CHAPTER **12**

ANIMAL EXPERIMENTAL PSYCHOLOGY

The next chapter considers behaviorism, probably the most important school of thought in the history of American psychology. In starting its conceptual revolution, behaviorism borrowed from functionalism. But of equal importance was the legacy from animal psychology. This chapter focuses on animal work, not in the sense of providing a history of animal psychology but for providing the context necessary to understand its contributions to behaviorism.

Once Darwin had removed humans from their lofty perch and placed them with the rest of the animal kingdom, the study of animal behavior took on a new meaning. In 1882, the year of Darwin's death, George Romanes (1848–1894), an English biologist, published his *Animal Intelligence,* a book that is considered by many historians as the first textbook on comparative psychology. Romanes studied both vertebrates and invertebrates, attempting to compare their mental processes, which he investigated by his technique of *introspection by analogy.* That means that in observing animals he would try to understand their behavior by asking himself what he would do in a similar situation. Not surprisingly, his book was considerably anthropomorphic.

C. Lloyd Morgan (1852–1936), another of the English biologists influenced by Darwin, objected to the practice of Romanes and others of attributing human faculties, such as reason, to animals lower in the phylogenetic scale, when in fact such attributions might not be warranted. In his 1894 book, *Introduction to Comparative Psychology,* Morgan stated what has become known as Morgan's Canon: that in explaining animal behavior, a higher mental process should not be invoked if the behavior can be adequately explained by a lower mental process. Although Morgan insisted on parsimonious explanations for animal behavior, he did not object to introspection by analogy and used the method himself. However, he also performed experiments with animals in their natural settings, an important step forward for animal psychology.

Whereas Romanes, Morgan, and others sought to explain the mental processes of animals, the German biologist Jacques Loeb (1859–1924), who did much of his research in the United States, was arguing that much animal behavior occurred without regard to any mental activity. He introduced his concept of *tropism*, meaning a response that occurred involuntarily to a stimulus. He noted that plants turned their leaves toward the sun in an automatic response (heliotropism) and argued that much animal behavior could be explained in a similar fashion. For the behaviorists, Loeb's ideas had special appeal: "If the actions of lower organisms can be explained without reference to mental events, why cannot human behavior be explained in the same way?" (Kendler, 1987, p. 153).

In opposition to Loeb, an American psychologist, Edward L. Thorndike (1874–1949), sought to show the relationship between mental processes in lower animals and those in humans. Thorndike, whose interests in animal behavior were attributed to C. Lloyd Morgan, began his animal research career testing baby chicks in mazes set up in the basement of William James's home. He later moved from Harvard University to Columbia University, where he continued his animal research in Cattell's laboratories, taking his doctorate in psychology there in 1898. His dissertation, entitled "Animal Intelligence," described his maze studies with chicks and his now-classic puzzle-box experiments with cats and dogs. Thorndike constructed fifteen puzzle boxes in which the animals were placed (see Burnham, 1972). Each box required a different response for escape. Once the animal had made the correct response and had escaped from the box, it was rewarded with food. Thorndike found that his animal subjects learned to escape the boxes in a trial-and-error fashion (which he took as evidence against the operation of mental processes); the correct responses were gradually learned, whereas those responses that did not lead to escape were gradually eliminated from the animal's behavior in the box. From this he formulated his *law of effect*, which is today recognized as the forerunner of the *law of reinforcement:*

> Any act which in a given situation produces satisfaction becomes associated with that situation, so that when the situation recurs the act is more likely than before to recur also. Conversely, any act which in a given situation produces discomfort becomes disassociated from the situation, so that when the situation recurs the act is less likely than before to recur. (Thorndike, 1905, p. 203)

The first part of that law describes the effects of what has come to be called reinforcement, and the second part the effects of punishment. Much later, Thorndike eliminated the second part when research showed that punishment suppressed stimulus-response connections but did not necessarily weaken them (this subsequent version is called the *truncated law of effect*).

Thorndike was a busy researcher and a prolific writer throughout his career, publishing more than five hundred works, a number of those books. But his animal research was confined to the early years of his career, and was largely abandoned by 1911 as he pursued his interests in educational psychology and mental testing (see O'Donnell, 1985). Nevertheless, his animal work ranks among his most important work, both methodologically and theoretically. It would play a very influential role in the rise of learning research and the dominance of learning theory throughout the reign of behaviorism (see Chapters 13 and 14). Further, Thorndike was among the first scientists (some historians say the first) to conduct research with animals in a laboratory setting. His procedures served as models for much of the early animal psychology in the United States (Gottlieb, 1979).

