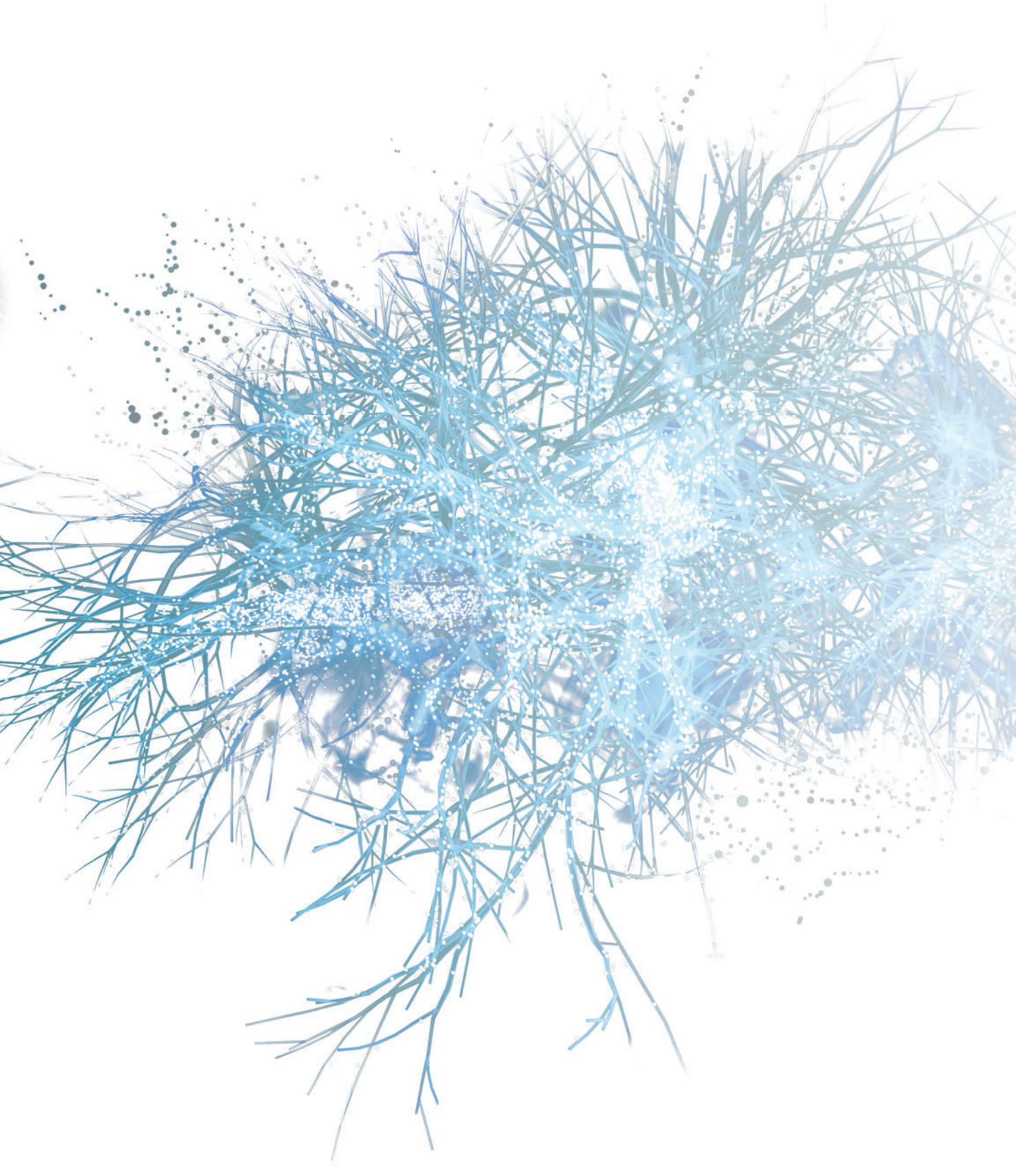
Cognition

Drawing on a modern neurocognitive framework, this full-color textbook introduces the entire field of cognition through an engaging narrative. Emphasizing the common neural mechanisms that underlie all aspects of perception, learning, and reasoning, the text encourages students to recognize the interconnectivity between cognitive processes. Elements of social psychology and developmental psychology are integrated into the discussion, leading students to understand and appreciate the connection between cognitive processing and social behavior. Numerous learning features provide extensive student support: chapter summaries encourage students to reflect on the main points of each chapter; end-of-chapter questions allow students to review their understanding of key topics; approximately 200 figures, photos, and charts clarify complex topics; and suggestions for further reading point students to resources for deeper self-study. The textbook is also accompanied by 800 multiple-choice questions, for use before, during, and after class, which have been proved to dramatically improve student understanding and exam performance.

Arnold Lewis Glass is a professor in the Department of Psychology at Rutgers University.



COGNITION

Arnold Lewis Glass

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To my wife, Lynne, and my son, Brian, because the writing of this book was a family project that benefited from their enthusiasm, insights, and general good judgment.

