

**STEVENS'  
HANDBOOK OF  
EXPERIMENTAL  
PSYCHOLOGY**

Second Edition

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**VOLUME 2**  
**Learning and Cognition**

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# STEVENS' HANDBOOK OF EXPERIMENTAL PSYCHOLOGY

Second Edition

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## VOLUME 2: Learning and Cognition

*Edited by*

**RICHARD C. ATKINSON**  
**RICHARD J. HERRNSTEIN**  
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## PREFACE

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Stanley Smith Stevens' original *Handbook of Experimental Psychology*, published in 1951, comprised 36 chapters in six sections, all in one large volume. Here, the number of chapters has shrunk to 27, the sections to four, and the whole made more manageable as two volumes. The shrinkage is not in experimental psychology, for what has vanished are mainly importations into psychology from other disciplines. The original *Handbook* had chapters on the neuron, on synapses, on neural maturation, on the mathematics of growth curves, and on the anatomy of motor systems. Also missing are topics that now seem less pertinent to experimental psychology than they did right after World War II, such as engineering psychology, equipment design, and manpower training. As experimental psychology developed, it grew less dependent on other sciences and focused more sharply on its own territory.

Experimental psychology has grown differentially. What was a single chapter on Cognitive Processes has become a section of nine chapters in the present edition, a full third of the entire undertaking. The section on Sensory Processes has been transformed into Perception, a shift away from the physical and physiological to the more purely psychological. Physics and physiology remain, as they must, but the hope is that they make more meaningful contact with psychology's variables. The section on Motivation has grown from three chapters to five, almost all of the growth owing to the enriching convergence of behavioral biology and experimental psychology. The section on Learning and Adjustment changed its name to Learning and ceded Cognitive Processes and Speech and Language to other sections. It abandoned a mixture of substantive and methodological chapter topics that has become unwieldy, and it now presents four fundamental issues of simple learning: conditioning processes, stimulus discrimination, response strength, and the physiology of learning and memory.

This work is not so much a revision of Stevens' *Handbook* as it is a tribute to its editor. Although the present editors had quite different relations with our predecessor, all of us were significantly influenced by him in our work, and we are unified in our admiration for him as a scientist, scholar, and person. It is difficult to say anything about Smitty without saying a great deal. Here space permits us only to point to his distinguished contributions to sensory psychology and measurement, and to his Harvard presence for four decades, where in his highly individual manner he molded generations of experimental psychologists. So, too, did his *Handbook* shape experimental psychology in its time. Readers who are not familiar with him and his work may wish to consult his fascinating autobiography, which says much of interest about him and about our science (S. S. Stevens, *Autobiography*. In G. Lindzey (ed.), *A History of Psychology in Autobiography, Vol VI*. New York: Appleton-Century-Crofts, 1974, pp 395-420).

Conversations among the editors about a possible new edition of Stevens' *Handbook* began in the fall of 1977. The old edition was out of date and out of print, but the question was whether a new one of so comprehensive a scope would be useful at a time when fine handbooks in perception, learning, and other specialized areas of experimental psychology have become available. Or were the fissures within experimental psychology so deep, we wondered, that it was pointless to try to span them in a single work. We came to believe that the very fractionation of our subject that

almost deterred us could be blamed in part on the lack of a contemporary *Handbook*. Experimental psychology has more coherence than is reflected in the specialized textbooks, handbooks, journals, and monographs of our time, or so we thought. Wiley, publisher of the original *Handbook*, agreed. The next step was to try to discover whether colleagues elsewhere agreed as well.

In the summer of 1978, a tentative outline, drafted by the editors, was sent to several dozen psychologists and other scholars. They were asked for advice on the idea of a new edition, on our outline, and on possible authors. Their answers helped mold our tentative plan into the present *Handbook*. Because of their generous response to our inquiry, the outline was extensively revised, a list of prospective authors drawn up, and, most significantly, the editors felt encouraged to proceed with the project. We acknowledge, but cannot fully repay, our debt to these consultants by listing their names.

Authors were recruited to write chapters of a level of scholarship sufficient to serve the needs of scholars and a level of clarity to serve those of beginning graduate students in experimental psychology. That was Stevens' conception of his *Handbook*, as it is the present editors'. All who were asked accepted or provided advice, about the outline of the *Handbook* or about alternative authors. Soon we had the assemblage here represented. Only the enduring and versatile George A. Miller turns up as author in both editions, although several others of the original authors helped as consultants.

Also enduring is Geraldine Stone Stevens, whom Stevens gratefully acknowledged in his Preface. We are grateful to her, too, for allowing us to grace this edition with "Stevens" in its title, for advice about how to put a handbook together, for editing about one-third of the chapters, and for her enthusiasm and encouragement.

The editors needed further help as the chapters came in. The reviewers listed below provided expertise where the editors' expertise fell short. Their criticisms and suggestions were often detailed, and occasionally fundamental. We know we speak not just for ourselves but also for the authors when we express most earnest thanks to these reviewers for accepting the largely thankless task of careful editorial reading and commenting. Much, though not all, of this edition's long delay from conception to publication is accounted for by the slow pace of the successive exchanges from reviewer to author and back again, always via an editor.

