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Pavlov's Legacy

How and What Animals Learn

Pavlov claimed that his experiments with dogs would transform the study of psychology and the treatment of mental illness. His work inspired researchers to study how animals learn to traverse mazes, avoid shocks or press levers to obtain food and also to compare the learning and cognitive abilities of different species, ranging from apes and dolphins to rats and pigeons. This book describes five decades of research into animal learning and comparative psychology, examining Pavlov's influence on this research and discoveries made by scientists who accepted many of his claims, while others looked for evidence to reject them. Drawing together diverse strands of research and providing historical and biographical information to bring the details to life, this is an ideal resource for graduate students and researchers in behavioral neuroscience, as well as for anyone in adjacent fields with an interest in learning theory.

Robert A. Boakes is Emeritus Professor of Psychology at the University of Sydney. He has held positions at universities in the UK and USA, focusing his research efforts on the study of learning, mainly in animals. He has published numerous articles on animal learning and coauthored a Cambridge handbook on animal training, *Carrots and Sticks* (2007), following his highly regarded previous Cambridge book, *From Darwin to Behaviourism* (1984).

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Preface

In the late 1890s in St. Petersburg, Ivan Pavlov began to study what he came to call "*conditional* reflexes," a term that became converted into "*conditioned* reflexes" in translations from Russian into English. The importance of Pavlov's research was appreciated by several American psychologists, to the extent that John Watson proposed that it should provide the theoretical framework for the behaviorist movement in psychology that Watson was the first to promote. However, at the time knowledge of Pavlov's studies among those unable to understand Russian was limited to translations of the presentations given by Pavlov at a handful of international conferences. It was not until 1927, with the first translation into English of a set of lectures that Pavlov had given a few years earlier in St. Petersburg, that the non-Russian speaking world could appreciate the enormous amount of experimental work over the previous three decades that Pavlov and his many collaborators and students had completed. This body of research could now be fully appreciated in the English-speaking world.

The present book provides an account of how Pavlov's research influenced either directly or indirectly studies of how and what animals learn over the 50 years or so years after 1927. Some theories and research programs followed Watson in that they were based on the belief that the study of conditioning – even if not Pavlov's own version – was fundamental to understanding how animals learn and what they learn. Others completely rejected this belief and to a large extent sought in their experiments for evidence that would demonstrate the limitations of conditioning theory.

The nine chapters in this book are organized around topics. They can be read independently of each other. However, in most cases, it will help the reader to have at least skimmed through one or two of the earlier chapters. In addition to describing key projects, accounts of the lives of many of the more influential researchers are included.

Chapter 1 describes Pavlov's life and major research achievements. It also follows research on one of the topics he was the first to investigate. Pavlov believed that his experiments on dogs contributed to understanding various aspects of human psychology. One such topic was *experimental neurosis*. The chapter describes how his approach influenced other researchers and eventually led to what has become a standard tool used by many clinical psychologists. Despite such interests, Pavlov always described himself as a physiologist and maintained that the main point of his experiments was to obtain greater understanding of the brain. Yet, as described in this chapter, his concept of how the brain works ignored mainstream developments

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in neurophysiology and was a major target for a critical admirer, the Polish scientist, Jerzy Konorski.

Chapter 2 describes the theories of Clark Hull, who had an enormous influence on American psychology from the time he first wrote about – and reinterpreted – Pavlov's work in the early 1930s to well into the 1960s. Hull's ambition was to develop a general theory of learning and motivation based on the development of habits, as studied mainly in rats; Hull's theory was intended to provide psychology with the equivalent of Newton's contribution to physics. His vision inspired some of the brightest and most productive researchers into animal learning in the 1950s and 1960s.

Chapter 3 centers on the work of Hull's arch critic, Edward Tolman. He was convinced that the Pavlov-inspired approach to the study of learning was far too narrow. Using a variety of mazes, Tolman and his students obtained evidence that their rats could anticipate events – rather just make conditioned responses – and could learn about the spatial properties of environments they were placed in. In the late 1960s, various researchers – most with little connection to Tolman – discovered the important role of the context in which an animal was conditioned. In the 1970s, experiments by neuroscientists on the function of the hippocampus led to a revival of interest in spatial learning and renewed appreciation of Tolman's suggestion that animals form representations – "maps" – of their environment.

