Chapter 2

E. L. THORNDIKE: THE ORIGINAL CONNECTIONISM

BIOGRAPHY

Edward Lee Thorndike was born in Williamsburg, Massachusetts in 1874, the son of a Methodist minister (see Figure 2.1). He attended Wesleyan University as an undergraduate, then studied at Harvard, where he obtained a second bachelor's degree and a master's degree. During this time, he took a course with William James, the most eminent of American psychologists, which led him to concentrate his efforts in psychology rather than English. Before finishing a doctorate, he was attracted to Columbia University, where he obtained his Ph.D. in 1898 under the famous hereditarian and mental tester James M. Cattell. After a year on the faculty at Case Western Reserve, he joined the faculty of Teachers College, associated with Columbia University, where he spent the remainder of his 43-year academic career.

Thorndike's dissertation was published as a monograph, *Animal Intelligence*, in 1898. It included the essential aspects of his connectionism, emphasizing the importance of trial and error (or success and error) in the performing of seemingly insightful acts. Thorndike published more than 450 articles, books, and monographs during his career; the following are some of the more influential pieces:

"Transfer of Training: The Influence of Improvement in One Mental Function upon the Efficiency of Other Functions," 1901 (with R. S. Woodworth)

Educational Psychology, 1903 (first of several editions)

An Introduction to the Theory of Mental and Social Measurements, 1904

The Psychology of Wants, Interests, and Attitudes, 1935

Selected Writings From a Connectionist's Psychology, 1949

Thorndike has had a tremendous influence in psychology and in education, in part because of

FIGURE 2.1 Edward L. Thorndike, 1874–1949. *Photo courtesy of the Archives of the History of American Psychology*

his extraordinary productivity. More than any other figure of his time, he argued that psychology could not remain solely concerned with the analysis of consciousness. He claimed that if we treat mind as a part of nature, we find that our thoughts, attitudes, and wants depend upon the same factors that determine behavior in general. His proposal was the first serious alternative to the mentalism of the time.

INTRODUCTION

Section 1 of this chapter discusses the significance of Thorndike's early work for the psychology of that time. Thorndike was the first to question the view of what has been common sense for thousands of years. His alternative altered the course of education and laid the groundwork for many current ideas.

Section 2 presents his theory of learning, derived from the famous early experiments he carried out with animals. His results were surprising, and, as Tolman said much later, they led to a theory of learning that influenced psychologists for more than a half a century: Later theories could be classified according to whether they agreed or disagreed with Thorndike. This was quite an accomplishment for a 24-year-old psychologist.

Section 3 considers some of the most frequent criticisms of his views, both present and past. If he did truly revolutionize thinking, then one must expect criticisms from those who held to the displaced ways of looking at things as well as from those who questioned the value of his alternative.

In 1923, President Coffman of the University of Minnesota said, "There are only two schools of psychology, one of them is Thorndike's and the other one isn't" (Joncich, 1968). What was it about Thorndike's theories that so strongly (and so rapidly) affected psychology?

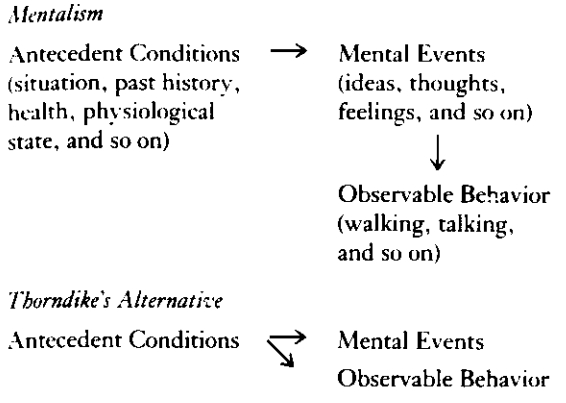
1. THE SIGNIFICANCE OF THORNDIKE'S EARLY WORK

Mentalism

Mentalism is the ancient belief that our actions are caused by mental processes; these include our thoughts, hopes, expectations, and so on. Before Thorndike, almost everyone accepted this view; most people still do. We are brought up as mentalists, and it may seem odd that anyone would question such a view.

We all feel that our experience is in large part a private affair. We have ideas, passing thoughts, and daydreams. We feel emotions, urges, pleasures, and pains. This private experience seems totally different from our comings and goings,

TABLE 2.1 Mentalism versus Thorndike's Alternative View



our walking and talking, and the rest of our activity that is open for others to see. It also seems that our outward behavior is often *caused* by private (mental) events. For example, you mentally plan to speak, walk, write, or strike out at someone, and the act follows, unless you mentally decide not to do it. When you find yourself "at a loss for words," you might stop and try to privately recapture your train of thought. Your own experience is yours alone; for the most part, your hopes, dreams, sufferings, and joys can be known to others only if you choose to communicate them. I often find this to be very difficult; private experience is not easily verbalized. One of the marks of great literature, music, and art is its success in communicating such feelings.

