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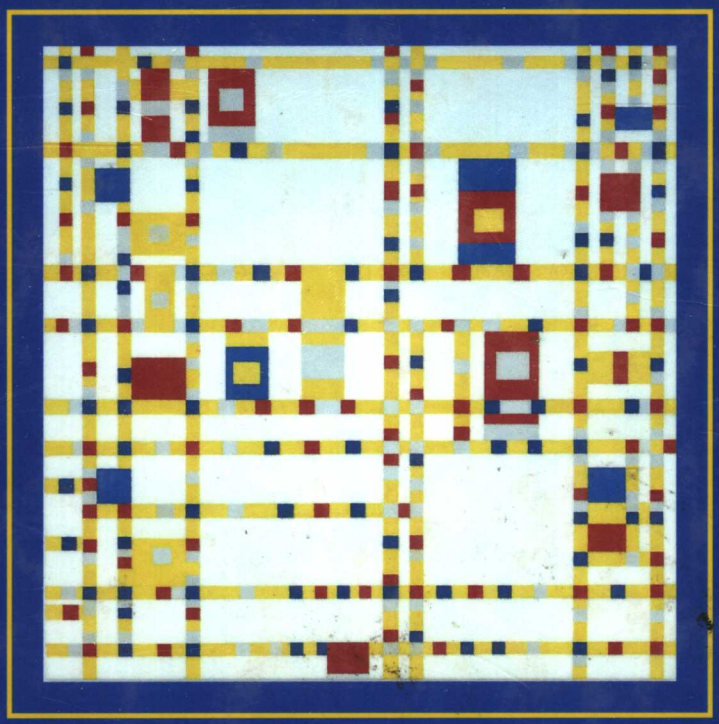

COGNITIVE PSYCHOLOGY

THIRD EDITION

JOHN B. BEST

Cognitive Psychology

THIRD EDITION

John B. Best
Eastern Illinois University

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PREFACE

It's very gratifying for authors to know that their work has found a hearing, an audience, and I certainly appreciate the audience that has given me the opportunity to prepare this edition of my book. I think also, that using the singular term "audience" to describe the book's readership is somewhat incorrect. At least two very different types of readers are involved here. First, we have the student reader who is probably taking his or her first course in cognition, has not had much to do with choosing this book, and is perhaps reading it under some duress. The second type of reader is the professor who may be casting about for a book to use in a cognitive psychology course, or who has made that decision and is reading this book in preparation of teaching. I'd like to address some comments to each group.

First, the student readership. I've intended that the book be read by upper-division students taking their first course in cognition. The book can be comfortably read in a course that is either a quarter or a semester long. The book should be understandable even if you haven't had much background in psychology, although completion of the introductory course would be helpful. In some places, I've used some statistical and experimental design terms such as "independent variable." If you haven't had a statistics course or experimental design course, you may want to review the meaning of such terms in an introductory book. As you probably have heard from other students, cognitive psychology is frequently regarded as a hard class. It's true that much of the material can be challenging, but I've included some features that I hope will help you. The book's 12 chapters are grouped into five sections. Each section begins with a part opener that will provide you with a brief orientation to the important

questions that I'll be covering in the next several chapters. Each chapter begins with an overview. In the overviews, I've tried to use an anecdote as a springboard into the questions and issues of the chapter. Each chapter contains summary sections at various points—these should offer breathing spaces and logical starting and stopping places within the chapter. Each chapter also contains a focus section. In the focus section, I've tried to go into some specific research question or phenomenon in more detail than we do in the main narrative. One of the issues that students frequently bring up is the validity of the cognitive enterprise: Given that cognitive processes are so "interior" (the argument goes), how can we use scientific practices to study them? The focus sections are designed in part to show you how cognitive scientists go about making these interior processes more overt. From these sections too, I also hope you'll get a clue about how cognitive scientists think. One of my hopes is that you will develop an appreciation of the cleverness and resourcefulness of cognitive scientists as they tackle the problem of making hidden processes visible. Each chapter closes with some concluding comments. The comments are intended as a summary, but I didn't want them to be simply a rehash of the material in the chapter. So, while the concluding comments are a summary, they are more than that: I use the concluding comments to point out some implications of the material in the chapter, to examine how certain "themes" or ideas in cognitive psychology are reworked in different areas, and so on. Following the concluding comments is a list of "key terms" that were used in the chapter. Most of the key terms also appear in the glossary. I recommend that you use each of these features actively. Finally, the chapters include a section called "Using Your Knowledge of Cognition." Sometimes students complain that the material in cognitive psychology is rather abstract, and by implication, alien. I can appreciate the complaint, but I'd like to point out too that cognitive psychology is really about us. We talk, solve problems, and remember things all day long. The point of the "Using Your Knowledge" sections is to show you that cognitive psychology can be applied, sometimes without much difficulty, to many issues that may arise during a typical day. If you use each of these features, I think that you'll get more out of the course, and I think that it may be much less painful than your peers have told you.

