HUMAN MEMORY AND COGNITION

MARK H. ASHCRAFT
Cleveland State University

SCOTT, FORESMAN AND COMPANY
Glenview, Illinois  Boston London
To the three who matter most:

Mary Helen Homerin Ashcraft,
Jordan Mark Ashcraft, and
Laura Catherine Ashcraft.

Credit lines for copyrighted materials appearing in this work are placed in the "Credit" section at the end of this book.

Copyright © 1989 Scott, Foresman and Company
All Rights Reserved.
Printed in the United States of America.
3456 KPF 9392919089

Library of Congress Cataloging-in-Publication Data
Ashcraft, Mark H.
Human memory and cognition.
Includes bibliographies and index.
1. Memory. 2. Cognition. I. Title.
BF371.A68 1988 153 88-15538
ISBN 0-673-18862-0
Chapter 1

COGNITIVE PSYCHOLOGY: AN INTRODUCTION

- Thinking About Thinking
- Memory and Cognition Defined
- An Introductory History of Cognitive Psychology
  - Anticipations of Psychology
  - Early Psychology
  - Behaviorism and Neobehaviorism
  - Dissatisfaction with Behaviorism—The Seeds of Cognitive Revolution
  - Challenges Within Neobehaviorism
  - Challenges from Outside

- Cognitive Psychology and Information Processing: The New Direction
  - The Assumptions of Cognitive Psychology
  - Mental Processes Exist
  - Active Information Processors
  - Time and Accuracy Measures
What a piece of work is man. How noble in reason! How infinite in faculty! In form and moving how express and admirable! In action how like an angel! In apprehension, how like a god! (Act 2, scene 2, of Shakespeare’s Hamlet)

One difficulty in the psychological sciences lies in the familiarity of the phenomena with which they deal. A certain intellectual effort is required to see how such phenomena can pose serious problems or call for intricate explanatory theories. One is inclined to take them for granted as necessary or somehow “natural.” (Chomsky, 1968, p. 24)

It can be very difficult to appreciate just how complex human cognition really is, because so much of what we call cognition is so ordinary and commonplace. I’ve certainly not had much success at impressing my own son with it. When he was three, we stayed overnight with some friends who had a swimming pool in their backyard—a big attraction to a three-year-old boy, of course. Many months later, long after he had stopped talking about the visit, he brought the topic up again, quite unexpectedly. His remembering the event struck me at the time as an obvious, early, and deliberate cognitive act. Being a proud father and a cognitive psychologist, I made a point of stressing how terrific his recollection was, saying, “Jordan, that’s really great! You’re remembering things, you’re thinking about them, you’re using your memory.” His reaction to this was succinct—he shrugged and walked away, as if to say “Yeah, no big deal.” But of course it is a big deal. Our infinite mental faculties are no less interesting because they are routine, or because we take them for granted. But it certainly can be hard to convince someone of this.

This book is about human memory and cognition, and specifically about the scientific study of human memory and cognition. We need a quick definition to get us started. For the moment, consider the topic of this book to be the mental events and knowledge used in activities like recognizing an object, remembering a name, having an idea, understanding a sentence, and solving a problem. In this book, we will consider a very broad range of subjects, from basic perception through complex decision making, from seemingly simple mental acts such as recognizing a letter of the alphabet to very complicated acts such as participating in a conversation. How do we read for meaning? How do we memorize facts? What does it mean to “forget” something? Do we reason out the answers to questions in a logical fashion? How do we know that we don’t know something? The unifying theme behind all of this is one of the most fascinating and important questions of all time—How do people think?

1Unlike Shakespeare, modern writers have been sensitized to the sexist bias implied by the generic terms man, he, and so forth. I have attempted in this book to avoid such usage whenever possible. On those stylistic occasions where the generic term couldn’t be avoided, or when I simply grew tired of the plural or collective terms, I have tried to alternate between the generic he and she, on a section-by-section basis.

Notice right away that we are interested in a scientific approach to human memory and thought. This places us in the branch of modern psychology usually labeled cognitive psychology. To a very large extent, cognitive psychology is an empirical field, a field built on the results of experiments and the explanations of models and theories. We will be dealing with many of these experiments, explaining why they were done, what sorts of questions they answer, what directions they suggest for future studies, and so forth. By contrast, this book does not deal with nonempirical or philosophical approaches to the human mind. It is true, of course, that philosophy has had a profound influence on psychology—indeed, psychology began as an offshoot of philosophy. And, it is obviously true that all of us, cognitive psychologists included, have been shaped and influenced by our culture and intellectual history in countless ways. Nonetheless, the discipline of psychology has largely accepted that body of work concerned with scientific approaches to the world; the purely philosophical approaches are viewed rather skeptically. Thus, one of the central characteristics of modern cognitive psychology is its allegiance to objective, empirical methods of investigation—this is one of the shiniest badges we wear. For reasons discussed below, cognitive psychology maintains an arm’s-length distance from subjective, “armchair” explanations of the nature of thought. We are experimentalists, and this is the approach you’ll read about in this book.

A few of you, having read the previous paragraph, may be thinking “Well, that’s the bad news. Now, where’s the good news?” Here it is: within the boundaries of objective scientific methods, cognitive psychology is asking a whole host of fascinating questions. Since the beginnings of modern cognitive psychology some 30 to 35 years ago, there has been a true explosion of interest in cognition, and in the “cognitive approach” to human behavior and thought. Questions that had been on psychology’s back burner for too long, such as “How do we read?” or “How do we use language,” have become active areas of investigation. The pent-up interest in these questions, unleashed during the “cognitive revolution” of the late 1950s, has yielded tremendous progress.

The most basic purpose of this book is to tell you what has been discovered about human memory and cognitive processes and to share cognitive psychology’s conclusions and insights about that particularly human activity called thought. The most highly sophisticated, flexible, and efficient “computer” available today is your memory, with its collection of mental processes. How does it work? As amazing as electronic computers are, their capabilities are literally kid stuff compared to what you routinely do in even a single minute’s worth of thinking. The need to understand ourselves is basic, and this includes an understanding of how our own mental apparatus operates. While this book is not an owner’s manual, it does nonetheless describe and explain what is known about the psychological functioning of the human mind.

Another purpose of this book is to describe how cognitive psychology has made these discoveries. Your appreciation of the information in this
Table 1-1  SUMMARY OF THE INTUITIVE COGNITIVE ANALYSIS

<table>
<thead>
<tr>
<th>Sensory and Perceptual Processes</th>
<th>Topic and Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOCUS eyes on print.</td>
<td>Visual perception and sensory memory-Ch. 3</td>
</tr>
<tr>
<td>Encode/perceive the printed material.</td>
<td>Pattern recognition—Ch. 3</td>
</tr>
<tr>
<td></td>
<td>Reading—Ch. 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Memory and Retrieval Processes</th>
<th>Topic and Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Look up” letters and words in memory.</td>
<td>Memory retrieval—Chs. 4–7</td>
</tr>
<tr>
<td>Identify words. Retrieve word meanings and connections.</td>
<td>Semantic memory—Ch. 6</td>
</tr>
<tr>
<td>Comprehension Processes</td>
<td>Semantic retrieval and comprehension—Chs. 7, 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Judgment and Decision Processes</th>
<th>Topic and Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine answer to the question. Determine “reasonableness” of the question. Judge speaker’s intent. Judge own knowledge of topic.</td>
<td>Semantic retrieval—Ch. 7, 8</td>
</tr>
<tr>
<td>Comprehension/Conversation—Ch. 9 Decision Making/Reasoning—Ch. 11</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computational Processes (question 2 only)</th>
<th>Topic and Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve knowledge of “how to divide.” Carry out the procedure of long division.</td>
<td>Procedural knowledge/Problem solving—Ch. 12</td>
</tr>
</tbody>
</table>

Now we’re getting into the meat of the process. With little effort, we retrieve the information from memory that the word Aristotle refers to a human being, a historical figure from the distant past. Many people know little else about Aristotle than the fact that he was a Greek philosopher. Yet this seems to be enough, combined with what we know to be true of people in general, ‘to decide that he was probably just like everyone else—he had two hands. Those who consider Aristotle Onassis seem to reach the same stage as well. Even though they may know a few facts about this more contemporary person (Greek shipping magnate, married Jacqueline Kennedy), they probably find no specific information in memory concerning the number of hands he had, so they make the default assumption that it was two. Think of the uncertainty you might have felt if the question had asked “How many hands does Aristotle have?” Tipped off by the present tense, would you have searched your memory for a still-living person named Aristotle; would you have explicitly asked yourself if Aristotle

Onassis was dead or not; or would you have tried to find some unusual, maybe metaphorical way of interpreting the question?