The unique nature of private experience is taken for granted by all of us; given our education by society, it is not surprising. This way of looking at things has been common in western society for a great many centuries. The seventeenth-century philosopher Descartes is credited with making the case for the distinction between mind and body, but the belief that our mental and physical aspects are fundamentally different in kind was popular long before. The philosophers of the eighteenth and nineteenth centuries argued that all that we can know are our personal mental activities (see Chapter 1), and it was therefore natural that the earliest psychologists in the late nineteenth century should see their task exclusively as the analysis of consciousness. Given the assumption that our actions depend upon our mental states, it follows that an understanding of these mental states must precede an understanding of our actions.

Mentalism is this doctrine, which holds that the mind is imprisoned in the body and that our actions depend in part upon mental causes. We cry because of (mental) sadness, we solve problems with (mental) reasoning, we attack because of (mental) anger, we recall past experiences because of (mental) memory powers, and so on. All of these causes originate in the mind. The terrible problem with this view is that it leaves sadness, reasoning, anger, and memory unexplained. Instead, we merely begin with some activity, such as recalling the past, and we simply rename it *memory*. In so doing, we neglect the causes of recalling or memory and are no further ahead in an understanding of how we seem to recall the past.

The Alternative to Mentalism

Criticizing mentalism often is seen as suggesting that we have no private experience—no thoughts, dreams, expectations, or memories. This, of course, would be absurd, and, despite rumors to the contrary, no one has ever seriously suggested this. However, some psychologists have denied that the mind is separate from the body and that the mind somehow influences physical processes in the body.

What if we broaden the definition of activity to suggest more than the movement of muscles and the secretion of glands? What if we treat our mental life as part of what we do? As we rise in the morning, work, walk, and talk, we also think, hear, see, and dream. If rising, working, walking, talking, thinking, seeing, hearing, and dreaming are all activities in which we engage, then we can seek out the factors that influence each of these activities. We already know something of the fac-

tors that influence overt behavior; could we also train creative thinking, alter moods and attitudes, and improve other mental activities?

Much of western philosophy, as well as common sense, opposes such a possibility; the chasm separating thought and action seems unbreachable. At the turn of the century we seemed limited forever to the analysis of consciousness for its own sake. Indeed this practice had even been extended to the study of consciousness in animals; such "introspection by analogy" had been advocated by both Romanes and Lloyd-Morgan (see Chapter 1). Thorndike believed that mental processes could be treated as part of what we do; thus, he believed that they can be altered just as our outward behavior can be altered. And much of what we do can be explained without the need to refer to mental processes; often, none are present. It was largely Thorndike's influence during half a century that kept this view alive. As he put it, the same general laws of human behavior explain why a student puts his clothes on or takes them off, whether he eats his breakfast, and whether he succeeds or fails in solving a geometry problem (Thorndike, 1917). And awareness is certainly not necessary for learning to occur:

> We should, of course, make the situation identifiable and the response available when it is practicable to do so. Unconscious learning is relatively undependable and slow. But it is not magical or fortuitous. (Thorndike, 1935, p. 70)

2. BASICS OF THORNDIKE'S THEORY

Thorndike's research began with observations of cats learning to escape from 27 problem boxes. He evaluated the results based on his doctrine of the *law of effect*, which held that responses were connected to or disconnected from situations depending on the effect produced by the response. He concluded that the law of effect was sufficient to account for the learning that occurred in the puzzle boxes. That is, some of the cats' behaviors were selected by *satisfiers*, which stamped in connections between situations and behaviors (for example, *sight of string—pull*). Other consequences —*annoyers*—stamped out connections (for example, *sight of wood slats—squeeze through*). Thorndike used the terms *stamping in* and *stamping out* to describe the strengthening or weakening of a stimulus-response (S-R) association.

The question at once arose concerning what makes an event satisfying or annoying. Defining *satisfaction* and *annoyance* is more difficult than one might think, and Thorndike spent a good deal of time wrestling with this problem. He explained some cases of satisfaction and annoyance as due to heredity, such as when an opportunity to rest acts as a satisfier for a weary organism. But what of all the countless cases that cannot possibly be genetically determined? How do praise and money come to act as satisfiers?

This question led Thorndike to a behavioral definition of *satisfaction* and *annoyance* as situations that the organism "does nothing to avoid" or that it does actively avoid. Ultimately, Thorndike relied on the *law of readiness* to explain the action of satisfiers and annoyers and thus to explain the law of effect. By *readiness*, Thorndike meant that the effect of a consequence depends on what an individual is doing when the consequence occurs.

The weakness of the law of effect lies in the difficulty in explaining why (and when) satisfiers and annoyers act as they do. Its strength lies in the fact that it is still immensely useful, even when we are uncertain when and why a given consequence satisfies or annoys. It also forces us to be specific in dealing with problems of education and it gives us a way of avoiding the problems of mentalism.

The Problem Box: Selecting and Connecting

Thorndike's research topic for his thesis at Harvard concerned mind reading in children (Thorndike, 1936). This amounted to a study of the method used by professional mind readers of the day, who were skilled in extracting information

from the facial expressions of their subjects as they were asked questions. The topic was unacceptable to the Harvard authorities, who suggested that he do a study of mentality in chickens. (Recall that the analysis of consciousness was extended to animals during the late nineteenth century.) Thorndike obtained the chickens but was unable to progress far in his work because the university had no space suitable for fowls, and, after a series of difficulties, he left Harvard for Columbia. He arrived in New York City in 1897 with a basket containing "the two most educated hens in the world."