Hull's and other theories of habit learning were based on the idea that "rewards" – or "reinforcements" following a response – "stamp in" connections between whatever stimulus or stimuli are present and the response. Such S-R-Reinforcement theories face a problem in explaining avoidance learning. As described in Chapter 4, the original experiments were first performed in the St. Petersburg laboratory of Pavlov's arch-rival, Vladimir Bekhterev. Researchers there arranged that, if when a signal was given, a dog failed to flex a leg, a shock would be delivered; if the leg was flexed in time, the shock was avoided. In general, these dogs learned quickly to flex the target leg as soon as the signal was given. Bekhterev considered this kind of learning to be a variant of Pavlov's conditioned reflexes. It took over 30 years before a widely accepted explanation was developed of how the absence of an event could promote learning. A key contribution was the "two-factor theory" developed by Hobart Mowrer. His studies of avoidance learning and those that followed, mainly by Richard Solomon and his students, laid the foundation for breakthroughs in the study of associative learning in the late 1960s.

At least until very late in his career, Pavlov believed that what was true of the dog's capacity for learning was true of any other vertebrate. However, he suggested that humans have the extra benefit of a "second signaling system," that is, language. Attempts to show that species differ in their learning and problem-solving abilities are described in Chapter 5. This chapter on comparative psychology starts with studies that attempted to teach a language to chimpanzees and examined their apparently remarkable ability to learn by imitation. The chapter then describes studies of complex learning in monkeys and dolphins. It ends with accounts of experiments in the 1970s that compared the learning abilities of corvids with those of pigeons.

While psychologists and neuroscientists have almost always studied learning in a laboratory setting, other scientists have mainly studied learning in more natural

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environments. One such form of learning was termed *imprinting* by the Austrian ethologist, Konrad Lorenz. Chapter 6 describes his claims about this phenomenon and how researchers that were more experimentally oriented than Lorenz tested these claims and rejected many of them. The interaction between ethologists and learning theorists led to studies of how species differed in regard to *constraints* on what they could learn, a topic that is covered in the second half of Chapter 6.

The beginning the twentieth century saw a steady increase in the number of experimental studies aimed at the question of how animals perceive their world. These included ones that, for example, tested whether a dog, cat, or rat could learn to discriminate between two stimuli that differed only in color. Chapter 7 describes developments in the study of discrimination learning that became increasingly theoretical. For example, one important issue had to do with the possible role of attention-like processes in such learning. This was a topic that was central to the work in the 1950s and 1960s of Stuart Sutherland and Nick Mackintosh in the UK.

Chapter 8 provides an account of the life and work of B.F. Skinner, a behaviorist who became one of the most famous and influential psychologists of his generation. It describes his development of the operant chamber – widely known as a *Skinner box* – and the increasingly sophisticated equipment used to control events with the chamber. These enabled increasingly complex experiments to be run, not only by "Skinnerians" who agreed with Skinner's radical views on science and on the preeminent role of operant conditioning in human life but also by those without any sympathy for his views. The chapter also traces the expansion of the movement, the Experimental Analysis of Behavior founded by Skinner and his close friend and associate, Charles Ferster, both within and beyond the United States.

Chapter 9, the final chapter, starts by describing the handful of key findings from the late 1960s that were obtained by Leon Kamin, Robert Rescorla and Allan Wagner from experiments on discrimination learning and fear conditioning. These led to a revolution in the way learning by animals was studied. Instead of concentrating of how their behavior changed, it took such changes as an index of what associations the animals had formed. A number of theories of associative learning that were developed in the 1970s remained influential for the next 50 years. In the 1980s, an important and influential distinction was drawn between *actions*, which are sensitive to the value of their consequences, and automatic habits.