At a final (for now) stage, people report a set of thoughts and judgments that involve the “reasonableness” of the question, similar in many respects to the interpretations of remarks in a conversation. In general, people do not ask obvious questions, at least not to other adults. If they do ask obvious questions, however, it is often for another reason—a trick question, for instance. Consequently, students report that for a time they decided that maybe the question wasn’t so obvious after all; in other words, there was a return to memory, to see if there is some special knowledge about Aristotle that pertains to his hands. The next step is truly fascinating; the majority of students claim to have thought to themselves “No, I would have known about it if he had had only one hand,” and decide that indeed it was an obvious question after all.

This “lack of knowledge” reasoning process is itself a fascinating topic in cognitive psychology, since so much of our everyday reasoning is done without benefit of complete knowledge. In an interesting variation, I have asked students “How many hands did Beethoven have?” The specific knowledge of Beethoven’s musical fame typically leads to the inference that “since he was a musician, he probably played the piano, and he couldn’t possibly have been very successful at it with only one hand; therefore, he must have had two.” An occasional student will even go further, with the intriguing answer “Two—but he did go deaf before he died.” This is a very interesting response. Some students found a connection between the physical handicap implied by the question “How many hands?” and a relevant shred of evidence in memory, Beethoven’s deafness. Such an answer shows how people can also consider implications, inferences, and other unstated connections as they reason and make decisions. The answer also illustrates the role of prior knowledge in such reasoning, where the richer body of information about Beethoven can lead to a more specific inference than was possible for the Aristotle question.

While this informal analysis does not in any way exhaust the discussion of cognitive processes in reading, memory retrieval, or comprehension, it does serve to orient you to some of the important features of cognitive psychology and its subject matter. Let’s continue with the other questions to see what else is in store for you in this book.

2. What is 723 divided by 6?

This question clearly relies on a different kind of knowledge than the Aristotle question; knowledge of arithmetic that you learned in grade school. Just as true in reading the words in the first question, many of your mental processes happened more or less automatically for the division problem—identifying the digits, accessing your knowledge of arithmetic procedures, and so forth. Yet, you were also no doubt consciously aware of the problem-solving steps in doing long division—divide 6 into 7, subtracting 6 from 7 to get the first remainder, bring down the 2 and then divide 12 by 6, etc. These steps suggest that we should add a different
kind of process to Table 1-1, something on the order of “computational processes” that would include your knowledge of how to do long division. Cognitive psychology is no less interested in your mental processing of arithmetic problems, or in the knowledge you acquired in school, than it is in the informal reasoning processes you used for Question 1. In other words, the fact that you were explicitly taught how to divide doesn’t make your mental processes less interesting to study. If anything, it may make them more interesting, since we might be able to find parallels between classroom teaching methods and people’s mental processes.

The third question is in many ways more typical of cognitive psychology’s interests and research than the first two. For reasons that will become more convincing throughout the book, a great deal of research in cognitive psychology has timed people as they make yes/no decisions about questions such as the following:

3. Does a robin have wings?

Unlike the first two examples, most adults find themselves unable to say much of anything about the train of thoughts they considered when answering this question. Indeed, many people insist, “I just knew the answer was yes.” (In honesty, many people also question the sanity of an investigator who asks such trivial questions.) One purpose of the informal analysis for Question 1 was to illustrate just how much of our cognitive processing can occur below the level of awareness; in other words, automatically. As you can no doubt guess by now, cognitive psychology does not find the notion that “I just knew it” to be a particularly useful scientific explanation, however certain you are that no other thoughts occurred to you. Clearly, you had to read the words, find their meanings in memory, check the relevant facts, and make your decision in a similar fashion to the previous examples. Each of these steps (and there are many more steps involved here) is a bona fide mental act, the very substance of cognitive psychology. Further, each step takes some amount of time to be completed. A sentence such as Question 3 takes adults about 1.3 seconds to answer; the question “Does a robin have feet?” takes longer, around 1.5 seconds. Even such small time differences can give us a wealth of information about mental processing and human memory.

What does seem strikingly different for Question 3, compared to the first two, is that virtually none of the mental processes required much in the way of awareness or conscious activity—the question seems to have been processed automatically. Because such automatic processes are so pervasive in mental activity, cognitive psychologists are particularly interested in understanding them. Before you continue reading, you may want to speculate a bit on the following questions: Did all automatic processes start out as conscious ones? Do we necessarily lose awareness of a process just because we can perform it automatically? Can any mental process become automatic? When might our automatic processes be disrupted?

\* Memory and Cognition Defined

Now that you have developed an idea of the topics we are concerned with in cognitive psychology, we need to state more formal definitions of the terms memory and cognition. It will also be useful to spend a moment discussing the subjects you will and will not find covered in this text.

Most of us have a reasonably good idea of what the term memory means, something like “being able to remember or recall” some information. As defined in Webster’s New World Dictionary, memory consists of “the power, act, or process of recalling to mind facts previously learned or past experiences.” Notice that both of these definitions are distressingly circular; memory is “being able to remember,” or “the process of recalling to mind.” While this circularity is unfortunate, the definitions do point to several critical ideas, however.

First, the event or information being recalled from memory is one from the past. In other words, we “remember” things from the past, but “experience” things in the present. Quite literally, any past event that is currently recalled is evidence for memory—even those very recent events of the last second or two. Second, memory usually refers to a process, a mental act in which stored information is recovered for some current use. It is this recovery or retrieval of what has been placed in memory that specifies the process of interest, a “getting out” of what was previously “put in.” Notice that the term retrieval here includes both varieties of remembering, the conscious, intentional “recalling to mind” implied in Webster’s definition, as well as the more automatic (or even unaware) kind of retrieval discussed in the examples above.

Finally, the term memory also refers to a place, a location where all the events, information, and knowledge of a lifetime are stored. This sense of the word, made more popular no doubt by the advent of computers, is especially evident in those models and theories of cognition that rely on divisions such as short-term and long-term memory. While it is surely true that there is indeed some physical location within your brain where each known fact is stored, we are not necessarily trying to pinpoint a physical structure or mechanism in the brain that corresponds to the various memory systems or processes. Instead, this “location” sense of the word is usually taken somewhat metaphorically; regardless of anatomy and physiology, there is some “memory system” that holds information for later retrieval.

Let’s offer a formal definition of the term memory now—one that captures the essential ingredients of the discussion above. Consider memory

\* Etymologically, the circularity may be unavoidable. The words memory, remember, mental, and mind all developed from related Indo-European bases, meaning “to think” and “to remember.” The base of the word cognition means “to know.” In our modern usage, cognition refers more to the processes of thinking, and memory more to the knowledge we have acquired and stored. (All etymological sources throughout the book are from Webster’s New World Dictionary of the American Language, unless otherwise noted.)
than change the definition, we will merely assume that cognition usually refers to those customary, commonplace mental activities that most people engage in as they interact with the world around them. (Some very interesting evidence about cognitive functioning has also been obtained from clearly abnormal individuals, for instance those with various brain disorders and dysfunctions; chapter 13 presents part of this research.)

What you will find in this book is a presentation of cognitive psychology's current interests and activities. As mentioned, a surprisingly large number of topics have been of interest to researchers in this field. Since cognitive psychology is a fairly recent creation, it is probably quite desirable that we cast a rather broad net at the outset as we fish for topics to investigate.

Nonetheless, there are still omissions, sometimes glaring and sometimes not. To the distress of some (e.g., Neisser, 1976), most of our research deals with the sense modalities of vision and hearing, and very little with the other sensory ways of knowing the world. More disturbing, probably, is our reliance on seemingly sterile experimental techniques and methods (this is Neisser's more substantive criticism), techniques that ask rather simple questions and may therefore yield overly simple views about the operation of cognitive systems. In Neisser's terms, much of our cognitive research lacks ecological validity, meaning that it is not representative of the real-world situations in which people think and act. As a simple example, imagine how different your reading and comprehension processes would be if you were shown this paragraph one word at a time, each word for only a fraction of a second. The method would prevent you from slowing down when your comprehension lagged, from returning your gaze to a previous word or sentence you may have misinterpreted, and so on. And yet, this very method has been used to investigate reading and comprehension.