Thorndike studied the behavior of chickens in mazes, which he formed using books placed on end. This research as well as research with several other types of animals, particularly cats, led to the 1898 publication of his famous monograph, *Animal Intelligence*, in which he focused on the behavior of cats in *problem boxes*. This work had an immense impact on subsequent psychological views and contained the essence of what would be Thorndike's views for the rest of his long career. Through this work, Thorndike developed his theory of *selecting and connecting*, which describes how satisfiers select a response and connect it to the situation accompanying that response.

Thorndike's subjects were stray cats, which he caught in the alleys near Columbia University. A captured cat soon found itself in the problem box, made of slats of wood, with no exit in sight. The cat typically nosed about exploring the box, reached through the slats with its paws, bit at whatever allowed biting, but remained imprisoned in the box.

Just as it seemed that there was no escape, its paw caught on a loop of string hanging from the ceiling, and the door of the box opened. In other versions of the 27 boxes Thorndike used, the escape trigger may have been a panel on the floor, a lever on the wall, or some aspect of the cat's own behavior (such as scratching its ear with its paw) that led to the opening of the door. Soon after escaping, the cat found itself back in the box. The question is, did the problem box then pose a problem for the cat to solve? The cat had the solution and now had only to apply it. If, by chance, it did not notice the connection between string pulling and escape during the first trial, surely another trial or two should be enough to make the connection clear to any but the densest cat. Within two or three trials the cat should be escaping at will.

The results were otherwise. A hungry cat placed in the problem box often made its first escape within several minutes, but the second, third, fourth, fifth, sixth, and later escapes showed little evidence that the cat had any insight into the nature of the problem. In a typical sequence of escapes, cat number twelve in box A made its first escape after two minutes and 40 seconds and the second escape after only 30 seconds. But the third escape required a minute and a half and the subsequent escapes took 60, 15, 28, 20, 30, and 22 seconds. After more than twenty trials, the cat was routinely escaping within six to eight seconds, but it was impossible to point to any one instant at which the cat had "gotten the idea." Figure 2.2 plots the escape time per trial for cat number twelve.

Long before these experiments—and today, long after they were done—psychologists had argued about the nature of learning: Does learning occur slowly and mechanically or rapidly, showing insight? Adams (1929) later reported that cats escape from problem boxes far more intelligently and rapidly than Thorndike reported. At least, Adams interpreted his cats' behavior as being more intelligent. He said that his cats attended closely to the important parts of the escape mechanism—a string loop hanging from the ceiling, which lifted a bolt holding the door, which was then pulled open by a rubber band. But, as Woodworth (1938) later noted, some of Adams's cats never escaped and others took far longer to escape than did Thorndike's cats.

The data presented in *Animal Intelligence* (1898), however, portrayed only animal stupidity, rather than insightful, intelligent behavior. It

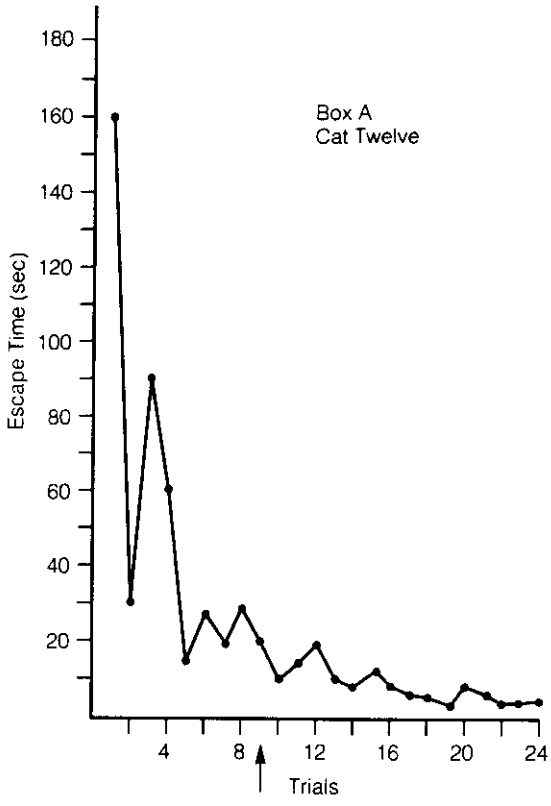


FIGURE 2.2 Results of Thorndike's problem box experiment for one subject, cat number twelve. The cat's escape time diminished over 24 trials, but at no point did the cat seem to gain insight into the problem solution. *From Thorndike, 1898*

seemed to Thorndike that these animals that had every opportunity for intelligent action and insightful solutions showed only the slow improvement that one would expect if the consequences of actions were slowly stamping in some behaviors and stamping out others. In the early trials, the animals reacted with the inherited behaviors that one would expect to be shown by a member of that species suddenly finding itself in confinement. Each response followed by escape and food became somewhat more likely to occur on the next trial, whereas the behaviors accompanied by continued confinement became less likely.

The Law of Effect

The cats' behavior depended on the consequences of past behavior: Responses that led to escape became more likely on the next trial, and those responses that did not lead to escape became progressively less likely. This principle, the law of effect, seems at first sight the most trivial piece of common knowledge imaginable; surely it has been known for many millennia that our acts are affected by their consequences. We humans do not endlessly touch hot stoves, and we do all manner of things for money, praise, and other such consequences.