For the professional readership: One of the questions of the '80s that has continued into the '90s is the relationship of cognitive psychology to the broader discipline of cognitive science. My graduate education was in psychology, and that has remained my vantage point, but I don't think that psychological perspectives are in any way privileged with regard to cognitive processes. This belief, coupled with my other monistic positions, has resulted in this book being more "biological" or "computational" than some of the other books may be. This is not to say that I want to endorse any sort of mindless reductionism, but rather that, where I think that perspectives from artificial intelligence study or computer science can aid in our understanding of cognition, I've tried to bring those perspectives into the book. In addition, if you view this book as a snapshot of our field circa 1992, then I think the snapshot shows strands of evidence that may once have been regarded as bearing on different problems, as coming together.

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For example, I see the biologically driven work of certain vision researchers and the computer science-driven work of others as being blended sometimes in connectionistic models and sometimes in more conventional information-processing or symbol-processing models. Along these lines, when the history of cognitive science is written in a century or so, it may well be the case that the spectacular success of connectionism is explained as much by the fact that it is an architecture allowing for a comfortable blending of different perspectives, as by its empirical triumphs, as fine as they are.

I couldn't possibly name everyone who has helped with me with this edition, but I will try to mention those whose contributions have been particularly salient. First, my thinking about how to organize this edition, what to include, expand, abbreviate, or delete was aided tremendously by a group of reviewers who read and commented on the second edition. They are:

Stephen Chew, Gustavus Adolphus College
Patrick DeBoli, Nassau Community College
Peter Derks, College of William and Mary
Charles Folk, Villanova University
Jan Lynch, Roanoke College
Neil Montgomery, Keene State University
Mark Reinitz, Boston University
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Sheldon Rosenberg, University of Illinois, Chicago
James St. James, Milliken University
Sandra Stein, Rider College
John W. Webster, Towson State University

At West Publishing, I've continued to enjoy and rely upon the support of my editors, Clark Baxter and Nancy Crochiere. At Eastern Illinois University, my colleagues have been very supportive of the revision effort; I really appreciate their sympathy and encouragement. I was also helped tremendously by Fred L. Yaffe, the chairperson of our department, who released me from some of my teaching obligations so that I could write. My graduate assistants, Lisa Carlisle and Kathy Robinson, and my undergraduate assistant, Traci Sachteleben, were all just terrific in helping me with references, permissions, the permissions log, and all the other details involved in creating a book. Of course, I have to thank my family too: My wife, Lorraine, and our older son, Frank, were so nice to tolerate my absenteeism from the home with nary a whimper. One more person to mention, and that's our younger son, Matthew, who arrived in the interval between the second edition and this one. Matthew, I bet you didn't know how much I learned about cognition from listening to you. Thanks, everybody. And now, I have a story to tell . . .

John B. Best
Charleston, Illinois
May 27, 1991
Memorial Day

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PART ONE

Introduction

Preceding each section of this book is a part opener that describes some of the issues that are dealt with in the section. These part openers also provide a preliminary orientation to the material by describing some key phrases or concepts that are designed to help students organize the material as they read.

Students might get more out of this introduction if they understand at the outset that much of this chapter is concerned with "approaches" to cognition, and that these approaches have metaphors as their bases. There are two commonly used approaches in cognitive psychology. The information-processing approach has as its metaphorical base the idea that "the mind works like a computer," and the connectionist approach has as its metaphorical base the idea that "the mind works like a brain." Let's briefly consider what each of these metaphorical statements might mean.