Some histories of psychology label Thorndike a functionalist, others see him as a behaviorist. He denied membership in either. His placement in this chapter is meant to show his work as intermediate between the two.

While Thorndike was watching his animals escape from the puzzle boxes, a Russian physiologist was beginning to explore what he termed a *psychic reflex*—the salivation that could be elicited in an animal upon ringing a bell, when the bell had been previously paired with food. Ivan Pavlov (1849–1936) spent the last thirty-four years of his life working out the various facets of what we call *classical conditioning* (or Pavlovian conditioning). Independent of Thorndike, he discovered the principle of reinforcement and many other learning phenomena such as extinction, spontaneous recovery, generalization, discrimination, conditioned inhibition, conditioned emotional reactions, and higher-order conditioning. Once his work became known to American psychologists, around 1909, it proved to be an important influence for those looking to move psychology away from mentalism to a more objective study of observable behavior.

Unlike Romanes, who had attributed much consciousness to animals, Thorndike found little evidence for animal consciousness in his puzzle-box studies. Consistent with that view was Loeb's emphasis on animal tropisms, which discarded any need for assuming animal consciousness. Pavlov's work added weight to this view as well. He rejected the mentalism of psychology (indeed, he rejected all of psychology until the last few years of his life) and called for a total explanation of the higher mental processes in terms of physiological processes. Perhaps, as the behaviorists would soon assert, psychology could discard the mind and provide a wholly scientific account based on observable behavior and physiology.

The first selection in this chapter is on the psychology of learning, written by Edward L. Thorndike. In it he discusses his laws of effect, exercise, and readiness in the context of his animal studies. It is an elegant statement of this classic early work in learning.

The second selection is on Pavlov's work, but it was not written by Pavlov. Instead, it is the article published in the *Psychological Bulletin* in 1909 that first introduced American psychologists to the work of Pavlov. The authors are Robert M. Yerkes (1876–1956), a pioneer researcher in animal behavior, and a Russian student, Sergius Morgulis. In spite of Pavlov's negative views toward psychology, it was a paper that would generate considerable interest, particularly for behaviorist John B. Watson (whose use of it is described in the next chapter).

The third selection is by Philip J. Pauly, a historian of science, and concerns a debate on animal tropisms between Jacques Loeb and another American biologist, Herbert Spencer Jennings (1868–1947). The paper discusses the significance of the debate for the science of animal behavior and concludes with a brief section considering the influence of Loeb and Jennings on the work of John B. Watson.

The last selection, by another historian of science, Deborah J. Coon, focuses on the dissertation research on the knee-jerk reflex by the University of Pennsylvania psychologist Edwin B. Twitmyer (1873–1943). In his research, Twitmyer rang a bell to signal to the subject that the patellar tendon was about to be struck with a rubber hammer. He discovered that eventually the ringing of the bell alone would produce a knee-jerk response. He reported those results at a 1904 meeting of the American Psychological Association and published them in *Psychological Bulletin* the following year, a year before Pavlov's initial publication on the subject. Was Twitmyer the discoverer of the conditioned response as some historians claim, or did the conditioned response discover him (see Misceo & Samelson, 1983)? Coon discusses the various hypotheses that have been offered to explain why Twitmyer's work was not recognized and provides her own interpretation in the social and intellectual contexts of both Pavlov and Twitmyer. Perhaps this controversy is best settled in the context of a distinction between anticipation and foundation as described by Sarup in the first chapter of this book. Whatever the verdict, the Coon article provides an interesting look at a little-known episode in the history of the conditioned reflex.

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The Laws of Learning in Animals

Edward L. Thorndike

SAMPLES OF ANIMAL LEARNING

The complexities of human learning will in the end be best understood if at first we avoid them, examining rather the behavior of the lower animals as they learn to meet certain situations in changed, and more remunerative, ways.