But what Thorndike pointed out was that the consequences of action account for far more than had been previously suspected; if the law of effect can account for problem solving in cats, why can't it account for problem solving in humans? How much of our behavior and experience depends upon the consequences that have followed them in the past? Can the law of effect account for our comings and goings, our reasonings and imaginings, our attitudes and interests? Thorndike believed that it could, and, in many of the books and articles he published during his career, he tried to show how the law of effect might account for human behavior. Table 2.2 gives some examples.

The law of effect has proved immensely useful during this century, having been successfully applied in teaching, psychotherapy, and even in the training of creativity. But it has its limits as an explanation for all of our behavior and experience. These limits become clear when we consider the nature of satisfiers and annoyers.

If we do not understand how satisfiers and annoyers work, then we cannot predict what will act as a satisfier or as an annoyer. This means that we may have to apply a consequence, note the effect that it has on the frequency of the behavior that preceded it, and then classify it as either a satisfier or an annoyer. Do we really have to do that? Surely we can discover some way to predict whether an event will act as a satisfier or as an annoyer.

TABLE 2.2 Ways in Which the Law of Effect Might Operate in Determining Attitudes, Interests, and Traits

Simple Arithmetic Knowledge

Stimulus:	A teacher asks, "What is eight plus six?"
Response:	A student answers, "Fourteen."
Consequence:	Approval from teacher.
S-R connection:	8 + 6 = 14

Attitudes

Stimulus:	Relatives ask for an opinion on the issue of labor unions.
Response:	"Labor unions damage the economy."
Consequence:	Approval and agreement from listeners.
S-R connection:	Labor unions are bad (example of an antilabor attitude).

Interests

Stimulus:	Someone is presented with paper and pencil.
Response:	The person draws pictures of landscapes.
Consequence:	Approval, admiration from parents and friends.
S-R connection:	The connection is between drawing materials and drawing landscapes (or interest in drawing, desire for drawing materials).

Trait of Perseverance and Effort

Stimulus:	A difficult puzzle or other problem is presented.
Response:	A person displays persistent effort to solve it.
Consequence:	Praise from others.
S-R connection:	The connection is between challenging situations and effort.

Trait of Creativity

Stimulus:	A problem is stated verbally.
Response:	A person gives an unusual answer.
Consequence:	Criticism, repetition of problem.
S-R connection:	A connection forms between verbally stated problems and conventional solutions (or stifled creativity, conformity).

Trait of Aggressiveness

Stimulus:	A schoolmate has an attractive toy.
Response:	A child takes the toy by force.
Consequence:	Possession of the toy.
S-R connection:	A connection forms between others' attractive possessions and taking them (bullying).

Seeing Clearly ("Fidelity of Visual Images")

Stimulus:	A person moving within the immediate environment.
Response:	He or she notices the environment and focuses appropriately.
Consequence:	Moving without bumping into things.
S-R connection:	The connection is between the environment and focusing properly.

Satisfiers and Annoyers: Difficult to Define

In his earliest writings Thorndike used the terms *satisfier* and *annoyer* as if they were synonymous with *pleasure* and *pain*, and many criticisms of the law of effect assume that this is an instance of *hedonism*, the doctrine that all conduct is governed by anticipated pleasures and pains. If one considers the law of effect only in its application to animals' escapes from confinement or their gaining of food, then pleasure and pain seem reasonable attendants.

But when we consider human affairs, such a simple hedonistic interpretation is implausible; after all, the satisfier that Thorndike used most often with people was the word *right*. Thorndike quickly pointed out that the law of effect had no necessary connection with what we usually think of as pleasure and pain. He attempted, with difficulty, to arrive at a proper conception of satisfaction and annoyance.

What do satisfiers have in common? Thorndike began (1913) by suggesting that some states of affairs act as satisfiers owing to heredity. He suggested that for humans such things as being with other humans (especially familiar ones), moving when refreshed, resting when tired, and being partly covered when resting or in bed are innate satisfiers. Innate annoyers include the taste of bitter substances, physical restraint, hunger, being scorned, and the sight of blood and entrails. According to Thorndike, all other desires and aversions grow from these "original" satisfiers and annoyers. (We will return to this topic later in the chapter.)

However, all satisfiers and annoyers are not innately determined; money, praise, and fame have little effect on the behavior of an infant, and Thorndike's list of original satisfiers and annoyers seems to have little bearing on most human behavior. Perhaps satisfiers and annoyers are better defined simply in terms of their effect on behavior; thus:

> By a satisfying state of affairs is meant roughly one which the animal does nothing to avoid, often doing such things as will attain and preserve it. By an annoying state of affairs is meant roughly one which the animal avoids or changes. (1913, p. 2)

But what makes a satisfier a satisfier? What do all of the "states of affairs," which act as satisfiers or as annoyers at a given time, have in common? Thorndike struggled to answer the question by referring to what he called *original behavior series*, a sequence of activities that are determined innately and that constitute satisfaction when completed. When an original behavior series is started and operates successfully, its activities are satisfying, as are the situations they produce.