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PREFACE

The modern study of cognition began with the associative theory in the eighteenth century. According to this theory, spatial contiguity and temporal contiguity cause more simple visual and auditory features to be combined into more complicated representations, and the manipulation of these representations corresponds to thoughts. Associative theory motivated the experimental studies that began the science of cognitive psychology in the nineteenth century. In the early twentieth century behaviorism provided an alternative theoretical framework for psychology, whose content was observable behavior instead of mental states. The focus on behavior led to important advances in the experimental methodologies for observing behavior coupled with a complete lack of progress in explaining the mental processes causing the behaviors. This non-mental psychology came to an abrupt end with the publication of Ulric Neisser's (1967) *Cognitive Psychology*. Although the theories that followed its publication were much more sophisticated, they were within the associative tradition. Thought was represented as the manipulation of sensory features. My contribution at that time was a textbook that was a best-seller and certainly influenced those that came after it. Even the most recent textbooks published today still follow the same basic organization and cover the same basic topics.

Because of their theoretical orientation, all current cognitive textbooks are now out of date. The theoretical framework is not wrong but it is incomplete. The conceptualization of cognition in terms of the combination of sensory features suggests that a good place to begin is with perception – i.e. with the construction of a representation of the world from sensory features. Unfortunately, this means that we begin with a passive description of cognition. An observer is not doing anything other than constructing a representation of the surrounding environment. This leads to analogies with passive mechanical recording devices such as cameras. The passive, perception-first, approach to the study of cognition has dominated introductory psychology textbooks, as well as much research, ever since Neisser's (1967) seminal work. This was not Neisser's fault. The theory he presented, called analysis-by-synthesis, was an active approach to all of cognition, including perception. However, it was difficult to understand and not as influential as the classical organization of the material around perception. In this century it has become increasingly difficult to describe cognition within the framework of the traditional organization beginning with simple visual features because of new findings demonstrating that basic units of memory represent purposeful actions to meaningful targets and that novelty rather than contiguity drives learning. The central purpose of this textbook is to present cognition as purposeful action. This approach provides a more accurate description of what cognition is.

This new textbook is a rethink of the entire field, reflecting what is known and what is under active research today. Both neuroscience and social psychology are much more important, and influence this text. Instructors and students alike will benefit by being introduced to relevant topic areas that they may not be well versed in and that will give them a new way of looking at the discipline.

The text includes more and better neuroscience, social, and developmental perspectives, which are absent from other texts. This is evident from the first two chapters, which provide a foundation not available in other texts. In terms of neuroscience, the emphasis is always on functional systems. In Chapter 1 we see how reflexes emerged in the spinal cord and brain stem and how conditioning emerged in the brain stem, midbrain and cerebellum. Not

every instructor will have time to include the pre-cognitive evolution of the nervous system in a human cognition course. It is available for those instructors who are interested. In Chapter 2 we see how voluntary action emerged through the functioning of the frontal cortex, striatum, and hippocampus. The advantage of this approach is that, rather than have an introductory chapter on the brain, right from the beginning the emphasis is on behavior, how neural computation makes behavior possible, and how inter-species behavioral competition has led to the increasing complexity and sophistication of behavior and the neural computational systems that make behavior possible. There is complete integration from the social level down to the neural, and each evolutionary advance emerges inevitably from the challenges provided by the increasing sophistication of competitors. By explaining to students the "Why?" of "cognition" they acquire a framework for understanding the "What?" as well.

In Chapter 2 the habit system and instrumental system are both introduced. The seminal animal work on these systems is widely influential in the behavioral cognitive neuroscience literature. Here it is introduced into a cognitive psychology text for the first time. Once this foundation is laid, we can see in Chapters 3, 4, and 5 how both systems cooperate to control motor and mental action, respectively. In Chapters 5 and 6 we see how the ability to rapidly encode task-relevant perceptual targets makes possible the accumulation of knowledge of the world. We see that both systems are necessary components of the meaningful encoding of events in semantic memory and are necessary components of the neural systems for language production and comprehension. Throughout the later chapters of the text we see how both systems influence our abilities to learn, remember, and reason. Hence, Chapter 2 provides an organizing framework for the entire textbook.

It is argued in Chapter 2 that higher cognitive functions evolved to support social behavior. Evidence for this claim is presented throughout the second half of the book. Chapter 8 is about how infants learn, and especially how infants are able to learn language. We see that caretaker–infant social interaction is the driver of the development of cognitive abilities, especially language development. In Chapter 9 categorization, causal learning, and reasoning are shown to be largely social in nature. Throughout the later chapters of the text we continue to see how the higher cognitive functions have been shaped for social ends.

In addition, beginning with the discussion of the amygdala in Chapters 1 and 2, the role of emotion in cognition is discussed with respect to attention, learning, and reasoning.