Let a number of chicks, say six to twelve days old, be kept in a yard (YY of Figure 1) adjoining which is a pen or maze (A B C D E of Figure 1). A chick is taken from the group and put in alone at A. It is confronted by a situation which is, in essence, *Confining walls and the absence of the other chicks, food and familiar surroundings*. It reacts to the situation by running around, making loud sounds, and jumping at the walls. When it jumps at the walls, it has the discomforts of thwarted effort, and when it runs to B, or C, or D, it has a continuation of the situation just described; when it runs to E, it gets out and has the satisfaction of being with the other chicks, of eating, and of being in its usual habitat. If it is repeatedly put in again at A, one finds that it jumps and runs to B or C less and less often, until finally its only act is to run to D, E, and out. It has formed an association, or connection, or bond, between the situation due to its removal to A and the response of going to E. In common language, it has learned to go to E when put at A—has learned the way out. The decrease in the useless running and jumping and standing still finds a representative in the decreasing amount of time taken by the chick to escape. The two chicks that formed this particular association, for example, averaged three and a half minutes (one about three and the other about four) for their first five trials, but came finally to escape invariably within five or six seconds.

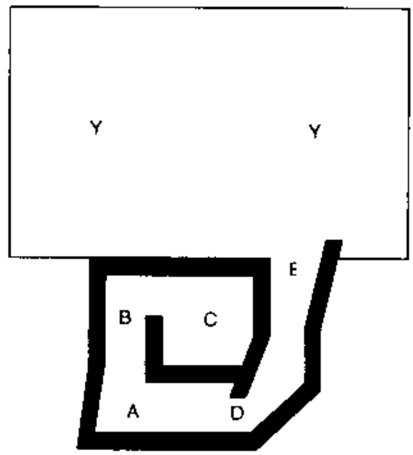


FIGURE 1

The following schemes represent the animal's behavior (1) during an early trial and (2) after the association has been fully formed—after it has learned the way out perfectly. A graphic representation of the progress from an early trial to a

1
BEHAVIOR IN AN EARLY TRIAL

Situation	Responses	Resulting States of Affairs
As described above, in the text	To chirp, etc.	Annoying continuation of the situation and thwarting of the inner tendencies.
	To jump at various places.	" " "
	To run to B.	" " "
	To run to C.	" " "
	To run to D.	" " "
	To run to E.	Satisfying company, food and surroundings.

Adapted from Thorndike, E. L. (1913). *Educational psychology: The psychology of learning*, Volume 2. New York: Teachers College Press, pp. 6–16.

2
BEHAVIOR IN A TRIAL AFTER LEARNING

Situation	Responses	Resulting States of Affairs
Same as in (1).	To run to E.	Satisfying as above.

trial after the association has been fully formed is given in the following figures, in which the dotted lines represent the path taken by a turtle in his fifth (Figure 2) and fiftieth (Figure 3) experiences in learning the way from the point A to his nest. The straight lines represent walls of boards. Besides the useless movements, there were, in the fifth trial, useless stoppings. The time taken to reach the nest in the fifth trial was seven minutes; in the fiftieth, thirty-five seconds. The figures represent typical early and late trials, chosen from a number of experiments on different individuals in different situations, by Dr. R. M. Yerkes, to whom I am indebted for permission to use these figures.

Let us next examine a somewhat more ambitious performance than the mere discovery of the proper path by a chick or turtle. If we take a box twenty by fifteen by twelve inches, replace its cover and front side by bars an inch apart, and make in this front side a door arranged so as to fall open when a wooden button inside is turned from a vertical to a horizontal position, we shall have means to observe such. A kitten, three to six months old, if put in this box when hungry, a bit of fish being left outside, reacts as follows: It tries to squeeze through between the bars, claws at the bars and at loose things in and out of the box, stretches its paws out between the bars, and bites at its confining walls. Some one of all these promiscuous clawings, squeezings, and bitings turns round the wooden button, and the kitten gains freedom and food. By repeating the experience again and again, the animal gradually comes to omit all the useless clawings, and the like, and to manifest only the particular impulse (e.g., to claw hard at the top of the button with the paw, or to push against one side of it with the nose) which has resulted successfully. It turns the button around without delay whenever put in the box. It has formed an association between the situation, *confinement in a box of a certain appearance,* and the response of *clawing at a certain part of that box in a certain definite way*. Popularly speaking, it has learned to open a door by turning a button. To the uninitiated observer the behavior of the six kittens that

FIGURE 2
The path taken by a turtle in finding his way from A to his nest, in his 5th trial.