When he used the term *original*, Thorndike typically meant "hereditary." Thus, he was speaking of sequences of instinctive behaviors, such as pouncing on prey and ingesting food. In an accompanying example, he referred not only to lost food and missed prey, but to a withdrawn toy as examples of interrupted original behavior series. At any rate, the effects of satisfiers and annoyers thus depend on the ongoing behavior series. If the series operates successfully, the results are satisfying. If the series is thwarted, the result is annoyance. The unimpeded completion of an original behavior series is thus referred to as *successful operation*.

The problem remaining is what constitutes successful operation. If we don't know, then we are left with the definition of a satisfier being the successful completion of a behavior series, with *successful operation* meaning "ending with a satisfier"! Thorndike had problems here, as has anyone else who has tried to deal with this problem. Successful operation does not simply mean life furthering and adaptive. (For example, cigarette smoking acts as a satisfier for many people.) Successful operation is finally left as "unimpeded" or "unthwarted" activity. This just means freedom to complete the activities produced by our original nature. Such a conclusion is less than satisfying, however, and the whole matter is translated to the analogy of the neurons; the law of readiness determines when the law of effect works and when it doesn't. Table 2.3 highlights the definition of a satisfier.

TABLE 2.3 What Are Satisfiers and When Do They Work?

Defining Satisfiers	
Original Nature (Innate Satisfiers):	Being with familiar humans Moving when refreshed Resting when tired Partial cover when resting And many more
Behavioral Definition:	Things that are not avoided and are often sought and maintained
When Do They Work?	
Successful Operation:	A satisfier ends a behavior series "successfully," defined by the law of readiness
Law of Readiness:	Firing of a conduction unit ready to fire, sensitized by units already firing

The Law of Readiness

Thorndike's contribution is often summarized as the argument for the widespread application of the law of effect. But his writings usually include two other laws, the law of exercise and the law of readiness. His *law of exercise* refers to his assumption that repetition alone could strengthen a habit. (In 1929 he abandoned this assumption.) His law of readiness was of prime importance to him; it was not, as is often thought, a mere appendage to the law of effect. Readiness specifies the conditions under which effect operates by attempting to define successful operation, those conditions that make a satisfier a satisfier and an annoyer an annoyer.

The law of readiness is cast in terms of the activity of neurons, their readiness to fire and whether they do fire. This readiness is determined by innate factors (original nature). A given situation (for example, the sight of prey or a moving flame) produces firing in some neurons (owing to the seeing) and a readiness to fire in others. The sight of prey thus produces a readiness to chase and seize, and the sight of a flame may produce a readiness to touch. Given a state of readiness, the firing of such a prepared *conduction unit* is satisfying, and the thwarting of it is annoying. A conduction unit that is not ready to fire (unprepared) but that is forced to fire constitutes annoyance (for example, eating your twelfth piece of pizza).

Conduction units aside, we find that Thorndike's law of effect is not the simple formula that critics and some advocates often have supposed it to be. It would be nice if it were possible to choose any behavior or aspect of experience we wish to strengthen and follow its occurrences with food, praise, or another consequence that often acts as a satisfier. But Thorndike, common experience, and a good deal of research tells us that things are just not that simple. The law of readiness says that the effect of a satisfier depends upon preparedness—that is, it depends upon existing, ongoing behavior. Food acts as a satisfier when it is presented in the context of preparatory eating behavior, and praise has an effect only when an individual's behavior is already oriented (prepared) for such a consequence. We now know, for example, that it is immensely difficult to train a pigeon to peck a disk to avoid shock: Pecking is preparatory behavior for eating and not for shock avoidance.

When Is a Satisfier a Satisfier?

It takes little reflection to see that all the things we view as satisfying, as rewards, as payoffs, and as goals have their typical effects only under specific conditions. When we think of them, we usually assume that these conditions prevail, but this often is not the case. For example, food *is* a satisfier, so it can be used to train all sorts of behaviors in all sorts of situations. But the twelfth piece of pizza already referred to has the effect of an annoyer. Ten dollars may be effective as a reward,

depending upon whether the customary reward is one or twenty dollars! The effect of praise from a professor may not be the same if it is delivered as you sit in a crowded classroom as opposed to in a personal letter.

In short, the law of effect is not a magic formula, although it may often work so well that it may seem to be. One cannot depend on a given satisfier to increase the frequency of every behavior that it follows under all circumstances. The only safe way to employ the law of effect is to determine what particular consequence acts as a satisfier for the particular behavior of concern to us in particular individuals at the particular time we have in mind.

The Significance of the Law of Effect: Are There General Abilities?

Thorndike's early (and persisting) influence was due to two factors, his amazing rate of publication and the great versatility of his theory of selecting and connecting, especially in comparison with other available theories of the day. The application of the law of effect meant that more attention needed to be paid to the specifics of the teaching and learning process. If learning is the selecting of behaviors and the connecting of them to stimuli or situations, then it is necessary to specify precisely what is to be connected. How does one teach citizenship, mathematics, reading, logic, and so on? Unlike the prevailing mental discipline theories passed on from the nineteenth century, which advocated that mental faculties be exercised as muscles are exercised, Thorndike argued against the possibility of training any such general abilities.