But the delay would have been worse, perhaps infinite, had it not been for the efforts of Susan Herrnstein, of whom we write, as Stevens wrote of Geraldine Stone Stevens in his Preface, that "she did more work on this handbook than anyone else." Detecting a vacuum, Susan Herrnstein took administrative command—organizing, advising, and keeping the communication and paper flowing among editors, authors, publisher, and, at last, printer. Despite a schedule already too busy, she found the time and energy to do the work that needed to be done when the rest of us did not. We cannot begin to repay our debt to her, but our profound gratitude we can at least acknowledge here.

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PART 1

LEARNING

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# FUNDAMENTALS OF LEARNING AND CONDITIONING

Eliot Hearst, *Indiana University*

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## INTRODUCTION

Together with the study of vision and audition, experiments on conditioning and learning constitute a large part of the laboratory research performed during the first century of scientific psychology. To uncover basic mechanisms of sensation and perception, rigorous psychophysical techniques with both animals and humans

The writing of this chapter was supported by National Institute of Mental Health Research Grant MH 19300 and a James McKeen Cattell Fellowship. I thank the many students and colleagues who read and criticized versions of the manuscript. Particularly valuable was the help of Robert Rescorla, who generously supplied constructive suggestions and detailed commentary at various stages of the work. I acknowledge both Rescorla's and Herbert M. Jenkins's specific influence on my organization of the chapter and on my thinking about many topics covered here. For example, the classification of learning procedures derives mainly from Rescorla and Holland (1976). Useful reviews of the final draft of the manuscript were furnished by Abram Amsel, James Dinsmoor, Ralph Miller, Charles Perkins, Michael Rashotte, Herbert Terrace, and Allan Wagner; I am sorry I could not incorporate even more of their suggestions into the published version and I hope they will forgive me for deciding to omit some points about which they felt strongly. Finally, Dexter Gormley, Jim Hull, Susie Hull, and Sheryl Mobley deserve great credit for providing expert assistance in preparation of the manuscript and illustrative material.

have proved invaluable. Similarly, students of classical and instrumental conditioning have adopted objective methods and measurements to determine principles of learning and memory in animals and humans. As in other biological sciences, which also rely heavily on model systems involving convenient infrahuman organisms, the study of learning has depended on rats, pigeons, dogs, cats, and monkeys as subjects, in the hope that consistent results would emerge, revealing basic laws with substantial generality across situations, response classes, and species.

The domain of animal behavior and conditioning can easily justify its own separate existence. However, in the long run an understanding of "simple" processes of learning is also assumed to be important, either for its direct application to human behavior or, perhaps more realistically, for its establishment of the degree to which various conditioning mechanisms participate in complex human activities. These crucial questions can be settled only after we attain a reasonably complete knowledge of animal learning mechanisms—which, as this chapter will demonstrate, are not so simple after all.

Besides their inherent appeal and potential

implications for human behavior and cognition, experiments on animal learning have furnished specific tools and models for studying many topics of general psychological significance, including the workings of the brain, the analysis of development and aging, and the nature and evolution of intelligence. The use of surgical, pharmacological, and electrical stimulation techniques can rarely be ethically justified with healthy human beings; therefore basic research on the biological foundations of behavior must rely, at least initially, on animal work that permits measurement of phenomena resembling as closely as possible aspects of human learning and memory. And even experimental psychologists concerned with less molecular issues—such as social interactions, pedagogy, personality, or psychopathology—have found techniques or analogues from the animal learning laboratory useful in their research and theorizing.

This chapter concentrates on the most important procedures, findings, and theoretical accounts that have guided the study of learning in infrahuman organisms. Human laboratory research and practical implications will not be disregarded, however (see also Estes, Chapter 5, and Pew & Rosenbaum, Chapter 7, in this volume). The chapter emphasizes work performed and new directions taken since the earlier edition of this handbook, which highlighted the topic of animal learning in four relatively disparate contributions (Brogden; Hilgard; Miller; and Spence; all 1951). First I offer a bit of history, sketching the major intellectual paths that converged in the modern study of learning. Then a discussion of some definitional issues follows and previews the three general kinds of learning procedures that have captured experimental interest. Next, in the main parts of the chapter, there is a survey of relevant methods, results, and theories for each of the three paradigms.

Throughout the chapter the reader should detect the increasing liberalization of views and the broadened scope of topics that characterize contemporary research in the field. Many concepts and themes prominent in today's experimental psychology of human cognition and memory appear in work with animals too—for example, discrepant information, causal attribution, context dependency, short-term retention, inference and representation, cognitive maps, selective attention, priming effects, patterning and organization. And discernible also

in current animal research are the influences of sociobiology, ethology, and developmental neurobiology toward heightened recognition of evolutionary specialization, genetic determinants of behavior, and species differences.