While Neisser's criticism was sensible, it was also possibly premature. We find great complexity in cognitive processing, even when artificially simple tasks are performed. At our current level of sophistication, we truly might be overwhelmed if our tasks were also permitted to be more complex, or if we tried to investigate the full range of a behavior in all its detail and nuance. In other words, at the beginning of an investigation it is reasonable for scientists to take a reductionistic approach to complex events, attempting to understand them by investigating their components. After all, an artificially simple situation can sometimes reveal rather than obscure a process, and sometimes we gain insight by preventing a process from occurring in its regular fashion (see Mook, 1983, for a useful discussion of the entire issue of ecological validity). Of course, it is also reasonable to expect that scientists will eventually put the parts back together again and deal with the larger event as a whole. To the extent the research permits, this book will present both the component processes that have been investigated and the larger aspects of cognition built out of those components. You can judge whether Neisser's decade-old criticism is still valid today.
An Introductory History of Cognitive Psychology

Having presented cognitive psychology to you first by example, then by definition, we now present it in terms of its history and development. This treatment should give you a better appreciation of what cognitive psychology is, and how it became so (more thorough presentations of this material are listed in the Suggested Readings at the end of the chapter). Figure 1–1 summarizes the main patterns of influence that produced cognitive psychology. As you read, study the figure to decide which pathways indicate positive influences, where ideas and questions from an earlier movement continued to inspire the approach that followed, and which pathways indicate negative influences, where the later approach specifically rejected elements of its predecessor.

To a remarkable extent, the scientific study of human memory and cognition is new—the relevant body of work and theorizing, with only a handful of exceptions, has been created within the last 30 or 35 years. And yet, as is true of most topics in psychology, interest in human memory and cognitive processes is as old as recorded history. Aristotle, born in 384 B.C., considered the basic principles of human memory and proposed a theory of memory in his treatise De Memoria (Concerning Memory; Hothersall, 1984). Even a casual reading of ancient works such as Homer’s Iliad or Odyssey reveals that people have always been curious about how the mind works, how to improve its functioning, or even how to influence someone else’s thoughts and behavior (is there a single character in Homer’s poems who didn’t at one point or another try a little apple-polishing with the gods?). Philosophers of every age, from Plato to the present, have considered questions of the nature of thought and memory. Descartes even decided that the ultimate proof of human existence is our awareness of our own thought—Cogito ergo sum, “I think therefore I am” (Descartes 1637, p. 52, in Hothersall, 1984, p. 28). Given this preoccupation with thought and mind in Western culture, it is no wonder that Ebbinghaus’s comment “Psychology has a long past but only a short history” (1910) is so widely repeated in histories of psychology.

It is without doubt crude, simplistic, and even egocentric of psychologists to lump all of recorded history up until 1879 as the “pre-psychology era,” dwelling in great detail only with the period 1879 to the present. And yet this is what we do. In 1879, Wilhelm Wundt established the first laboratory for psychological experiments. Of course, several notable individuals had already begun what was later seen as research on psychological topics—Weber and Fechner’s work in psychophysics and Helmholtz’s discoveries about the speed of neural impulses, for instance.

There was even a laboratory established by William James, the American psychologist, in 1875, although it apparently was used largely for classroom demonstrations rather than experimental studies. Despite these developments, there is a general consensus that the date of 1879 marks the beginning of the formal academic, empirical discipline of psychology, a separate discipline from either philosophy or physiology. Wundt, of course, built his work on the advances that came before him, developments that gave rise to psychology and psychological research. It is these developments we turn to now.

---

4 Hothersall’s History of Psychology (1984) in this section. And my intellectual debt to Lachman, Lachman, and Butterfield (1979), especially on the development of cognitive psychology, is even more extensive. Readers should consult this source to flesh out my sketchy summary of this influential analysis.

---

5 Watson (1968) points out that James and Wundt both established their labs in 1875 and insists that the 1879 date is notable only “for the appearance of the first student to do publishable psychological research with Wundt” (p. 266). Hothersall, on the other hand, suggests that the 1875 Wundt lab was largely for classroom demonstration purposes, with experiments independent of such demonstrations beginning only in 1879. The American Psychological Association has given its blessing to the 1879 date, and we celebrated the centennial of Psychology in the year 1979.
Anticipations of Psychology

Let's begin with Aristotle, who for two reasons is the historical "first" we typically point to in psychology. Aristotle is generally viewed as the first philosopher to have advocated an empirically based "natural science" approach to understanding. While he was certainly not the only great thinker to have insisted on observation as the basis for all science, he did "get there first" with this fundamentally important idea. Secondly, Aristotle's inquiry into the nature of thought and mind by his own natural science method led him to a reasonably objective explanation of how learning and memory take place. This explanation could not truly be considered a theory of memory, by modern standards, nor should we expect it to be. On the other hand, the basic principle that Aristotle identified, that of associations, has certainly figured prominently in most psychological theories of the past century.

Equally important to psychology as a whole was Aristotle's insistence that the mind is a "blank slate" at birth, a tabula rasa or clean sheet of paper (Watson, 1968; this term is also frequently translated as the "wax tablet"). This notion claims that the experiences of the individual are of paramount importance, since experience, rather than inborn factors, "writes" a record onto the blank paper. It is possible that no other issue has so preoccupied philosophers of all ages, an issue we refer to as the "nature/nurture" or "heredity/environment" debate. In cognitive psychology, we encounter the controversy in several places, most notably when we discuss theories of language acquisition.

Most of the other anticipations of psychology date from the Renaissance period and after and largely consist of developments in the area of scientific methods and approaches. By the time of the mid-1800s, positions such as Descartes's "rational" approach had been discarded by scientists, in favor of observational or empirical methods. Thus, by the time psychology was "invented," the general procedures of scientific inquiry had been developed and were, for the most part, accepted by all scientific disciplines and areas. There was widespread agreement on the need for science to be based on objective procedures and methods such as careful quantification and definition, empirical observation, and so forth; of course, this agreement continues through today's scientific enterprises as well. Given the obvious progress made in scientific fields such as physics, biology, and medicine by the mid-1800s, it is not surprising that a "science of the mind" was viewed as a distinct possibility by the early psychologists.

Early Psychology

Four early psychologists are of particular interest in our study of cognitive psychology. They are Wilhelm Wundt, Edward Titchener, Hermann von Ebbinghaus, and William James.

Wilhelm Wundt

To a large extent, the early psychologists were students of Wilhelm Wundt (1832–1920). Beginning in 1875, when he moved to the University of Leipzig, Germany, he directed over 100 doctoral theses on psychological topics. Such important psychologists as William James, Hugo Munsterberg, Charles Spearman, James McKeen Cattell, and Edward Titchener studied with Wundt, investigating primarily those topics that Wundt felt were appropriate to the new "science of the mind." With such an array of students, it is no wonder that Wundt was a highly productive researcher. His book, Principles of Physiological Psychology, was continually updated, reporting the new results obtained in his laboratory. He also founded the first journal devoted to psychological research, Philosophical Studies (neither of these titles seems quite accurate, according to modern connotations of the terms). His influence was far reaching, since his was the first truly psychological system. Unfortunately for the future of psychology, Wundt's interests in the last 20 years of his career have gone largely unrecognized until quite recently. His work on language, child psychology, and other topics was virtually rejected by Titchener, who believed these topics simply did not belong in psychology. Such an attitude was probably strengthened by Wundt's own conclusion that these broad areas could not be studied experimentally.

In the early Leipzig years, Wundt was apparently rather dogmatic in choosing research problems for his students, believing that the proper topic for psychology to study was "conscious processes and immediate experience" (today, we would place these topics somewhere near the areas of sensation, perception, and attention). To study such processes in a scientific manner, an approach Wundt was thoroughly dedicated to, he devised the methodology of selbst-beobachtung. Translated literally as "self-observation," this method of investigation is generally known in English as introspection, a method in which one looks carefully "inward," reporting on inner sensations and experiences. By all accounts, Wundt intended this to be a carefully controlled, highly reliable, and, above all, scientific method. For instance, Hothersall (1984) notes, "Wundt's introspection was a rigidly controlled, arduous, experimental procedure.... To yield valid introspections Wundt insisted that certain rules be enforced: the observer had to be 'master of the situation,' that is, in a state of 'strained attention,'.... All observations were to be repeated many times; and finally, experimental conditions were to be varied systematically to allow a general description of mental contents" (pp. 88–89). The observers in these experiments required a great deal of training in the method, so that they would report only those elements of experience
that were “immediate” and conscious. Reports in which memory intruded
(Wundt’s term was mediate experience) were excluded.