Thorndike argued in his early paper (Thorndike & Woodworth, 1901) that only specifics are selected and connected. The *discipline method* of training memory in general through the forced memorization of poetry was of no help in improving memory in general because there is no memory in general. There are memories for specific classes of things, such as poetry, faces, letters, words, and so on. But practice memorizing per se does not seem to help us to memorize in general.

Similarly, *attention* is a single word that refers to a host of tendencies. Even attention to words may be restricted to the spelling, length, sounds, or grammatical class (noun, verb, or other) of words. The point is that education should be specific about what is to be learned. For example, educators should consider what is meant by *patriotism*, *understanding of grammar*, and other vague and general goals of education.

All of this argues that many of the terms we use are unsuitable; they either refer to faculties or powers of mind that are, in fact, not single entities (such as memory and attention) or they refer to classes of behavior that also are not unitary things. As Thorndike pointed out in 1913, when we consider ways to deal with anger and aggression, we must distinguish between anger due to restraint, to overcoming an obstacle, to counterattacking, to sudden pain, to combat in rivalry, and to various thwartings, as well as to anger due to other causes. His continual emphasis of specifics, of just what is to be selected and connected, may well be the most important aspect of Thorndike's work.

The specificity of connections established by the law of effect applies to our ideas and experience, as well as to our observable actions. Thorndike illustrated this in a 1933 paper:

> When an animal that runs about seeking food attains it, the strengthening will be more likely to influence the Cs [connections] concerned with its locomotion, its hunger, and its ideas about food and eating than those concerned with contemporaneous casual scratchings of an itching ear, or stray thoughts about Shakespeare's sonnets or Brahms' symphonies. (p. 435)

To complete the picture, the major laws—the laws of readiness, exercise, and effect—must be supplemented by subsidiary laws. These are reasonable principles that were common in nineteenth-century psychology and that appeared in part in Thorndike's early (1900) book, *Human Nature Club*.

Subsidiary Laws

Law of Multiple Response The first try in learning a new skill or doing a new task is often an inadequate response to a situation and we are forced to keep trying. For example, most of us cannot successfully pronounce the German umlaut sound or do a smooth backstroke or properly swing a baseball bat on the first try. Eventually we do learn and the proper behaviors are selected and connected. But our initial efforts usually are only "the best we can do"; the better of our imperfect efforts are selected either by their natural consequences (for example, we move more smoothly through the water) or by social consequences (for example, we gain approval for our German pronunciation). Our progress in a new situation will therefore depend upon the behaviors we bring with us from the start. This condition describes the law of *multiple response*.

Law of Attitude or Set Thorndike was well aware of the main findings of the Würzburg School (see Chapter 1) and cited them when he pointed to the importance of set and other terms that refer to the condition of the learner. Selecting and connecting is by no means a simple formula to be carelessly applied to any individual at any time. The effect of a situation depends in great part on the condition of the individual: What instructions has the person been given, and what has his or her experience of the past hour or the past year led the person to expect in a given situation? Is he or she reading for pleasure or because he will be tested in an hour? What effect does twenty years' experience as a poet, a proofreader, a parent, or a minister have on present reactions? Experience acts on individuals prepared in countless ways, and this preparation largely determines the effects of present experience and guides their response in new situations.

Attitudes, *dispositions*, *preadjustments*, and *sets* are synonymous terms that refer to the effects of prior experience and may determine what will act as satisfiers and annoyers. How long has it been since we last ate? Are we throwing a ball for distance or to strike out a batter? Are we running the last mile of a marathon? Consider the following example: A top contender for a boxing title may feel indifferent toward a victory over an opponent which, were we in his place, would be occasion for great rejoicing. In education, the goal is to "set" the student to respond to academic subject matter with enthusiasm, open-mindedness, and a problem-solving attitude. This all reduces to an emphasis of the law of readiness.

Law of Piecemeal Activity We virtually never respond to all elements of a situation; some aspects act more strongly than others, and we typically react to subtle elements that a dog or cat would never notice. Most elements we ignore.

> [A]ll man's learning and indeed all of his behavior, is *selective*. Man does not, in any useful sense of the words, ever absorb, or represent, or mirror, or copy, a situation uniformly. He never acts like a *tabula rasa*. (Thorndike, 1913, p. 35)

Our responses to words and relations and our insights into new aspects of long familiar situations are constant determinants of what is selected and connected. Our whole past history (and the history of our species) determines which parts of a situation will be connected with some strong response of feeling, thought, or action and which parts will be barely noticed and which will have no effect. The selective nature of perception constitutes the subsidiary law known as *partial or piecemeal activity*.

The selective response in one form is the insight into the essential elements of a situation. For example, attention to the relevant leads the genius to see that electricity, with all of its more conspicuous properties, acts as if it flows. Therefore, it may be treated as a fluid and thus may be stored, channeled, and so on. This belief was held by many scientists, such as Benjamin Franklin. Electricity is not a fluid, nor does it flow. But it appears to, and attention to that aspect of it has proved more useful than the alternative, which is to treat it as magic.

The fact that we do routinely respond to subtle features of situations seems different from the simple conceptions of selecting and connecting. Thus, it seems that selective thinking, responding to abstractions, and attention to relationships is different in kind from the simple formation of habits through selecting and connecting. Thorndike, however, held that this was not the case.