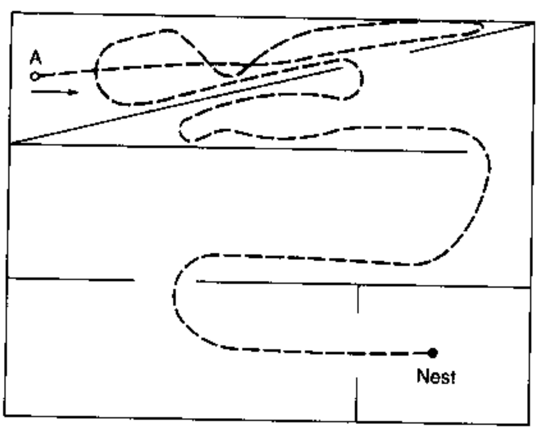
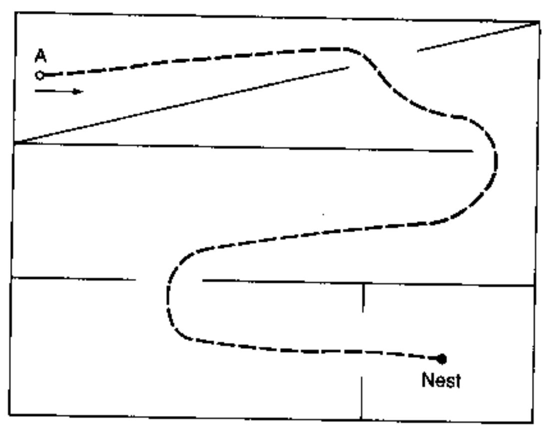


FIGURE 3
The path taken by a turtle in finding his way from A to his nest, in his 50th trial.



thus freed themselves from such a box would seem wonderful and quite unlike their ordinary accomplishments of finding their way to their food or beds, but the reader will realize that the activity is of just the same sort as that displayed by the chick in the pen. A certain situation arouses, by virtue of accident or, more often, instinctive equipment, certain responses. One of these happens to be an act appropriate to secure freedom. It is stamped in connection with that situation. Here the act is clawing at a certain spot instead of running to E, and is selected from a far greater number of useless acts.

In the examples so far given there is a certain congruity between the 'set' associated with the situation and the learning. The act which lets the cat out is hit upon by the cat while, as we say, trying to get out, and is, so to speak, a likely means of release. But there need be no such congruity between the 'set' and the learning. If we confine a cat, opening the door and letting it out to get food only when it scratches itself, we shall, after enough trials, find the cat scratching itself the moment it is put into the box. Yet in the first trials it did not scratch itself in order to get out, or indeed until after it had given up the unavailing clawings and squeezings, and stopped to rest. The association is formed with such an 'unlikely' or 'incongruous' response as that of scratching, or licking, or (in the case of chicks) pecking at the wing to dress it, as truly as with a response which original nature or previous habit has put in connection with the set of the organism toward release, food, and company.

The examples chosen so far show the animal forming a single association, but such may be combined into series. For instance, a chick learns to get out of a pen by climbing up an inclined plane. A second pen is then so arranged that the chick can, say by walking up a slat and through a hole in the wall, get from it into pen No. 1. After a number of trials the chick will, when put in pen No. 2, go at once to pen No. 1, and thence out. A third pen is then so arranged that the chick, by forming another association, can get from it to pen No. 2, and so on. In such a series of associations the response of one brings the animal into the *situation* of the next, thus arousing its response, and so on to the end. Three chicks thus learned to go through a sort of long labyrinth without mistakes, the 'learning' representing twenty-three associations.

The learning of the chick, turtle, and kitten in the cases quoted is characterized negatively by the absence of inferential, ratiocinative thinking; and indeed by the absence of effective use of 'ideas' of any sort. Were the reader confined in a maze or cage, or left at some distance from home, his responses to these situations would almost certainly include many ideas, judgments, or thoughts about the situation; and his acts would probably in large measure be led up to or 'mediated' by such sequences of ideas as are commonly called reasoning. Between the annoying situation and the response which relieves the annoyance there might for the reader well intervene an hour of inner consideration, thought, planning, and the like. But there is no evidence that any ideas about the maze, the cage, the food, or anything else, were present to determine the acts of the chicks or kittens in question. Their responses were made directly to the situation as sensed, not *via* ideas suggested by it. The three cases of learning quoted are adequately accounted for as the strengthening and weakening of bonds between a situation present to sense and responses in the nervous system which issue then and there in movement. The lower animals do occasionally show signs of ideas and of their influence on behavior, but the great bulk of their learning has been found explainable by such direct binding of acts to situations, unmediated by ideas.