It is intuitively obvious to many students that minds and computers have certain similarities. Both humans and computers have memories that are organized in particular ways, and both are capable of following directions on a line-by-line basis. Computers and people are similar in some other, less obvious ways, too. Both humans and computers *represent* information internally. In other words, they take in information from the world in one form (keystrokes or mouse-clicks in the case of computers, senses in the case of humans) and store it in some other form. Once stored, this information can be altered by the computer's program, or in the humans, by cognitive processes. Cognitive processes become the equivalent of mental programs according to the information-processing approach. These processes operate on the information we have stored, modifying it to suit our current purposes.

As obvious as the computer-mind similarity is, the brain-mind metaphor underlying the connectionist approach is even more obvious to many students—so obvious in fact that many students think this metaphor is simply a trivial cliché. But we should resist the temptation to dismiss the connectionist approach. Theorists and researchers have pointed out that digital computers do one thing at a time; the advantage of such machines is their incredible speed. But my cognitive system and yours are not at all like this. Relative to computing machines, our cognitive systems are much, much slower. But they possess an awesome advantage nevertheless. Our cognitive systems can do more than one thing at a time; in fact, they are usually doing more than one thing at a time. This fact suggests that our cognitive systems, like our brains, work as *parallel* (many things at once) machines, rather than as *serial* (one thing at a time) machines as computers do.

If you keep this distinction in mind as you wind your way through this chapter, I think you'll get a good grasp on why cognitive psychologists approach specific problems the way they do. One other thing: I hope you don't feel a need to decide which of these perspectives is "right" and which is "wrong." Both the information-processing and the connectionist approach have their uses, as we'll see directly.

CHAPTER 1

Cognitive Psychology: Definitions, Roots, and Metaphors

OVERVIEW

Overview

Last week I did something that I thought was very strange. After supper, I told my wife that I was going to the grocery store to buy milk, and she asked me, as long as I was going out, to return a book to the library. Some minutes intervened while I did some other chores, and then I finally got going, almost forgetting the book, then remembering to put it on the passenger seat beside me in the car. The weather had turned quite a bit colder in the past week, and so I thought I could go to the grocery store first, leaving the milk in the car while I returned the book, without the milk being spoiled by warm temperatures. Having made this plan, I sort of put my mind on automatic pilot while I drove. I bought the milk, put it on the front seat next to the book, drove to the library, got out, went around to the passenger side, grabbed an object, walked into the library, walked all the way to the circulation desk, and met the somewhat quizzical eyes of the librarian before I realized that I had the milk, not the book. I sheepishly retreated and brought back the correct object a few minutes later.

On the drive home, I tried to figure out why I had made this mistake. At first, I couldn't come up with an answer. Milk gallons and books don't look alike; they don't have similar functions; and the objects weren't the same temperature, or the same weight. So how could I get them confused? To answer this question, we first must realize that my cognitive system created internal representations of both the milk and the book, and second, that these internal representations have properties all their own. Some of the properties are based on what I know about the object in question, and hence, these properties are stable and more or less unchanging over time. For example, I know that milk is food, and I know that a book is not food, and these characteristics are part of my permanent internal representation of these objects. But some of the properties of the internal representation refer to characteristics that the object may possess temporarily, but not permanently. That is, our cognitive system seems to have a batch of "temporary files" into which an object can be placed for the time being, probably for the sake of some convenience. In these files the object may be represented on the basis of characteristics that it probably does not have permanently. Essentially, this is how I explained my mistake to myself: In my daydreaming, automatic-pilot state, both the objects on the front seat were represented simply as "things on the front seat" and were not "tagged" with their complete and permanent specification. Given that there were two things on

the seat, I think that I had about a 50 percent chance of carrying the wrong object into the library.

From this example emerge several questions and themes that will be dealt with in this chapter, and that will come into play again and again throughout this book. What is the relationship of cognition to conscious awareness? How can human knowledge be described and explained? Are cognitive processes really as separate or as "modular" from one another as they seem to be in this case? We'll begin our exploration of these issues in this chapter.