> Man's habits of response to the subtler hidden elements, especially the relations which are embedded or held in solution in gross situations, lead to consequences so different from habits of response to gross total situations or easily abstracted elements of them, that the essential continuity from the latter to the former has been neglected or even denied. Selective thinking, the management of abstractions and responsiveness to relations are thus contrasted too sharply with memory, habit, and association by contiguity. As has been suggested, and as I shall try to prove later, the former also are matters of habit, due to the laws of readiness, exercise and effect, acting under the conditions of human capacity and training, the bonds being in the main with elements or aspects of facts and with symbols therefor. (Thorndike, 1913, pp. 27–28)

Again, Thorndike opposed the belief in *faculties*, or powers of mind, as explanations for our behavior and experience. If selective thinking, the piecemeal response, and insight are treated as part of what we do and as examples of habits no different in kind from our other activities, then we should be able to train selective thinking and insight just as we train other habits. If we propose that such activity depends on some mental power, a faculty of insight, then we gain nothing, having named only what we wish to explain.

Law of Assimilation or Response by Analogy The laws of readiness, exercise, and effect determine what we will do in a given situation; if we find ourselves in a situation that is basically the same as past situations, then we will do what we did in the past. But situations are never precisely repeated. A new situation is simply more or less like previous situations. If we act at all, other than instinctively, we will do what past experience has taught us to do. If a situation is unusual, we will still obey the law of habit and react to it as we did to past novelty.

This is Thorndike's famous principle of transfer by identical elements; he called the principle *response by analogy*. According to Thorndike, we act in a new situation as we did in a past similar situation. In education, this means that the benefits of training may be expected to generalize to similar situations: The more elements shared by the training and the practical situations, the greater the benefit of training. What constitutes similarity is, of course, an immense problem. Very often it is necessary to see how an individual behaves in a new situation before one can say that the person treats it like an old situation.

This further qualifies the apparently simple original notion of selecting and connecting. The laws of readiness, exercise, and effect depend in part on set or attitude, on the fact that only some of the elements in a situation are effective (piecemeal response), and on the similarity of present and past situations, with similarity difficult to define.

Nonetheless, applications of Thorndike's basic principle of selecting and connecting through the action of the law of effect still work quite well. The additional laws do not really muddy things; they simply tell us when and why the law of effect works and when it seems not to work, as well as when learning in one situation will transfer to new situations. The law of effect is not a simple formula that, alone, accounts for all learning.

Law of Associative Shifting *Associative shifting* is a special case of response by analogy, or responding to a new situation as if it were an old one. Associative shifting occurs when the change from the old to the new situation occurs while the old response continues; it thus becomes connected to the newly changed situation. One way in which this occurs takes the form of what was later called classical conditioning. Another way in which it occurs has been called fading.

Let us first look at classical conditioning. Suppose that food in a dog's mouth produces saliva-

tion and other food-related behavior. When a new food dish is used, it soon comes to evoke salivation on its own. The dish is presented with the food, which already produces salivation; in Thorndike's view, the response to food and dish generalizes to the dish alone. Just as the dish may come to produce a food-related response, the original responses to worldly goods transfer to the pieces of paper that people use as money. (Thus does the small number of "original" satisfiers grow to the infinite set of adult life.)

In the case of fading, the stimulus complex is gradually changed, slowly enough that the reaction to the original situation is maintained and becomes connected to the new situation. This procedure is now part of the therapy commonly used in the treatment of phobias, or strong fearful reactions to inappropriate stimuli. For example, a patient with a strong spider phobia would be trained to relax in the presence of a therapist, who would then introduce a graded series of spider-like stimuli.

While the patient maintains relaxation behavior, the therapist might present a rubber spider at forty feet, then at twenty feet, then in the patient's lap. The therapist might then progress to presenting real spiders at ever decreasing distances, with successive presentations ordered in such a way that the patient remains relaxed. If properly done, the patient's relaxation (the old response) continues as the situation changes. Through associative shifting, now called systematic desensitization, the behavior of relaxing shifts from spider-absent to spider-present conditions.

Note that the difference between this procedure and the procedure involved in classical conditioning (for example, pairing a dish with food) is only one of degree. In the classical conditioning case, a new stimulus (the dish) is presented in full strength with another stimulus that already produces a given response (food); the situation "food" is changed to the new situation "food plus dish." In the case of fading, the situation is gradually changed.

Thorndike saw associative shifting as the principle that explains how an initially insignificant item, such as a dollar bill or a rejection letter, can become a satisfier or an annoyer. Similarly, other events that may at one time act as satisfiers—such as sports, children's merriment, and daily life—may become annoyers through associative shifting. This could happen if they occur during periods in which we respond to an annoyer, such as continual defeat, the death of a child, or a long illness.

Summary of Subsidiary Laws The five subsidiary laws make the major laws—readiness, exercise, and effect—reasonable (see Table 2.4). Four of these laws refer to the influence of the individual learner's condition in determining what is learned. The learner comes with a set of behaviors resulting from past training and species membership. The law of multiple response tells us that this repertoire of behaviors is available and that we may expect a varied attack on the problem: When one behavior fails, another from the repertoire will take its place.