CHARACTERISTICS OF ANIMAL LEARNING

These cases, and the hundreds of which they are typical, show the laws of readiness, exercise, and effect, uncomplicated by any pseudo-aid from imitation, ideo-motor action, or superior faculties of inference. There are certain states of affairs which the animal welcomes and does nothing to avoid—its satisfiers. There are others which it is intolerant of and rejects, doing one thing or another until relieved from them. Of the bonds which the animal's behavior makes between a situation and responses those grow stronger which are accompanied by satisfying states of affairs, while those accompanied by annoyance weaken and disappear. Exercise strengthens and disuse weakens bonds. Such is the sum and substance of the bulk of animal learning.

These cases exemplify also five characteristics of learning which are secondary in scope and importance only to the laws of readiness, exercise, and effect.

The first is the fact of *multiple response to the same external situation*. The animal reacts to being confined in the pen in several ways, and so has the possibility of selecting for future connection with that situation one or another of these ways. Its own inner state changes when jumping at the wall at B produces a drop back into the pen, so that it then is less likely to jump again—more likely to chirp and run. Running to C and being still confronted with the confining walls may arouse an inner state which impels it to turn and run back. So one after another of the responses which, by original nature or previous learning, are produced by the confining walls *plus* the failure of the useless chirpings, jumpings, and runnings, are made.

This principle of *Multiple Response* or *Varied Reaction* will be found to pervade at least nine-tenths of animal and human learning. As ordinarily interpreted, it is not universal, since, even if only one response is made, the animal may change its behavior—that is, learn—either by strengthening the connection so as to make that response more surely, more quickly, and after a longer interval of disuse; or by weakening the connection so as to be more likely to do nothing at all in that situation, inactivity being a variety of response which is always a possible alternative. If we interpret variety of reaction so as to include the cases where an animal either makes one active response or is inactive—that is, either alters what it was doing when the situation began to act, or does not alter what it was doing—the principle of varied response is universal in learning.

The second of the five subsidiary principles is what we may call the law of the learner's *Set* or *Attitude* or *Adjustment* or *Determination*. The learning cannot be described adequately in a simple equation involving the pen and a chick taken abstractly. The chick; according to his age, hunger, vitality, sleepiness and the like, may be in one or another attitude toward the external situation. A sleepier and less hungry chick will, as a rule, be 'set' less toward escape-movements when confined; its neurones involved in roaming, perceiving companions and feeding will be less ready to act; it will not, in popular language, 'try so hard to' get out or 'care so much about' being out. As Woodworth says in commenting upon similar cases of animal learning:

> In the first place we must assume in the animal an adjustment or determination of the psycho-physical mechanism toward a certain end. The animal desires, as we like to say, to get out and to reach the food. Whatever be his consciousness, his behavior shows that he is, as an organism, set in that direction. This adjustment persists till the motor reaction is consummated; it is the driving force in the unremitting efforts of the animal to attain the desired end. His reactions are, therefore, the joint result of the adjustment and of stimuli from various features of the cage. Each single reaction tends to become associated with the adjustment. [Ladd and Woodworth, 1911, p. 551.]

The principle that in any external situation, the responses made are the product of the 'set' or 'attitude' of the animal, that the satisfyingness or annoyingness produced by a response is conditioned by that attitude, and that the 'successful' response is by the law of effect connected with that attitude as well as with the external situation *per se*—is general. Any process of learning is conditioned by the mind's 'set' at the time.

Animal learning shows also the fact, which becomes of tremendous moment in human learning, that one or another element of the situation may be prepotent in determining the response. For example, the cats with which I experimented, would, after a time, be determined by my behavior more than by other features of the general situations of which that behavior was a part; so that they could then learn, as they could not have done earlier, to form habits of response to signals which I gave. Similarly, a cat that has learned to get out of a dozen boxes—in each case by pulling some loop, turning some bar, depressing a platform, or the like—will, in a new box, be, as we say, 'more attentive to' small objects on the sides of the box than it was before. The connections made may then be, not absolutely with the gross situation as a total, but predominantly with some element or elements of it. Thus, it makes little or no difference whether the box from which a cat has learned to escape by turning a button, is faced North, South, East, or West; and not much difference if it is painted ten per cent blacker or enlarged by a fifth. The cat will operate the mechanism substantially as well as it did before. It is, of course, the case that the animals do not, as a thoughtful man might do, connect the response with perfect strictness just to the one essential element of the situation. They can be much more easily confused by variations in the element's concomitants; and in certain cases many of the irrelevant concomitants have to be supplied to enable them to give the right response. Nevertheless they clearly make connections with certain parts or elements or features of gross total situations. Even in the lower animals, that is, we find that the action of a situation is more or less separable into the action of the elements that compose it—that even they illustrate the general *Law of Partial Activity*—that a part or element or aspect of a situation may be prepotent in causing response, and may have responses bound more or less exclusively to it regardless of some or all of its accompaniments.