This chapter also considers some of the many origins of cognitive psychology. Its roots are to be found in (among other places) linguistics, computer science, neurology, and human factors research. You may be somewhat surprised to find out that cognitive psychology has a relatively short history. Although the problems it investigates are ancient, virtually all of its founding figures are still alive.

In addition, this chapter will examine two approaches to the problems of cognitive psychology: the information-processing approach; and the connectionist approach. As we'll see, these approaches differ fundamentally in the assumptions they make about human cognition, although they don't necessarily differ in the predictions they make about human cognition. The chapter concludes with a description of some of the research methods and techniques that cognitive psychologists use.

Introduction to Cognitive Psychology

By the time you reach the period at the end of this sentence, you will have engaged in several distinct cognitive processes. Without any particularly strenuous effort on your part, you're grasping the meaning of this sentence right now, even as (perhaps) your attention has already begun to wander to an upcoming rendezvous, a test tomorrow, hunger pangs, or whatever. However, the ease with which we engage in cognitive processes shouldn't blind us to their complexity. The remaining 125,000 words of this text are spent in an effort to foster your appreciation of just how great that complexity is.

Neisser's Definition of Cognition

In 1967, Ulric Neisser published the now-classic text *Cognitive Psychology,* which offers the following definition: "Cognitive psychology refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used." The definition is worth elaborating. As Neisser states, cognition begins with sensory input. Our cognitive processes are perhaps most useful in responding to information that is present in the world and that is capable of being picked up by our sensory apparatus. Next, the sensory input is transformed—that is, altered. Our sensory apparatus is finely attuned to certain kinds of energy present in the world. This sensory apparatus converts physical energy into neural energy, or as a cognitive psychologist might say, physical stimulation is encoded into neural events.

The notion of a code is an important idea in cognitive psychology and so deserves at least a brief description. To what does the process of encoding refer? Literally, a code is a system of signals used to represent letters or numbers in transmitting messages. For example, children make up secret alphabets and use them to send messages to their closest friends in school. These messages are coded; the symbols used are the result of some (presumably) systematic transformation of the alphabet, and the squiggles that children make up bear the same relationship to one another that characters in the alphabet do. If *e* is the most commonly occurring letter in English text, then the character representing *e* in the code also would be the most frequently occurring symbol.

Apparently, our nervous systems are capable of a similar coding procedure. That is, physical stimulation is represented by the activity of the nervous system in a way that preserves many of the characteristics of the original stimuli. The transformation of the physical stimulation produces more than just a neural code, however. The transformation also results in the creation of a **cognitive code.** The creation of this cognitive code can be demonstrated quite simply. Look out the window or across the room for a few seconds, then look back at your book. Can you now imagine the scene outside the window without looking back out? You probably can do so without difficulty. The image thus created demonstrates the existence of a cognitive code—in this case, a mental event that seems to preserve many of the characteristics of the original physical stimulation. Cognitive codes are created by the activity of our nervous systems. For our purposes, the term refers to transformations of physical energy that are potentially capable of entering our awareness (i.e., mental events), or those transformations that form the basis of such an event.

The distinction between these two kinds of cognitions is necessary because our awareness of our cognitive codes is not complete. Some cognitive codes enter our awareness, but others don't. To see this, think about the process of reading. If you set out to read a word, the meaning of this word almost certainly enters your awareness. The experience of "meaning entering your awareness" is hard to describe, but you know the experience you're having was produced by reading that particular word. However, other transformations of the physical energy were certainly involved, and probably none of these entered your awareness. For example, the light reflected from the page had to be converted into a code that preserved the lines of the letters; these lines had to be assembled in some meaningful way; the resulting pattern of lines had to be recognized as letters; and, presumably, at least some of the letters had to be identified. In each case, a cognitive code was created, although the results of such processing almost certainly did not enter your awareness.

Neisser describes the fate of the cognitive code in the next part of the definition. Once created, the cognitive code can be reduced or elaborated. The reduction of a cognitive code refers to the fact that neither the neural code nor the cognitive code preserves and retains *all* the characteristics of the original physical stimulation. This reduction isn't bad, because most of the physical energy in the environment isn't very informative and therefore isn't worth keeping. Even now, if you try to remember the exact words that began this chapter, you'll find it difficult to recall them, and you probably won't remember them accurately. Even when you read the words the first time, you probably recognized that the

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