**Edward Titchener** For American psychology in Wundt’s tradition,
the most important figure was Edward Titchener, an Englishman who
came to Cornell University in 1892 to direct its psychology laboratory.
Titchener’s work with Wundt had convinced him that psychology’s
knowledge was obtainable only with the introspective method. As his
career at Cornell progressed, Titchener became even more firm in
his conviction and even more narrow in his definition of psychology.
Questions with mental illness, educational applications, social psychology,
and other areas (including Wundt’s broader interests as well) were “impure,”
since they could not be studied with introspective methods. Like Wundt,
Titchener insisted on careful control and rigorous training for his introspectors,
who were required to avoid what Titchener called “the stimulus error” of
describing the physical stimulus rather than the mental experience of that
stimulus. Moreover, “Certain introspections were defined as correct, and
certain others as in error, with the final authority being Titchener himself”
(Protzmann, 1984, p. 105). By these means, Titchener studied the
structure of the conscious mind, the sensations, images, and feelings that
were the very elements of the mind’s structure. The term he used to
describe this psychology was **structuralism**, the first major movement
or school of psychological thought (see Figure 1–1).

As you might expect, such an exclusive system of psychology, relying
as it did on the ultimate authority of Titchener to validate its observations,
was destined for difficulties. As other researchers applied the introspective
methods in their own laboratories, differences and contradictory
results began to crop up. For instance, a controversy developed over
imageless thought; researchers of the Wurzburg School found evidence
for imageless thought in their studies, but Titchener found no such evidence
in his own studies. Consequently, Titchener claimed that the Wurzburg
researchers’ findings were merely the product of sloppy research and
poorly trained observers. A similar dispute ensued over sensory and motor
reaction times, again with Titchener rejecting the contradictory findings
as the result of poor methodology (in this dispute, Titchener’s biggest
complaint was that the subjects had been untrained observers. He would
surely have disapproved of modern insistence on naive volunteers from
Intro Psych.). As these discrepancies multiplied, the influence of Titchener’s
structuralism began to decline.

**Hermann von Ebbinghaus** In contrast to the doomed structuralism
of Wundt and Titchener, there was the theoretically modest but
eventually more influential work of Hermann Ebbinghaus (see chapter 5).
Ebbinghaus was a contemporary of Wundt’s in Germany, although he
never studied with Wundt in person. In fact, Ebbinghaus’s achievements
in studying human memory and forgetting are all the more impressive
largely because he worked outside of the “establishment” of the time.

Watson (1968) notes that Ebbinghaus was familiar with Wundt’s writings,
but if anything viewed Wundt’s pessimism about studying higher mental
processes as a challenge rather than a deterrent to pursuing that work.
Historical accounts suggest that Ebbinghaus read Wundt’s book, decided
instead that a study of the mind by objective, experimental methods was
possible, and set about the task of figuring out how to do it.

Lacking a formal laboratory, and serving in a nonpsychological aca-
demic position with no similar-minded colleagues, Ebbinghaus was forced
to rely on his own resources to study memory, even to the extent that he
alone served as a subject in his research. Ebbinghaus’s goal was to study
the mind’s process of association formation, using thoroughly objective
methods. He reasoned that for this goal to be accomplished, he needed to
use materials that had no preexisting associations. Thus, the first step in
his method involved the construction of stimulus lists of “nonsense syllable”
of CVCC, consonant-vowel-consonant stimuli that, seemingly by
definition, were of uniform meaningfulness—to wit, they had no meaning
whatsoever. Following this, Ebbinghaus would learn a list, say of 16 items.
to an arbitrary criterion of mastery, say two perfect recitations, then set
the list aside. On some later occasion, he would relearn the list, noting how
many fewer trials he needed for relearning to the same criterion. The mea-
ure of learning in these studies was the “savings score,” or the number of
trials that had been “saved” in memory between the first and second ses-
sions. By this method, Ebbinghaus examined forgetting as a function of
time, that is the amount of time intervening between the two learning
sessions, and to an extent the effect of nonsense versus meaningful mate-
rial (he compared forgetting curves for his syllables to those for the
forgetting of meaningful poetry).

Ebbinghaus’s methods and results, described in his 1885 book, were
acclaimed widely as the very model of scientific inquiry into the processes
of memory; for instance, Titchener praised Ebbinghaus’s work as the most
significant progress in studying associations since Aristotle (1919; cited in
Hall, 1971). Indeed, it is difficult to point to another psychologist of his
day, aside from Freud, whose specific contributions or methods continue
to be used. It is certainly true that the field of verbal learning, throughout
the 20th century, owed a great deal to Ebbinghaus—after all, he alone
seems to have discovered a reasonably scientific, enduring method to
study memory and mental processes. The Ebbinghaus tradition, depicted
in Figure 1–1, is in many ways the strongest of all the influences on cog-
nitive psychology; no other influence in the figure is as positive as this 100-
year-old tradition begun by Ebbinghaus. Yet Ebbinghaus himself partici-
pated in no formal “school” of psychology, and his later work veered in
the direction of intelligence testing in educational settings.

**William James** The American philosopher and psychologist Wil-
liam James, a contemporary of Wundt, Titchener, and Ebbinghaus, pro-
vided at Harvard an alternative to Titchener’s rigid and inflexible system.
His approach to psychology was a kind of **functionalism** in which the
functions of consciousness, rather than its structure, were of interest. Thus, James was interested in questions such as “how does the mind function?” and “how does it adapt to new circumstances?”—not in issues such as “what are the elements of the mind’s structure?”

James’s rather informal analyses led to some strikingly useful observations on a variety of topics in psychology. To note one of interest to cognitive psychology, he proposed that memory consisted of two parts, an immediately available memory of which we are currently aware, and a larger memory, usually hidden or passive, that is the repository for past experience. The notion of a memory system divided into several parts, based on their different functions, is a widely popular idea today. Indeed, the first serious models of human information processing included exactly the two kinds of memories that James had discussed.

Probably because of his personal distaste for experimentation and his far-reaching interests beyond the topic of memory, James seems not to have espoused the Ebbinghaus methods of studying memory, although he apparently had high regard for Ebbinghaus’s work. Titchener no doubt dismissed James and his writings, since James was only a “half hearted” researcher (Boring, 1950). Nonetheless, James’s writings, partly because of his breadth of interest, have been far more influential to the whole of psychology than any of Titchener’s work (see Miller’s introduction to the 1983 edition of James’s 1890 book).

Given psychology’s course of development, however, James’s influence on the psychology of human memory and cognition was considerably delayed. For it was John B. Watson, in 1913, who stridently proclaimed the new direction of American psychology, a direction that specifically rejected both the structuralist and functionalist approaches, a direction that also rejected many of the previous concerns of psychology. This new direction, of course, was behaviorism.

Behaviorism and Neobehaviorism

To begin with, it is a mistake to suggest that the entirety of American psychology from 1910 to 1960 was completely and thoroughly behaviorist in its viewpoint. During this period, the fields of clinical, educational, and social psychology, to name just a few, continued in their own develop-

ment. As just one example, Freud’s theory of personality, and the various developments in clinical application of personality theory, continued throughout this period, largely unconcerned with the behavioral approach to psychology. In a sense, these other branches of psychology developed in parallel to behaviorism—they were contemporary fields with little contact or mutual influence. Experimental psychology, however, has traditionally been the discipline of researchers concerned with learning, memory, perception, thought, and related topics. It was these psychologists, mostly in academic settings, who were responsible for the birth and rearing of behaviorism and for its eventual status as the dominant force in academic, experimental psychology.

Everyone who has taken introductory psychology knows of John B. Watson, the early behaviorist who offered: “Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I’ll guarantee to take any one at random and train him to become any type of specialist I might select—doctor, lawyer, artist, merchant, priest, and yes, even beggarman and thief, regardless of the talents, penchants, tendencies, abilities, vocations, and race of his ancestors.” (Watson, 1924, p. 104) It is clear from such quotations that Watson viewed experience as the primary factor in determining even the largest aspects of one’s behavior (Watson admitted he was exaggerating, in his next sentence). Rarely in the history of science has anyone taken so extreme a position on the nature/nurture issue as Watson did (histories of psychology note that this extremism was not characteristic of his early, scholarly works, but was typical of his later writings, as his views on the importance of experience versus instinct changed in the direction of “environmentalism,” the supremacy of learning over innate factors).

Watson’s firm belief was that behavior, not the fuzzy and unscientific concepts of thought, mind, and consciousness, was the ultimate topic of psychology. He viewed any and all attempts to understand such “unobservable” as mind and thought as inherently and hopelessly unscientific and offered observable stimuli that caused it, as the proper focus of psychological research (indeed, many psychologists still feel a little queasy using the term mind, preferring instead the more scientific sounding memory and mental processes). Thus, behaviorism was the scientific study of behavior—that is, observable, quantifiable behavior; there was no room in behaviorism for hidden or internal mental processes, since behavioral laws were supposed to relate observable behavior to objective, observable stimulus conditions within the environment. To Watson, then, being a doctor was merely a matter of learning appropriate “doctor behaviors.” No appeal to the mind, to innate abilities, or to mental activities was at all necessary.