If a cat which has never been confined in a box or cage of any sort is put into a box like that described a few pages back, it responds chiefly by trying to squeeze through the openings, clawing at the bars and at loose objects within the box, reaching out between the bars, and pulling at anything then within its grasp. In short, it responds to this artificial situation as it would by original nature to confinement, as in a thicket. If a cat which has learned to escape from a number of such boxes by manipulating various mechanical contrivances, is confined in a new box, it responds to it by a mixture of the responses originally bound to confining obstacles and of those which it has learned to make to boxes like the new one.

In both cases it illustrates the *Law of Assimilation* or *Analogy* that to any situations, which have no special original or acquired response of their own, the response made will be that which by original or acquired nature is connected with some situation which they resemble. For S_2 to resemble S_1 means for it to arouse more or less of the sensory neurones which S_1 would arouse, and in more or less the same fashion.

The last important principle which stands out clearly in the learning of the lower animals is that which I shall call *Associative Shifting*. The ordinary animal 'tricks' in response to verbal signals are convenient illustrations. One, for example, holds up before a cat a bit of fish, saying, "Stand up." The cat, if hungry enough, and not of fixed contrary habit, will stand up in response to the fish. The response, however, contracts bonds also with the total situation, and hence to the human being in that position giving that signal as well as to the fish. After enough trials, by proper arrangement, the fish can be omitted, the other elements of the situation serving to evoke the response. Association may later be further shifted to the oral signal alone. With certain limitations due to the necessity of getting an element of a situation attended to, a response to the total situation A B C D E may thus be shifted to B C D E to C D E, to D E, to E. Moreover, by adding to the situation new elements F, G, H, etc., we may, subject to similar limitations, get *any response of which a learner is capable* associated with *any situation to which he is sensitive*. Thus, what was at the start utterly without power to evoke a certain response may come to do so to perfection. Indeed, the situation may be one which at the start would have aroused an exactly opposite response. So a monkey can be taught to go to the top of his cage whenever you hold a piece of banana at the bottom of it.

These simple, semi-mechanical phenomena—multiple response, the coöperation of the animal's set or attitude with the external situation, the predominant activity of parts or elements of a situation, the response to new situations as to the situations most like them, and the shifting of a response from one situation to another by gradually changing a situation without disturbing the response to it—which animal learning discloses, are the fundamentals of human learning also. They are, of course, much complicated in the more advanced stages of human learning, such as the acquisition of skill with the violin, or of knowledge of the calculus, or of inventiveness in engineering. But it is impossible to understand the subtler and more planful learning of cultivated men without clear ideas of the forces which make learning possible in its first form of directly connecting some gross bodily response with a situation immediately present to the senses. Moreover, no matter how subtle, complicated, and advanced a form of learning one has to explain, these simple facts—the selection of connections by use and satisfaction and their elimination by disuse and annoyance, multiple reaction, the mind's set as a condition, piecemeal activity of a situation, with prepotency of certain elements in determining the response, response by analogy, and shifting of bonds—will, as a matter of fact, still be the main, and perhaps the only, facts needed to explain it.

The Method of Pavlov in Animal Psychology

Robert M. Yerkes and Sergius Morgulis

About eight years ago Professor J. P. Pawlow,* Director of the physiological department of the Institute of Experimental Medicine in St. Petersburg, devised and introduced into his great research laboratory an ingenious and valuable new method of investigating the physiology of the nervous system in its relations to the so-called psychic reactions of organisms. This method—now widely known as the Pawlow salivary reflex method—has been extensively employed by Pawlow and his students in St. Petersburg. Recently it has been introduced into the Physiological Institute of Berlin by Nicolai, a former student of Pawlow. It consists in the quantitative study of those modifications of the salivary reflex which are conditioned by complex receptive and elaborative processes (psychic reactions) in the central nervous system.

Inasmuch as practically all of the results of the method have been published in Russia, it has seemed to us important that a general descrip-

Adapted from Yerkes, R. M., & Morgulis, S. (1909). The method of Pawlow in animal psychology. *Psychological Bulletin, 6*, 257–273.

* J. P. Pawlow is, of course, Ivan P. Pavlov. The spelling is due to the differences between the Russian and English alphabets. (Ed. note)