The effect of this organization is that the cognitive psychology course is no longer a collection of research areas – perception, attention, language, learning, memory, reasoning, and problem solving – that are treated as a set of independent topics without reference to a common neural mechanism or overarching function. Instead, it is the single story of how cognition makes action more effective by solving two great problems: how to respond to novel events and how to respond to familiar events. It is the story of how the control of mental action evolved from the control of physical action, and so reasoning and problem solving ultimately evolved from motor control.

The brilliant research of the past twenty years has illuminated both the common frontal-temporal neural system that underlies all these abilities and the common social function they all share. Beginning in Chapter 2, the common neural system and the common social function will be used to integrate all human cognitive abilities, and consequently all the research topics, within a single narrative. It is much easier for students to understand a single story, whereby one chapter follows naturally from its predecessor, than to understand

a loose connection of topics. Consequently, my students have found the material not only accessible but also intriguing and even exciting.

To facilitate the presentation, some new terminology is introduced in the hope that it will be widely adopted. Despite wide agreement within the cognitive and behavioral neuroscience research communities on the basic brain systems for cognition, there has been no agreement on what to call them. This has had the unfortunate effect of masking the underlying consensus. In their classic foundational review describing the two systems in detail, Yin and Knowlton (2006) call one system the action–outcome (A–O) system and the other system the stimulus–response (S–R) system. However, virtually no subsequent report has adopted this nomenclature. Yin and Knowlton refer to the function of the S–R system as habit learning, so it is simply called the habit system here. The complementary A–O system is called the instrumental system, which implies an action and its outcome.

The central audience is anyone taking cognitive psychology at any college or university. However, anyone with an interest in the topic will find the book accessible. It will therefore be of benefit to students and instructors in other areas who are interested in this exciting area of study.

In addition to presenting the astounding new findings of this century, it is worthwhile to present the new and old methodologies that produced these findings. However, I have not done this by providing an introductory historical chapter. Physics and chemistry texts do not begin with such a chapter. I have always felt that such a chapter was unnecessary and betrayed a defensive attitude about what was actually known. It seemed to say, "We don't know much yet about mental life but here is how we have been trying to find out about it." Such a chapter often introduced a text that appeared to be a collection of experimental results rather than a description of how the mind works. Instead, I have integrated the methods and conclusions through the use of elaborate figures that illustrate both the experimental method and its result. Each chapter contains visual descriptions of one or two iconic experiments.

When I began teaching forty years ago, I felt that I had a special obligation to my students to teach effectively. After all, the course I was teaching was called cognitive psychology. One of the main topics was learning and memory. If I was presenting myself as an expert on learning and memory, how could I not fail to use what I claimed to know to help my students learn the material?

For many years it was not possible for me to carry out my intention to apply cognitive psychology to instruction. I could not collect enough information about student knowledge throughout class to assess the effectiveness of what I was doing. Finally, advances in technology in this twenty-first century have made my original plan possible. The introduction of personal response systems (clickers) made it possible to continuously monitor student knowledge in class and the use of an online course platform made it possible to measure what they knew from studying at home.

The use of these technologies has greatly benefited my instruction, and through this book I hope to confer those benefits on you. Because I teach multiple large sections with hundreds of students at the same time, I was able to perform counterbalanced within-student, within-item experimental studies of the comprehensibility of the study materials and of the effects of different instructional strategies.

One benefit was the development of highly effective question sets, which are integrated with the text and provide an effective means of learning the material through the

instructional methodology known as distributed questioning. About 150 question sets cover the principles and facts that comprise the discipline of cognitive psychology. Each set contains four or more questions such that all questions query the same principle or fact statement. The correct answers to all the questions in the set may be inferred from this single principle or fact statement. Three questions from the set are integrated with instruction, including a pre-lesson, post-lesson, and review question. The remaining question from the set becomes the exam question. Many studies (including my own) have now been published demonstrating the effectiveness of this instructional methodology in peer-reviewed journals. Distributed questioning has proved to be effective whether the questions are presented online or in the classroom, but appears to be most effective when the questions are presented as clicker questions in class. An extensive set of PowerPoint slides coordinated with the printed text is available that can be used in a lecture or integrated in an online presentation. These include the clicker question from the question sets.

A second benefit was that the student responses to specific questions provided the feedback necessary to repeatedly revise the content of this text, page by page and paragraph by paragraph, to make it clearer and more accessible.

A third benefit is that the technology, along with my varied teaching schedule, has made it possible to adapt the text and supporting materials to a variety of contexts. The book has been used in large lectures and small seminars. It has been used by undergraduate psychology students and by graduate students from a variety of disciplines who wanted to learn about human cognition. It has been used in hybrid courses in which much of the material was presented online. The result is a robust presentation in which the individual chapters can be presented as written, in a new order, or as stand-alone introductions to their topics. I am vividly aware that the first thing instructors (including me) do with a text they like is to tear it apart and reorganize it to conform to their own priorities for their students. I welcome this, and I am eager to hear from you all about what you used, what you did not use, and what you missed; what you liked and what needs to be improved.

Arnold Lewis Glass aglass@rutgers.edu

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