## HISTORICAL BACKGROUND

Excellent general accounts of the intellectual and experimental precursors of modern research in learning and conditioning can be found in several sources, including Anderson and Bower (1973), Bower and Hilgard (1981), Cofer (1979), Gottlieb (1979), Hilgard and Marquis (1940), Jenkins (1979), Keller (1973), and Kimble (1967). Aside from its intrinsic interest, a historical perspective helps one to understand and appreciate (1) why conditioning experiments were so readily accepted as bearing significance for numerous psychological processes and (2) why such experiments have typically been conducted in certain ways. The following short look at the heritage of the past emphasizes influential beliefs and methods, rather than the individual scientists who proposed and championed them. The various routes are not easily separable, and some complex issues had to be glossed over to keep this summary brief.

### Empiricism-Associationism versus Nativism-Rationalism

Associationism remains a central theme in current accounts of animal learning, which typically appeal to association between events as the main basis for learned changes in behavior. Proposals concerning the elementary laws of association—contiguity, similarity, and contrast—can be traced back at least as far as Aristotle (384–322 B.C.). Philosophers interested in the origins of knowledge and the nature of the human mind have expressed many views on the topic, but the British associationist-empiricist philosophers of the seventeenth to nineteenth centuries (e.g., Hobbes, Locke, Berkeley, Hume, Hartley, James Mill, John Stuart Mill, and Thomas Brown) receive major credit for propagating the belief that sensation and association are the two most basic mental processes. For the empiricist, past experience is the main if not the only source of human knowledge; complex ideas (like justice or psychology) that are not



directly sensed arise somehow from the association of simpler ideas. This type of doctrine differs from more rationalistic and nativistic views, which grant the mind a variety of innate or intrinsic perceptual and relational mechanisms that actively constrain or structure incoming sensory data. For example, Descartes (1596–1650) claimed that certain ideas are innate, like geometrical axioms and the concept of the self.

In contrast to Descartes, the British empiricists viewed the mind of the newborn infant as virtually a blank tablet (*tabula rasa*) on which only experience makes inscriptions. Relying not on experimentation but on shrewd introspection and logical analysis, these philosophers propounded certain primary laws, corresponding to those of Aristotle, that controlled the formation of associations between different ideas and could determine our judgments of causality. Contiguity of such ideas or elements (that is, their temporal or spatial proximity) was the most important principle, but similarity and contrast between elements were also thought to facilitate their association. Thomas Brown took a valuable step forward by proposing a number of secondary laws that govern associative strength, which included the duration, frequency, vividness, and recency of the associations (see Cofer, 1979). However, in opposition to the analytical approach of the early associationists and foreshadowing the concepts of organization and hierarchical structure used later by Gestalt psychologists and cognitive scientists, J.S. Mill argued in the 1840s that simple ideas may often combine into a more complex idea whose properties are not predictable from the properties of its elements.

The work on human learning and memory performed in the 1870s and 1880s by H. Ebbinghaus brought the associationistic tradition into the laboratory (see Estes, Chapter 5, this volume). Later on, the behaviorists, while shunning the mentalistic, introspective approaches of most predecessors, still retained a strong emphasis on association and analysis and on nurture over nature in determining human and animal behavior.

This long tradition helps to explain why laboratory research on associative processes in animals and humans was so quickly accepted as a worthwhile topic for psychologists to study. Conditioning experiments provided an objective way to investigate associations, not between

ideas but between different stimuli or between stimuli and responses. Furthermore, because *tabula rasa* theory was not only philosophically respectable but also in harmony with democratic principles, the study of learned responses was favored over the analysis of innate behavior patterns, particularly in North America. The associationistic tradition also tended to bias researchers against the study of what were considered nonassociative modifications of behavior. Continuing to reflect these emphases, Mackintosh's *The Psychology of Animal Learning* (1974)—a definitive survey of the field—stated at the outset that phenomena like habituation (the waning of response to a single, repeated stimulus) would not receive much attention and that the book would cover the “analytic study of the associative processes underlying learned modifications of behavior” (p. 1).

### Reflex Action versus Voluntary Behavior

Despite some of these beliefs about the role of experience in human knowledge, nature obviously endows all organisms with responses that are evoked in machinelike fashion by specific stimuli. In the seventeenth century Descartes had proposed a rudimentary physiological theory, said to hold for all animal behavior and some human behavior, that anticipated conceptions of reflex action that were widely discussed and analyzed experimentally by biologists in the eighteenth and nineteenth centuries (see Fearing, 1930/1964, for an exhaustive review). During those centuries a distinction was often made between voluntary and reflex muscular responses, with the former arising spontaneously and the latter instigated by appropriate environmental stimuli.

Physiologists originally applied the reflex concept only to inborn connections or correlations between stimuli and responses, and usually studied them in special “preparations” like frogs or cats with brains sectioned at various levels. Habituation of these reflexes after repeated stimulation was reported. However, at the beginning of the twentieth century I.P. Pavlov began to regard normal, behaving organisms as aggregates of both inborn and learned reflexes that could be released by more-or-less interchangeable stimuli. He found that salivary “psychic secretions” developed in