pathological memory disturbances; and educational writings on how to teach and memorize efficiently. Under the first two of these headings may be subsumed the various speculations as to the nature of the memory "trace": many of these theories were originally produced by philosophers or physiologists (see Gomulicki, 1953). In this introduction, we shall indicate briefly what was known about memory prior to the experimental work of Ebbinghaus; following this we shall discuss findings on long-term (LTM) and on short-term memory (STM) produced by Ebbinghaus and his immediate successors in the nineteenth century.

Background

So far as is known, few pre-Socratic philosophers discussed memory, and those who did, such as Diogenes of Apollonia and Parmenides, surmised that memories were stored as a mixture of natural "elements"—heat, cold, light, air—in the body (Beare, 1906). In the *Theaetetus*, however, Plato expounded the *tabula rasa* theory of memory, according to which memories were like seal-impressions upon wax: and in the *Philebus* he explicitly distinguished between the power of retention (often translated as "memory") and the power of recall (often translated as "reminiscence" or "recollection"). The first major work on memory was Aristotle's *De Memoria et Reminiscentia*. As the title indicates, Plato's distinction is pre-

This work was supported by National Research Council of Canada Grant A9126 to the author. The translated portions are also by the author.

From the *Canadian Journal of Psychology*, 1976, *30*, pp. 201–220. Reprinted by permission of the Canadian Psychological Association and the author.

served: "memory" is a consequence of the "stamping" of individual perceptions into a "receiving surface," while "recollection" is often based on the processes of association by contiguity, contrast, or similarity. Recollection is often difficult because of "counter-motions" based on previous habits, i.e. is subject to what we should now call "interference." Animals have memory, but not the power of recollection.

Aristotle's stress on association as being the basis for recollection was, of course, extremely influential. Essentially those later philosophers who discussed association asked two main questions: how can associations be classified? and, what happens to a given "association" when it forms part of a thought-process—will it coalesce with other associations, or preserve its identity intact? The first of these questions gave rise to a number of sets of "laws of association," most of which consisted of variations around the Aristotelean theme of "similarity, contrast, and contiguity." Detailed accounts of early Associationism will be found in Warren (1921): among philosophers who wrote extensively on the subject were Hobbes (1650), Locke (1690), Hume (1739), Condillac (1754), Brown (1820), J. Mill (1829), and J. S. Mill (1843). The Associationists of the nineteenth century, however, often combined their theorizing on association with what they knew of nervous functioning: this is best exemplified in the work of Bain (1855) and Spencer (1855). But as soon as speculation on association took on a physiological tinge, the second of the above questions was raised: it is interesting to note that among the first to assert that new associational complexes could be formed in the course of thought was Hartley (1749), who based this view on his own theory that the memory-trace consisted of "vibrations" in the medullary substance of the brain. So, similarly, at the end of the nineteenth century, philosophers and psychologists, basing their arguments on reasoning (J. S. Mill) or on physiological grounds (Wundt), came to assert that a "mental chemistry" of individual associations was possible. Yet this acceptance of possible fusion between ideas argued against the otherwise appealing atomism of associationist psychology, and as a result atomistic versions of Associationism came to be strongly attacked, both by philosophers such as Bradley (1887) and by psychologists such as James (1890, esp. Ch. XIV). James even went so far as to condemn all the previous "laws" of association: for him there was "no other *elementary* causal law of association than the law of neural habit" (p. 566). From this reaction against atomistic associationism would eventually emerge both the Gestalt movement and the Würzburg school, the latter of which relied heavily on introspection (see Humphrey, 1951), but from our point of view, the important result of Associationism was the fact that associations were among the first phenomena to be investigated experimentally at Wundt's laboratory (founded in 1879) and elsewhere. Few writers on memory at the time omitted reference to Associationism (e.g., Ebbinghaus, 1885, Ch. VI), while early experimenters on associations naturally related their findings to what was known of memory. Of these pioneering experiments, those by Galton (1883) are of particular interest to us: he took a word and wrote down, and timed, the associations which came to mind. He was surprised to discover that many of these (39%) came from boyhood and youth, and therefore argued that early memories had greater "fixity" than late (cf. Ribot's work, below). Words easily admitting of pictorial representation evoked the most frequent and vivid images.