Part of Watson’s enthusiasm for a psychology of behavior, and his belief that a science of behavior was a reasonable goal, was his familiarity with the work that Pavlov was doing on learning. Here was a definite, scientific methodology and approach that were going somewhere. In con-

---

*I am treating behaviorism and neobehaviorism here as if they were identical, which is clearly an oversimplification. The basic difference between behaviorism and neobehaviorism was that the neobehaviorists included a limited number and kind of “internal” and unobservable mechanisms in their theories, while the earlier behaviorists (and Skinner, for that matter) restricted themselves only to observables. These internal mechanisms, however, were quite different from those proposed by cognitive psychology. A classic example was Hull’s intervening variable of habit strength, s (e.g., 1943). While habit strength was technically unobservable, it was nonetheless tied explicitly to both observable stimulus conditions (for instance, the frequency of stimulus presentation) and observable response measures (for instance, the quickness of a subject’s response to a stimulus). This sort of unobservable was a true intervening variable, in that it was interposed between the stimulus and the response, but was clearly not a mental mechanism or process which “came from” the subject.*
with Bartlett of Great Britain a notable example, for the most part American experimental psychology focused instead on observable, learned behaviors, often those of animals. Even the decidedly cognitive approach of Tolman, whose paper “Cognitive Maps in Rats and Men” (1948) is still worth reading, included much of the behaviorist tradition—concern with the learning of new behaviors, animal studies, and interpretation based closely on the observable stimuli in an experimental situation. Gestalt psychology, which emigrated to the U.S. in the 1930s, always maintained an interest in human perception, thought, and problem solving, but never captured the loyalties of many American experimentalists (although we look back now at some of their research with greater respect).

Thus, the behaviorist viewpoint continued to dominate American experimental psychology until the 1940s, when B. F. Skinner emerged as one of its most vocal advocates. Much in keeping with Watson's earlier sentiments, Skinner has also argued that mental events such as thought have no place in the science of psychology—not that they are not real, necessarily, just that they are unobservable and unnecessary to a scientific explanation of behavior.

Dissatisfaction with Behaviorism: The Seeds of Cognitive Revolution

As we saw earlier, it is often difficult, if not impossible, to determine precisely when historical change takes place. We agree that 1879 saw the founding of academic, empirical psychology, yet we point to important research and even to books with “psychology” in their titles that predate 1879. It is even more difficult to pinpoint historical change when it is more recent and somewhat controversial. Nonetheless, many current psychologists look kindly on the idea that there was indeed a “cognitive revolution” in the mid- to late 1950s—an abrupt change in research activities and interests on the part of experimentalists. It is undisputably true that the experimental psychology of today is radically different from that of the '40s and '50s. Psychology seems to have “lost its head” during behaviorism's day in the sense that memory, thought, and other mental activities were largely ignored. Psychology of today has, to continue the figure of speech, "come back to its senses," though, and to its memory and mental processes as well.

Because of the nature and scope of these changes, many psychologists regard the current cognitive approach as a revolution against behaviorism, reflecting a widespread dissatisfaction with the lack of progress on impor-

---

1 One recent "way," a term we use when we don’t know the author of a remark, found Watson’s proposal so ludicrous that he said, roughly paraphrased, that “Watson whispered to himself about it, then made up his mind to act.” Having given up trying to find this quotation, I would appreciate any reader’s assistance.
Challenges Within Neobehaviorism

To neobehaviorism, the ultimate importance of learning—the acquisition of new behaviors by means of conditioning—was an absolute article of faith. This was psychology. While some behaviorists paid lip service to the notion of instincts, species-specific behaviors, and other nonlearned sorts of behavior, none of the various models or theories of learning gave serious consideration to these ideas. Speaking anthropomorphically, the animal subjects often thumbed their noses at such theoretical purity and proceeded to behave according to their own laws. Researchers began finding significant instances in which conditioned behaviors, supposedly under the control of reinforced learning, would begin to change in the direction of instinctive behavior. For instance, “The Brelands found instances in which animals did not perform as they should. In 1961, they reported their difficulties in a paper whose title, ‘The Misbehavior of Organisms,’ puns on Skinner’s first book, The Behavior of Organisms. For example, they tried to teach pigs to carry wooden coins and deposit them in a piggy bank. Although they could teach the behaviors, the Brelands found that the behavior degenerated in pig after pig. The animals would eventually pick up the coin, drop it on the ground and root it . . . [as if] ‘trapped by strong instinctive behaviors’ that overwhelm learned behaviors’ (Leahey, 1980, p. 357).

For the theoretical system of behaviorism, committed to the tabula rasa position that exalts learned behaviors, this was a serious difficulty. No ready explanation was available to account for this instinctive drift by means of the principles of reinforced learning. And incorporating instincts into the theories would have been a blunt admission that the laws of conditioning and learning were not general, that they were modified by other overpowering factors. To make matters worse, Skinner asserted that a theory of behavior was not even necessary, finding theory building to be somewhat of a distraction from the main business of gathering data. Such a position seemed to undermine the intense efforts that had been exerted in developing and testing theoretical positions such as Hull’s (e.g., 1943) or Tolman’s (e.g., 1948). Additionally, the formal theories were perceived by many to be going nowhere, to have merely degenerated into disputes that could not be resolved (Leahey, 1980). What an uneasy, unpleasant time to have been a behaviorist, beset by significant nonlearned behaviors, by unresolvable theoretical disputes, and by a position that asserted that theorizing was a waste of time!

World War II

Lachman et al. (1979; see also Broadbent, 1958) make an additional point concerning this growing dissatisfaction within the ranks of the neobehaviorists. They note that many academic psychologists were involved, in one capacity or another, with the U.S. war effort during World War II. Psychologists accustomed to studying animal learning in the laboratory were “put to work on the practical problems of making war . . . trying to understand problems of perception, judgment, thinking, and decision making” (p. 56). Many of these problems arose because of soldiers’ difficulties with sophisticated technical devices—pilots who crashed their aircraft, radar and sonar operators who either failed to detect or misidentified an “enemy blip,” and so forth.

Lachman et al. are quite succinct in their description of this situation: “Where could psychologists turn for concepts and methods to help them solve such problems? Certainly not to the academic laboratories of the day. The behavior of animals in mazes shed little light on the performance of airplane pilots and sonar operators. The kind of learning studied with nonsense syllables contributed little to psychologists trying to teach people how to operate complex machines accurately. In fact, learning was not the central problem during the war. Most problems arose after the tasks had already been learned, when normal skillful performance broke down. The focus was on performance rather than learning; and this left academic psychologists poorly prepared. . . .” (pp. 56–57). To quote Bruner, Goodnow, and Austin (1956), the “impeccable peripheralism” of stimulus-response (S-R) behaviorism became painfully obvious in the face of such practical concerns.

To deal with these practical concerns, wartime psychologists began to conceive of human behavior in a different fashion. The concepts of attention and vigilance, for instance, were important to an understanding of radar operators’ performance. Decision making was a necessary part of this performance too, and from these considerations came such developments as signal detection theory. Beyond this, these wartime psychologists also rubbed shoulders with professionals from different fields—those in communications engineering, for instance, from whom new outlooks and perspectives on human behavior were gained. Having seen firsthand how relatively impoverished the stock of tools was in their science of behavior, these psychologists returned to their laboratories after the war, determined to broaden their own research interests and those of psychology as well. Since they needed such mentalistic concepts as attention and decision making during the war, surely they needed them back home in the lab, and in their theories of human behavior.
Challenges from Outside

Aside from the influences of wartime activities, there were other traditions within experimental psychology that challenged neobehaviorism, notably verbal learning.

Verbal Learning The term verbal learning is the label attached to that branch of experimental psychology that deals with human subjects as they learn "verbal material," items or stimuli composed of letters or sometimes words. Earlier, the ground-breaking research of Hermann Ebbinghaus was mentioned, in which desirably objective methods for studying human memory were invented and used. This work started the verbal learning tradition within experimental psychology (see chapter 5). Even casual examination of published articles during the '20s and '30s reveals a fairly large body of verbal learning research, with reasonably well-established methods of testing subjects. Tasks such as serial learning, paired-associate learning, and, to an extent, free recall were the accepted methods of investigation, using Ebbinghaus-inspired nonsense syllables.

It is somewhat peculiar to list verbal learning as a significant challenger from outside behaviorism, since in many ways the verbal learners held beliefs similar to those of the behaviorists. Those in verbal learning agreed on the necessity of using objective methods; although an occasional allusion to subjects' introspections was made, this was usually in the sense that they "confirmed" the conclusions drawn from more objective measures. There seems to have been widespread acceptance of the central role of learning as well. And yet, much like their forefather Ebbinghaus, the verbal learners were curiously atheoretical—their allegiance to behaviorism seems to have been only skin-deep. A modest amount of explanation by means of presumed mental activity was present in their work, but this was rather noncommittal. They were rather pragmatic, all in all, in their outlook on research and theory. If a result suggested further interesting research, then it was pursued; if an unexpected outcome was encountered, it did not particularly matter whether the outcome supported or refuted theoretical positions or preconceptions.