In 1984, I published a book with the title, *From Darwin to Behaviorism*. As the title suggests, it examined the influence of late nineteenth-century theories of evolution and the new ideas about animal behavior and learning that these theories prompted on research into how animals learn. The latter led to the emergence of behaviorism as a major movement within American psychology. The present book is in some sense a sequel that could have been given the clumsy title, *From Pavlov to Associative Learning Theory*.

Writing the present book has been an entirely different experience from writing my book of 40 or so years ago. One obvious difference is provided by the Internet. Previously I needed to obtain a travel grant to visit various libraries in North America and to obtain permission, for example, from Cambridge University Library to examine

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Darwin's notebooks. Now only a few clicks on my laptop are needed to access almost any source I need.

The amount of easily available material is so abundant that I have had to be very selective in ways that reflect my own history of studying psychology. I was an undergraduate in the UK and then a Ph.D. student in the USA. I then taught psychology and carried out research in the UK for many years, for two years in the USA and, finally, for over 30 years in Australia. Someone with a different history would have written a very different book.

Another and more important way in which the present book differs from its predecessor is that in writing the latter, I could adopt the pose of an objective assessor, since I had had no direct or even indirect contact with any of the people I wrote about. This is not true of the present book. I have met many of the people whose lives and work are described in this book. Several were, or still are, good friends. Consequently, I have not tried to obscure the fact that this is in some ways a personal book. It contains potted biographies of many of the people who made major contributions. The rule I have maintained is to provide these only for researchers who have died.

I am an experimental psychologist with an interest in the history of this branch of science that goes back to when I was a graduate student. But I am not an historian. When I was a boy, my friends and I would go on long cycle rides and afterwards record where we had been and what happened – usually, very little! – in a book we called *The Chronicles*. The present book could be seen as a "chronicle" of theories and experiments concerned with understanding how animals learn. I believe these to be of considerable interest but fear they could well be entirely forgotten except by a handful of specialists. Thus, this book can be seen to celebrate a 50-year-long golden age of research on animal learning. It is an age that is unlikely to be repeated. Setting up and maintaining an animal research facility is expensive. Since the 1980s, it has become steadily more difficult to obtain funding for purely behavioral research. Instead, to be successful, the main focus of a project needs to be on underlying brain mechanisms and to use "cutting edge" neuroscientific techniques.

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Acknowledgments

The reader I often had in mind when writing these chapters was a student or early career researcher who already had an interest in learning or behavioral neuroscience. However, I also thought about whether some topic would be of more general interest and whether my treatment to a large extent be comprehensible to someone with no background at all in this area. Such a reader is my wife, Margaret Kirkwood, who read every draft chapter and let me know what sections were obscure or impossibly technical, and so needed re-writing, as well as pointing out typos and other minor errors. Without her amazing support for more than 25 years, this book would never have been written.

I also am pleased to give heartfelt thanks to the many colleagues, friends and previously unknown individuals who have also read and commented on drafts ranging from short sections to several whole chapters, have helped me locate photos or have let me use photos they own. They include – in no particular order – Vin LoLordo, Fred Westbrook, Tony Dickinson, Geoff Hall, Euan Macphail, David Booth, Billy Baum, Fred Toates, John Staddon, Charlie Catania, Terry Davidson, Ludy Benjamin, Don Dewsbury, Patricia Courvillon, Herb Jenkins, Bill Whitlow, Jerry Rudy, Sarah Shettleworth, Peter Holland, David Dickins, Donald Heth, John Pearce, Edgar Vogel, Jacqueline Glynn, Dick Stevenson, Marie-Claire Kamin, Gavin McNally, Shirley Steele, Lynn Nadel, Tony Riley and Herb Terrace.

I have normally relied on primary sources such as experimental reports, theoretical papers, obituaries and biographical sketches, all of which can be accessed via the Internet. The major exception has been in writing the first chapter, where I have relied heavily on an extraordinary, and the only complete, biography of Pavlov, the massive work of Daniel Todes (2014).

Finally, I would like to thank two groups of people. One consists of the many supportive colleagues at the University of Sydney, especially Evan, Justin and Ben. The other group are members of the Patonga non-fiction book club; Paul, Dain, Brad, Rob and Richard have taught me the different ways in which books can be read and the different features that can make for a "good book."

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