One philosopher whose work must be mentioned separately was Herbart (1776–1841). This successor to Kant at Königsberg attempted to quantify the interplay of associations, rather than simply to classify them: he attempted to account for the clearness or vividness of ideas by deriving mathematical formulae from basic assumptions concerning the initial strengths of the associations involved. Ideas or concepts (*Vorstellungen*) are either in consciousness or below the threshold of consciousness. However a given concept could be in part conscious and in part unconscious: the greater the ratio of the conscious to the unconscious part, the more vivid or clear the concept. A given concept could either be raised into consciousness with the help of another concept, or there could be mutual interference between two opposing concepts, leading either to the depression of both

into unconsciousness, or to an arrest of the weaker concept below the threshold. By assigning numerical values to the strength of such concepts, Herbart was able to conclude that (a) although two opposing concepts were mutually inhibitory, the one could not actually destroy the other; (b) the amount arrested of a concept would bear a constant relation to the total amount of the concept in consciousness at a given moment;[1] (c) if two concepts were each raised in part into consciousness, the clarity of the union of the two portions above threshold would vary both with the initial strength of the weaker concept assisted into consciousness by the stronger, and with the inital strength of the stronger concept. This last assumption yielded a formula remarkably similar to that of Hull's for habit-strength (Hull, 1943; see Bakan, 1952). Finally Herbart derived from the above conclusions proofs that "forward" associations within a series would be stronger than "backward," and also that if a list A B C D . . . were learned, A would be most strongly associated with B, less with C, and increasingly less with increasingly remote items. Herbart's work was important, not only because it constituted probably the first attempt at a mathematical theory of learning and forgetting, but also because it inspired some of the Ebbinghaus's experiments. The fact that Wundt in his monumental *Principles of Physiological Psychology* (1874) would devote much of his sections on memory and imagination to an exposition of Herbart's theory testifies to his influence on later psychologists. Herbart's views were put forward briefly in his *Textbook in Psychology* (1816) and at length in his *Psychology as Science* (1825): an example of his mathematical reasoning is given in Boring (1957, Ch. 13).

In the late nineteenth century, research on the physiology of memory was taking place on three fronts: enquiries into the nature of the "trace," attempts to localize memory-centers in the brain, and studies of memory abnormalities such as amnesia. With respect to the former, we may simply note here that extraordinary advances in the knowledge of nervous anatomy and functioning had been made in the first part of the century. Du Bois-Reymond and Bernstein had demonstrated the electrical nature of the nervous impulse; Helmholtz had measured its speed, Bell and Magendie had independently distinguished between the sensory and motor nerves, and spinal reflex action had been intensively studied by Marshall Hall (to give only a few examples). A good deal was also known about sensory functioning, particularly as a consequence of Helmholtz's masterpieces on vision (1856–66) and hearing (1863). Nor were theories of the trace lacking. Prior to the above discoveries, most trace-theories were based on the notion of persisting "movements" in the "animal spirits" which were supposed to run through the nerves, a view bequeathed by Galen and doubtless made more credible by analogy with the vascular system, but following microscopic studies of nerves and nerve-fibers,[2] models based on physical analogies became more frequent. However progress in the field was seriously retarded because of the prevailing ignorance as to whether the separate nerve-fibers formed a great network throughout the body, or alternatively consisted of discrete units, "neurons" separated from one another by small gaps. Since this problem was only solved at the end of the century—by Golgi, Cajal, and others—the word synapse, referring to the interneuronal gap, was given currency by Foster and Sherrington (1897)—pathway models of the trace, so prolific in the present century, were not available at the time of Ebbinghaus. Nevertheless, the view that a nerve-channel A could "drain" its energy specifically into a channel B other than to an alternative channel C was quite widely accepted (cf. Bain, 1855). The history of the discovery of the synapse is documented by Liddell (1960): more details of these earlier trace-theories will be found in Gomulicki's comprehensive review (1953) and in Burnham (1888–89).