Such theoretical agnosticism, as it were, led to some unusual published reports. Let's consider an interesting example, a paper in the Journal of Experimental Psychology of 1935, by J. Ridley Stroop. This paper, "Studies of Interference in Serial Verbal Reactions," reported three experiments on the commonly investigated phenomenon of interference. While the verbal materials Stroop used were, by his own admission, "quite different from any that have been used to study interference" (p. 647), no radically different kind of behavioral interpretation or model was offered (nor is there any hint of the future importance of the paper to cognitive psychology). In the introduction, Stroop described a study in which the numbers on four typewriter keys were reassigned to different locations as a test of interference, and in the next paragraph nonchalantly discussed a T-maze discrimination study with white rats. The modern reader is surprised, to say the least, at such juxtapositions. His speculation about the slight sex differences he found, women being somewhat faster at naming colors than men since "discussing colors relative to dress is much more common among girls than among boys," is equally noncommittal.

Lachman et al. have argued that this atheoretical viewpoint in verbal learning circles made it quite easy for psychologists to accept the new cognitive psychology of the '50s and '60s—if you're not committed to a theory, you don't mind switching to another when the time comes. It clearly also made them more open-minded, to be frank. There were many indications in their results that an adequate psychology of human learning and memory needed more than just observable behaviors. For instance, the presence of meaningfulness in virtually any "nonsense" syllable had been acknowledged early on; Glaze (1928) entitled his paper "The Association Value of Nonsense Syllables" (and apparently did so with a straight face). At first, such troublesome associations were merely controlled in the experiments, to avoid contamination of the results. Later, it became apparent that the memory processes that yielded those associations were in fact more interesting to study than to control. Hall (1971) termed this the "new look" in verbal learning, with its greater emphasis on memory rather than learning processes.

In this tradition, Bousfield (1953) reported that, under free recall instructions, words that were associated with one another (e.g., car and truck) tended to "cluster together" in recall, even though they had been arranged randomly in the stimulus list. In this research, there was clearly the implication that existing associations in human memory led to the reorganization of the words during recall. Such obvious evidence for processes occurring between the stimulus and the response—in other words, mental processes—slowly led verbal learning to propose a variety of mental operations such as rehearsal, organization, storage, and retrieval. The lack of theoretical commitment to the behaviorist canon of antimentalism facilitated this change.

We can point to one outstanding achievement of the verbal learning tradition, however theoretically undeveloped the work was. To a very large extent, the researchers in the verbal learning area devised laboratory tasks of learning and memory that remain useful today. In their acceptance of the scientific need for objective procedures and methods, the verbal learners borrowed from Ebbinghaus's example of careful attention to rigorous methodology. From this they developed tasks that, we still agree, seem to measure the outcomes of mental processes in valid and useful ways. Some of these tasks, naturally, were more closely associated with behaviorism than others, for instance the paired-associate learning task. As such, these tasks lent themselves to tests of S-R associations in seemingly direct ways. They thus became somewhat overused. (Some have noted the popularity of the paired-associate task and the verbal learners' tendency to study performance on the task rather than the principles of...
human memory revealed by the task. A professor of mine likened this situation to “‘an archaeologist who studies his shovel.’”) Nonetheless, verbal learning gave cognitive psychology an objective, reliable methodology for studying mental processes and a set of inferred processes such as storage and retrieval to begin investigating. As such, the influence from verbal learning to cognitive psychology, as shown in Figure 1–1, was almost entirely positive, unlike the negative, “reacting against” influence from behaviorism to cognitive psychology.

**Linguistics** The changes in verbal learning from its early work to its merger with cognitive psychology around 1960 seem to have been quite evolutionary, a gradual shifting of interests and interpretations that blended almost seamlessly into cognitive psychology. In sharp contrast to this, the year 1959 saw the publication of an explicit and defiant, abrupt and revolutionary challenge to the dominant status of behaviorism. Watson’s 1913 paper has been called a “behaviorist manifesto,” sounding the charge against introspective methods and those who practiced them. To an equal degree, Noam Chomsky’s 1959 paper was a “cognitive manifesto,” an utter rejection of purely behaviorist explanation of that most human of all behaviors—language.

A bit of background is necessary in order to appreciate the significance of Chomsky’s paper. In 1957, B. F. Skinner published a book entitled *Verbal Behavior*, a treatment of human language from the behaviorist standpoint of reinforcement, stimulus-response associations, extinction, and so forth. His central point in this book was that the psychology of learning, largely the conditioning of new behavior by means of reinforcement, provided a useful and scientific account of human language use. In oversimplified terms, Skinner’s basic notion was that human language use, that is, verbal behavior, followed the same laws of learning that had been discovered in the animal learning laboratory: A reinforced response is expected to increase in frequency, a nonreinforced response should extinguish, a response conditioned to a certain stimulus should be emitted to the same stimulus in the future, and so forth. In principle then, human language, obviously a learned behavior, can be explained by the same sort of mechanism as any learned behavior—with knowledge of the current reinforcement contingencies and past reinforcement history of the individual.

Noam Chomsky, a linguist at M.I.T., reviewed Skinner’s book in the journal *Language* in 1959. The very first sentence of his review notes that many linguists and philosophers of language had “expressed the hope that their studies might ultimately be embedded in a framework provided by behaviorist psychology,” and as such were interested in Skinner’s formulation. Chomsky alluded to Skinner’s optimism that the problem of verbal behavior would yield to behavioral analysis, since the reinforcement principles discovered in the animal laboratory “are now fairly well understood . . . [and] can be extended to human behavior without serious modification” (Skinner, 1957, cited in Chomsky, 1959, p. 26).

And yet on the third page of his review, Chomsky states that “the insights that have been achieved in the laboratories of the reinforcement theorist, though quite genuine, can be applied to complex human behavior only in the most gross and superficial way. . . . The magnitude of the failure of this [Skinner’s] attempt to account for verbal behavior serves as a kind of measure of the importance of the factors omitted from consideration. . . .” (p. 28, emphasis added). The fighting words continue: Chomsky asserted that if the critical terms *stimulus, response, reinforcement,* etc., are used in their technical, animal laboratory sense, then “the book covers almost no aspect of linguistic behavior” (p. 31) of interest. His central theme was that Skinner’s account used the technical terms in a non-technical, metaphorical way, which “creates the illusion of a rigorous scientific theory [but] is no more scientific than the traditional approaches to this subject matter, and rarely as clear and careful” (pp. 30–31).

To illustrate his criticism, Chomsky notes the careful operational definition of “stimulus” that Skinner provides in the animal learning laboratory, say, the onset of a light to signal the animal that a response will be followed by reinforcement. When the animal responds, say, with a bar press, we conclude that the response is under stimulus control; since the response is reinforced, it is thereby strengthened. Turning to language, what shall we make of the verbal response “Dutch” made to a painting the individual sees? In Skinner’s view, Chomsky explained, the response is “under the control of extremely subtle properties” (p. 31) of the stimulus painting. “But what properties?” Chomsky demanded, since the individual might just as easily have responded, “Clashes with the wallpaper. . . ., Tilted, Hanging too low, Beautiful” (Chomsky, 1959, p. 31) and so on. Skinner would be forced to claim that other subtle properties were involved since other responses were emitted. And yet, Chomsky notes, this is a dogmatic, rather than scientific, explanation—Skinner has not demonstrated what these other properties might be, or how they might have come to be conditioned to different responses. Instead, he has just declared that this is what must have happened.

Not surprisingly, Chomsky is no kinder to Skinner’s position when he analyzes the terms *response, reinforcement,* and so on. Unlike the distinct and observable pellet of food in the Skinner box, Skinner claimed that reinforcement for verbal behavior can be administered by the individual himself (self-reinforcement), delayed for indefinite periods, or even never be delivered at all, as in the case of a writer who anticipates that her work may be read for centuries. When an explicit and immediate reinforcer in the laboratory, and its effect on behavior, is generalized to include nonexplicit and nonimmediate (and even nonexistent) reinforcers in the real world, it truly does seem, as Chomsky argued, that Skinner had brought along the trappings of a scientific explanation but left the sub-
stance behind. As Chomsky bluntly put it, "A mere terminological revision, in which a term borrowed from the laboratory is used with the full vagueness of the ordinary vocabulary, is of no conceivable interest" (p. 38).

Chomsky's own position on language, emphasizing the novelty of human language and the internal rules for language use, will be discussed in chapter 8; there, the strong influence of linguistics on cognitive psychology (Figure 1–1) will be described in some detail. For now, the essential message involves the impact Chomsky's review had on experimental psychology. As Lachman et al. (1979) point out, this was not a dispute that could be easily dismissed by psychologists as irrelevant. No—language was an important behavior to understand. A psychology that offered no help in understanding such an important behavior was useless, not to mention embarrassing. To a significant number of individuals, Chomsky's arguments made compellingly good sense. For these individuals, the irrelevance of behaviorism to the study of language, and by extension, to the study of any significant human behavior, was a crisis. In combination with the other developments, the wartime fling with mental processes, the verbal learning expansion of the catalog of such processes, and the disarray within behaviorism itself, it was clear that a new direction for psychology was needed.

Cognitive Psychology and Information Processing: The New Direction

If we had to pick a date that marks the beginning of cognitive psychology, one that indicates as accurately as possible when cognitive psychology started, we might pick 1960. This is not to say that significant developments in the study of cognition weren't present before this date, for they were. This is also not to say that most experimental psychologists who studied humans "became" cognitive psychologists that year, for they didn't. As with any such change in orientation, it takes a while for the new approach to catch on, for the people to learn the new rules, to feel free to speak the new language, and, indeed, to decide that the new direction is worth following. Several significant events clustered around the year 1960, however, events we look back on from our short period of hindsight as having been significant departures from the mainstream that came before. Just as 1879 approximates the formal beginning of psychology, and 1913 the beginning of behaviorism, so 1960 seems to approximate the beginning of cognitive psychology in its modern form. Let's pick up the threads of what came before this date, to see what the new cognitive psychology and information processing approaches were all about. One of the most significant threads, of course, was Chomsky's 1959 review; such a forceful argument against a purely behaviorist position could not be ignored. Chomsky argued that the truly interesting part of human language, indeed the very key to understanding it, was exactly what Skinner had omitted from his book—mental processes. Chomsky also argued that language users follow rules when they generate language—rules that are stored in memory, rules that imply mental processes. The so-called empty organism psychology of stimulus-response connections was empty in the sense that behaviorists did not deal with properties of the organism that come between the physical stimulus and the behavioral response. In Chomsky's view, it was exactly there, in the organism, where the key to understanding language would be found.

To a large extent, researchers in verbal learning and other fields were making the same claim. As noted, Bousfield (1953) found that subjects cluster or group words together on the basis of associations among the words. Memory, and a tendency to reorganize on the part of the subject, were clearly involved in this performance. Where were these associations? Where was this memory? And where was this tendency to reorganize? They were in the subject, of course, in human memory and mental processes. A particularly clear statement of the involvement of a subject's mental processes appeared in Tulving's 1962 paper, "Subjective Organization in Free Recall of 'Unrelated' Words." Even when the words to be learned were unrelated, subjects still reorganized them, a strategy for recall that was clearly coming from within the organism. During the 1950s, there were reports on human attention, first from English researchers such as Cherry, that were thematically related to the wartime concern with attention and vigilance. Again, fascinating attentional and perceptual processes were being isolated and investigated, processes whose unseen, mental nature could not be denied, and yet whose existence could not be denied either. A classic paper in this area, Sperling's monograph on visual sensory memory, appeared in 1960.

---

8Skinner, for one, is certain that this new direction is absolutely wrong. For instance: "Cognitive psychology is causing much more trouble (than humanistic psychology), but in a different way. . . . The word cognitive is sprinkled through the psychological literature like salt—and, like salt, not so much for any flavor of its own but to bring out the flavor of other things, things which a quarter of a century ago would have been called by other names [like learning]. . . . Cognitive psychology is frequently presented as a revolt against behaviorism, but it is not a revolt; it is a retreat to scientific language" (Skinner, 1964, pp. 948–50).

---

9Gardner (1985) states, "There has been nearly unanimous agreement among the surviving principals that cognitive science was officially recognized around 1956. The psychologist George A. Miller has even fixed the date, 11 September 1956" (p. 28). Miller recalls a conference from September 10–12, 1956, at M.I.T., attended by leading researchers in communication and psychology. On the second day of the conference, there were papers by Newell and Simon on the "Logic Theory Machine," by Chomsky on his theory of grammar and linguistic transformations, and by Miller himself on the capacity limitations of short-term memory. Others that Gardner cites suggest that, at a minimum, the five-year period 1955–60 was the critical time during which cognitive psychology emerged as a distinct and new approach. By analogy to psychology's selection of 1870 as the starting date for the whole discipline, however, 1960 is special in Gardner's analysis—in that year, Jerome Bruner and George Miller founded the Center for Cognitive Studies, at Harvard University.
Possibly the single most startling development of this period, certainly in terms of its impact on society, was the invention of the computer. Initial work had begun in the Forties on what we now call computer science, although philosophers had conceived of such a machine in general terms long before the technology existed to build one. At some point during the Fifties, a few psychologists realized the possible relevance of computing machinery to issues in psychology. It dawned on psychology, in a sense, that in some interesting and possibly useful ways, computers behave much like people. They take in information, do something with it internally, then eventually produce some observable product. The product, to a greater or lesser extent, reflects what went on during the “internal” phase. The various operations performed by the computer were not unknowable merely because they occurred internally, of course. They were in fact under the direct control of the computer program, the instructions given to the machine to tell it what operations to perform.

The realization that mental activity might be understood by using an analogy to this seemingly intelligent (or at least intelligent-acting) machine was a significant breakthrough. Consider the mentalistic notion of plans, for instance, suggesting some sort of intelligent consideration of alternatives, decisions among those alternatives, then implementation of the selected decision to solve a problem. Do people plan? Do people behave in problem-solving situations as if some plan had been followed? Can any scientific study of the unseen plan ever be conducted? “Why sure!” computer scientists and a few psychologists realized. We can program a computer to perform all of these steps, solving problems of some difficulty in what is viewed as an intelligent fashion. In some sense, then, we seem to have a “thinking machine,” a machine that behaves lawfully as it performs this mentalistic operation we call planning.

The computer, furthermore, is a symbol-manipulating machine—its operation involves interpreting the symbols fed to it in the computer program, then performing the operations that those symbols specify. The insight that the human mind might also be fruitfully considered as a symbol-manipulating “machine” or system is usually attributed to Allen Newell and Herbert Simon. Their conference in 1958, according to Lachman et al., had a tremendous impact on those who attended, for at this conference Newell and Simon presented an explicit analogy between information processing in the computer and information processing in humans (this important work, probably as much as anything he did in the field of economics, was the basis for the Nobel prize Simon was awarded in 1978).

Among the many indirect results of this conference was the publication, in 1960, of a book by Miller, Galanter, and Pribram, entitled Plans and the Structure of Behavior. The book suggested that human problem solving could be understood as a kind of planning, in which mental strategies or plans guide behavior toward its eventual goal. Why was this book viewed as a scientific contribution, involving as it did such mentalistic ideas as plans, goals, and strategies? Because the mentalistic plans, goals, and strategies weren’t just unobservable, hypothetical ideas. They were instead ideas that could be exactly specified, in a program running on a lawful, physical machine—the computer. (We will have much more to say about computers and computer models of cognition throughout the book.)

The Assumptions of Cognitive Psychology

We turn finally to three assumptions that pervade the field of cognitive psychology. They are: (1) that mental processes exist; (2) that people are active information processors; and (3) that mental processes and structures can be revealed by time and accuracy measures.

Mental Processes Exist After all of this review of the history and development of cognitive psychology, you can surely guess what the single most defining feature of the new cognitive psychology was—a scientific interest in human mental activity and processes. Whereas the behaviorists intentionally avoided any theorizing about the higher mental processes, these processes are exactly what cognitive psychology investigates. Our most basic assumption in cognitive psychology is that human mental processes exist, that they are lawful, systematic events, and that they can be studied scientifically.

We are of course very mindful of the checkered history of investigations into the higher mental processes. We fault the structuralists such as Wundt and Titchener not for their interests, but for their methods. Note that our biggest lesson from the behaviorist period, and also from the example set by verbal learning, was the lesson about scientific methods and procedures. Unlike the structuralists, we in cognitive psychology rely on measures of behavior that are as objective and reliable as possible. That is, we attempt to unravel the complex questions of mental activity with tasks and measures of behavior that are quantifiable, open to scientific scrutiny, easily replicated by other investigators, and, in short, faithful to the scientific empirical tradition. As best we can, we avoid measures that are colored by subjective bias or influence, as the old introspectionism was. And despite our tendency to tackle very big questions, such as “How do people comprehend?” our tasks usually require rather natural behaviors on the part of subjects; for instance, recall these words, paraphrase this paragraph, decide true or false, solve this problem aloud. All in all, cognitive psychology has been rather inventive in devising tasks and measures that yield scientifically acceptable evidence about mental processing.