With respect to the cerebral localization of memory, we may observe that in the early nineteenth century there was already controversy over whether the cerebral hemispheres acted as a whole or were subdivided into functionally discrete areas. Flourens (1824) championed the former view while Gall and Spurzheim (1800) argued for the latter. Amongst Gall's assertions was the opinion that speech was localized in the frontal lobes: this view persisted until Broca

(1861) was able to demonstrate two cases of aphasia in which there were lesions of the left temporal area (see Head, 1926). Following this, despite the caution advised by Hughlings Jackson, there were attempts to localize not only "memories" of spoken language, but also of written: for instance, Bastian (1882) distinguished between hand-kinaesthetic, tongue-kinaesthetic, visual word, and auditory word memories, assigning each to a region in the neighborhood of Broca's area. Thus "memories" of various types were speculatively localized in the cerebrum: there was little hint, prior to Ebbinghaus's time, that the subcortical regions might be concerned in memory. Nor did all authors distinguish between aphasia and agnosia, at least [not] before Hughlings Jackson.

Apart from the aphasias, amnesias generally were recognized as being either psychogenic or organic in origin. For example, the amnestic aspects of multiple personality were discussed in detail (see James, 1890, Ch. X), and many cases of organic amnesia were presented in medical texts of the time. It was also known that amnesia was a characteristic of senility and could be induced under hypnosis. However, it remained for Ribot (1881), in his classic *Diseases of Memory,* to collate the evidence available. He divided amnesias into "general" and "partial" types: included under the former were retrograde amnesia, hysterical and multiple personality cases, amnesia resulting from dementia and progressive brain-damage, and congenital inability to retain. Under "partial" amnesias were included the forgetting of isolated types of material such as proper names or melodies, and the forgetting of "signs" as illustrated in aphasia and related disorders. Ribot's best-known contribution occurs in his discussion of progressive general amnesia, which led him to put forward the "law of regression": "in cases of general dissolution of the memory, loss of recollection follows an invariable path: recent events, ideas in general, feelings, and acts" (p. 203). Forgetting, that is, proceeds from the new to the old, from the "unstable" to the "stable." Elsewhere he indicated that following temporary amnesia, the different kinds of recollection recover in inverse order. In view of the fact that Ribot's work was the first major contribution to draw attention to the distinction between memory for recent events and memory for remote events (though cf. Galton's work, above), it is worth noting that he considered the neural events underlying both to be of a common type, varying along a continuum of what he called "stability." His final sentence is: "memory consists of a process of organization of variable stages between two extreme limits—the new state, the organic registration" (p. 204).

There is some kind of amnesia, that found in Korsakoff's psychosis, which appears particularly to concern the transfer from STM to LTM. We might indicate here that Korsakoff first described this syndrome in 1889, although Wernicke had earlier described confusional states linking chronic alcoholism with amnesia. The first paper suggesting that subcortical lesions might be related to the Korsakoff state was apparently that of Gudden (1896).

Our comments on educational writings may be restricted to pointing out that, because much of the instruction in schools demanded rote-memorization (see Brubacher, 1947), it was inevitable both that aids to memorization came to be invented, and that educators would try to evaluate the merits of rote learning. With respect to the former, there arose over the centuries various mnemonic schemes, some of which had great popularity: these were, however, also used by adults for memorizing speeches and the like, rather than just by school children. The simplest kind of mnemonic is, of course, the verse that assists the pupil to memorize a complex set of facts: a historical example is the "Barbara Celarent . . ." stanza, summarizing the syllogisms valid in Aristotelean logic. But, in classical times and in the Middle Ages, "topographical" schemes were common: each of a set of items to be memorized was assigned to a separate "locality" in a visually imagined town or palace. In the sixteenth and seventeenth centuries, complicated letter-number codes were devised: each digit, for example, corresponded to one or a few letters, so that words could be made up to encode long series of digits. This kind of scheme was elaborated by various savants, including Leibnitz: the best-known version was given by Grey, in his *Memoria Technica* (1730), a book which was