Active Information Processors A second basic assumption, implied by the first assumption that mental processes exist, is the notion that the human subject is an active participant in the world of reality and behavior. The behaviorist, in contrast, viewed the subject as a largely pas-
sive creature, a creature who essentially waited around for a stimulus, then responded to it as determined by previous conditioning. We in cognitive psychology specifically reject this outlook as it applies to humans. We firmly believe that humans actively process the environmental stimuli around them, selecting some parts of that environment for further processing, relating those selected parts to already known information in memory, then doing something as a result of processing. People do not passively respond on the basis of simple conditioning or reinforcement, we believe. Instead, people respond actively on the basis of their mental processing of events and information.

To continue an example from earlier, we do not respond “Dutch” to a painting we are admiring in a museum because that response has become conditioned through reinforcement to some subtle stimulus configuration in the painting. I may respond “Dutch,” for example, because I think I remember from art appreciation class that the Dutch masters often portrayed people in strong shadows, and I’m making an educated guess; or because I know that the museum has many Dutch paintings, so that “Dutch” is a safe guess; or because I know specifically that this painting was done by Rembrandt, and I’m showing off my knowledge that Rembrandt was Dutch; or because I saw the sign “Dutch Masters” as I entered the room, and I’m masquerading as something of an expert. None of these possibilities is a simple S-R connection between the painting and my response. As you saw in the examples at the beginning of the chapter, an enormous amount of mental activity can underlie even very simple question answering. All of this mental processing is evidence for the active nature of people and their cognitive processes.

These two features form the core of cognitive psychology: our assumptions that human mental activities exist, and that the person doing the relevant mental activities is an active information processor. These ideas have a metatheoretical status in cognitive psychology; that is, they are above and beyond any particular theory of cognitive processes. In other words, they are so central to our discipline that they are assumed to be true. It is the various implications drawn from them that are tested in our experiments.

**Time and Accuracy Measures** Aside from these two important ideas, there is another common theme that runs through the research and theorizing in cognitive psychology. We assume that the mental processes and structures we are investigating can be revealed by two general classes of behavior, the time it takes to perform some task, and the accuracy of that performance. Since these measures are so pervasive in our research, it seems important to discuss them here at the outset.

Psychologists from different persuasions than cognitive psychology (and indeed, a few within cognitive psychology as well) bemoan our heavy reliance on measures such as reaction time (RT) or accuracy. Reaction time (abbreviated RT) is simply a measure of the time elapsed between some stimulus and the person’s response to the stimulus (RT is almost always measured in milliseconds, abbreviated msec, i.e., thousandths of a second). Our infatuation with such time-based measures, however, does have some justification. First, it has been known for a considerable time that individual differences among people can often be revealed by RT measures. In 1868, the Dutch physiologist Donders pointed out that the measure is potentially much more informative than this, in a proposal for studying the “Speed of Mental Processes” by means of reaction time (1868/1969). A moment’s reflection should reveal why cognitive psychology has used reaction time measures so frequently—mental events take time. Consequently, one way of “peering into the head” is to examine how long a certain set of mental processes takes to be completed. As Donders and many others have observed, careful comparisons of people’s reaction times to different stimuli can often give a strong clue to the mental processes going on internally (remember the rosin question earlier in the chapter?). Take a shot at it yourself; ask yourself, How do people read? Before you construct a theory of reading, however, notice the following: in general, it takes at least as much time, if not more, to recognize a single printed letter as it does to recognize a whole word. Is one of the typical components of reading skill a letter-by-letter process? No—now could it be, since we read words faster than the letters that compose the words?

It is a mistake to think that all of cognitive psychology’s research is based solely on time measures. Often we are interested instead in some measure of the subject’s accuracy, broadly defined. Sometimes we simply measure which words a subject recalled correctly and which were omitted in recall. In a variation of such a simple list learning experiment, it might also be of interest to examine the incorrect responses; that is, not just the words that were omitted, but also any words recalled that were not on the list that was studied. Did the subject “recall” a related word, rather than the exact word that was studied, saying “apple” instead of “pear”? Or, was an item recalled because it resembles the target stimulus in some other way, say substituting “G” for “D” when a string of letters is to be remembered?

In more complex situations, the term accuracy takes on other connotations. For instance, if we ask subjects to read and then paraphrase a paragraph, we don’t score the paraphrase according to verbatim criteria (although the lack of verbatim memory for a paragraph is interesting in its own right). Instead, we need to score the paraphrase on its meaning, on how well it preserves the ideas and relationships of the original. Accuracy and inaccuracy here are a bit harder to pin down, but are still informative. Particularly interesting in some research situations is an explicit consideration of the errors that people make, again as a way of peering in on the mental processes. Of course, this approach is quite similar to the Piagetian tradition of examining children’s errors in reasoning, such as failure to conserve quantity or number, to examine their cognitive processes.
These three basic assumptions, then, form the basis for modern cognitive psychology. First, we assume that there is a lawful, scientifically approachable collection of human cognitive activities and processes to study. Second, these arise from the person doing the cognition, the human who approaches the world in an active, information-seeking manner. Third, this mental activity is most often studied by means of time and accuracy measures, as indicators of the underlying mental processes of interest.

You've been introduced to cognitive psychology now. You've considered some thought-provoking questions, studied the definitions of some basic terms, read of our history and development, and discovered some of our basic assumptions. Yet, you probably do not know, in any specific sense, how cognitive psychologists do their research, or how they think and theorize about the topic of human memory and cognition. Chapter 2 will provide you with some introductory material on the methods of cognitive psychology, some insight into the major approaches cognitive psychology takes in its study of human memory and thought, and an overview of the human information processing system. Following chapter 2's intuitive introduction to the area, we'll turn to the actual research and theories that make up modern cognitive psychology.

CHAPTER SUMMARY

1. Cognitive psychology is the scientific study of human memory and mental processes, including such activities as perception, remembering, using language, reasoning, and solving problems.

2. Intuitive analysis of examples such as “How many hands did Aristotle have?” and “Does a robin have wings?” indicates that many important mental processes can occur automatically, that is, very rapidly and below the level of conscious awareness; experimental evidence presented later in the book supports these intuitive conclusions.

3. Memory refers to the mental processes of retaining information for later use and retrieving such information, and the mental storage system that allows this retention and retrieval. Cognition refers to the collection of mental processes and activities used in perceiving, remembering, and thinking, and the act of using those processes.

4. The modern history of cognitive psychology began in 1879 with Wundt, and his use of introspection. The behaviorist movement rejected the use of introspections and substituted the study of observable behavior as the true goal of psychology. Modern cognitive psychology, which dates from approximately 1960, rejected much of the behaviorist position, but accepted many viewpoints, assumptions, and methods from fields such as verbal learning, linguistics, and computer science.

5. The three most basic assumptions of cognitive psychology are: (1) mental processes exist and can be studied scientifically; (2) humans are active information processors; and (3) time and accuracy measures can provide important information on the nature of human mental processing.

SUGGESTED READINGS

Leahey's (1980) *A History of Psychology: Main Currents in Psychological Thought* gives particular emphasis to the development of cognitive psychology. The most thorough treatments of the cognitive revolution are contained in the Lachman et al. (1979) book, especially the first five chapters, and in Baars (1986). In this material you will find very careful analysis of the positive and negative contributions of the various influences on cognitive psychology and a complete account of the assumptions and beliefs of cognitive psychologists. Chomsky's 1959 paper is difficult reading at times, but the combative flavor of the behaviorist versus cognitive debate over language and the substantive issues of the debate are highlighted in the paper. A very approachable statement of the new direction versus the old is contained in Jenkins's paper, “Remember That Old Theory of Memory? Well, Forget It,” reprinted in the *American Psychologist*, 1974, pp. 785–95. And Gardner's *The Mind's New Science: A History of the Cognitive Revolution* (1985) is an absolutely fascinating analysis of the historical roots, present activities, and future prospects of the study of cognition. For anyone interested in the history of psychology, it's required reading.

Richard Mayer's 1981 book *The Promise of Cognitive Psychology* is a brief, very readable introduction to the field of cognitive psychology, as is the more recent "Essay in Cognitive Science" by Mandler (1985a). Kuhn's (1962, 1970) book is required reading for anyone interested in the philosophy and history of science. For an interesting application of Kuhn's and others' ideas to cognitive psychology, see Gholson and Barker (1985).