brought out in successive editions until the end of the nineteenth century. James (1890) argued that these schemes were of little value in aiding retentive capacity as such, though he admitted that, in the hands of skilled practitioners, they enabled difficult sequences to be memorized more rapidly. They did not, however, give rise to any significant experimentation: we mention them here because they formed such a large proportion of the early literature on memory. Histories of mnemonics will be found in Middleton (1887) and Yates (1966), and a comprehensive bibliography in Young (1961).

Queries as to the value of rote-memorization in school instruction, on the other hand, did result in valuable experimental work. Many of the great educators, such as Comenius, Herbart, and Froebel, had, of course, criticized rote-learning as being both unmotivating and of little value in training an enquiring, critical, and logical mind. But it seems to have been tacitly assumed by many other pedagogues that if one learned, for example, a long poem by heart, this would assist in the learning of other long poems or other types of material: some writers even asserted this dogmatically. Again, it was James (1890) who attacked this belief: partly as a consequence of his own report that he found little benefit for later memorizing to result from extended practice at memorizing, studies of "transfer of training" were initiated. Both experimental psychology and education were to benefit by a common interest in memory: many of the findings we shall report were produced by educational psychologists conversant with experimental method (such as Meumann, one of Wundt's students), while educational texts became increasingly infused with the findings of experimental psychologists such as Ebbinghaus (e.g., Lay, 1907; Watt, 1909).

Research on long-term memory in the nineteenth century

Very little of the above work concerned the experimental investigation of learning and memorizing: for the first studies in this area we are indebted to Hermann Ebbinghaus (1850–1909). His basic findings are worth presenting, for they provided the foundations for much later work on long-term memory (LTM), and there are few better ways of introducing LTM than that of describing what the first major worker in the area discovered. His work was begun in 1879, and finally published in 1885, when it had an immediate influence.

From a methodological point of view, Ebbinghaus was among the first to insist upon proper quantitative treatment of his data. In so doing he was probably influenced by Fechner (see Boring, 1957, pp. 386 ff.). For most arithmetic means that he quoted, he also gave the Probable Error[3] as an index of the variability of his scores about the mean. He invented nonsense-syllables: these consisted of a consonant-sound followed by a vowel-sound followed by a consonant-sound: diphthongs were permitted, e.g., "scheuch." He also devised the "savings method" (*Ersparnismethode*) for investigating retention: a list would be learned at a time t_0, then relearned later at a time t_1: the number of seconds required for relearning at t_1 was then compared with the time originally required at t_0 and the "savings" in time expressed as a percentage. In some of his studies he also reported the numbers of repetitions required for adequate learning at t_0 and at t_1.

In his first study, he related the total number of repetitions required for adequate learning of a list to the length of the list itself. Ebbinghaus's curve suggests that for long lists the curve is negatively accelerated with respect to list-length. However, Lyon (1917) extended the range of list-lengths up to 300 items, and obtained a positively accelerated curve. Meumann (1913) also failed to confirm Ebbinghaus's result. Ebbinghaus also noted that, if the material consisted of connected prose a certain number of syllables long, the number of repetitions needed to learn this was much fewer than that needed to learn an equally long list of nonsense syllables. Of particular interest to us is the fact that for lists less than about seven syllables long, only about one repetition was needed for perfect reproduction. This is one of the first hints of the existence of the immediate memory span. Ebbinghaus must have had good short-term retention, for most later workers have found the span for nonsense-syllables—as opposed to, say, digits—to be much less than