Secondly, prior instructions or experience in similar situations which demanded certain behaviors establishes an attitude or set to behave in certain ways. Third, the law of piecemeal response says that only certain aspects of the situation will be attended to, and which aspects these are depends upon the species and the personal history of the learner. If the elements noticed are seen as similar to elements encountered in previous situations, the individual's behavior will tend to be what it was in that earlier situation, according to the law of response by analogy. In addition to the four laws referring to the condition of the subject, conditions outside may cause associative shifting by pairing stimuli that produce weaker and stronger reactions so that the weaker stimulus when later presented alone produces the reaction formerly belonging to the strong stimulus.

Changes in Thorndike's Laws

Experiments done during the early part of the century and some done in the late 1920s with both human and chicken subjects led Thorndike to

TABLE 2.4 Thorndike's Laws

Major Laws (pre-1929)	
Law of Readiness:	This law refers to the conditions that determine what will act as satisfiers and annoyers.
Law of Exercise:	Responses are connected to situations simply because they occur frequently in those situations.
Law of Effect:	Responses are selected and connected to situations or are disconnected from situations depending upon the consequences they produce (satisfiers or annoyers).
Subsidiary Laws (referring to the history of the learner)	
Law of Multiple Response:	The learner's behavior is not random; rather, he or she comes with a set of responses supplied by heredity or by past experience.
Law of Attitude or Set:	The learner's behavior is influenced by what he or she has been led to expect of a task and its outcome. This may come from instructions or from prior experience.
Law of Piecemeal Activity:	The aspects of a situation that will be noticed depend upon the learner's species membership and past experience.
Law of Response by Analogy:	The learner's behavior will depend in part on the similarity of the present situation to past situations.
Law of Associative Shifting:	A transfer of responses to new stimuli takes place by their pairing with stimuli already connected to those responses.

greatly modify the law of effect and to discard the law of exercise (Thorndike, 1932a).

Exercise or Effect? Thorndike's long advocacy of the law of exercise was no doubt the product of the strong influence of nineteenth-century psychology, which held that repetition per se was enough to "wear grooves" in the brain and thereby establish habits. Is mere repetition enough, or is the effect accompanying repetition—the consequence produced—also necessary?

Thorndike (1932a) reported the results of a long series of experiments testing the law of exercise, some featuring him as the principal subject. In one experiment a subject (Thorndike) was shown strips of paper, one at a time, and asked to judge the length of each piece as it was shown. The strips varied in length from five inches to eleven inches, with ten instances of each value in quarter-inch steps (5, $5\frac{1}{4}$, $5\frac{1}{2}$, $5\frac{3}{4}$, and so on). The set of 250 strips was shuffled, and the subject made judgments on twenty sittings spanning five days. No feedback concerning the actual length of the strips was ever given.

Thorndike reasoned that frequent judgments of the length of each category of strip should become even more frequent with successive judgments, if the law of exercise is correct. That is, if a strip of whatever length were judged $5\frac{1}{2}$ inches most frequently on the first day, it should be judged to be that length more and more often on the second, third, and subsequent days. What he found, however, was that, although there was some change toward more consistent, stereotyped estimates, it was not clear that those estimates that were frequent during early sessions became the dominant estimates in later sessions.

Another experiment (Experiment 23 of the series) involved the subject hearing a list of 960

words and writing a digit (one to nine) for each word. Subjects were told to try to write the same digit the next time a given word was heard, if they could remember their original response. Some words were repeated 30, 40, 50, or 60 times during the experiment, and Thorndike painstakingly analyzed the responses to determine whether early frequent responses to a word displaced less frequent ones. He concluded that this was not the case.

The best known experiment (Experiment 5) testing the law of exercise was carried out with Thorndike again as the main subject. The task involved drawing lines of specified lengths. Thorndike wrote, "Subject T (the writer), with eyes closed, drew a line to be as nearly as possible 2″ long, then one to be 4″ long, then one to be 6″ long, then one to be 8″ long. This series of four acts he repeated 950 times." Thus, the subject drew 3,800 lines on sheets of paper, twelve lines to a sheet. If the law of exercise were valid, one might expect that the various lines drawn would become more similar in length. Thus, the attempted four-inch lines should not necessarily become any more accurate (closer to four inches long), but those lengths most frequently drawn in the earlier trials should become yet more frequent. Careful analysis convinced Thorndike that this did not occur.

He concluded that the data of the series of experiments "do not give any support to the doctrine that the response which an animal makes oftenest to a maze alley [sic] or puzzle box or a multiple-choice apparatus will thereby gain one iota in the probability of future response." Thus, experiments with human subjects showed that repetition per se cannot explain animal learning! Was Thorndike hasty in abandoning the old law of exercise, the belief that repetition is enough to build habits? Must there always be consequences, whether it be knowledge of results or other satisfiers and annoyers?

We will see that Watson, Guthrie, Tolman, many other psychologists, and the British empirical philosophers (Chapter 1) disagreed with Thorndike's conclusion. A particularly convincing demonstration of the effect of bare frequency of repetition was provided by Hebb (1961). Hebb's subjects were read nine-digit sequences, presented at a rate of one digit per second. No digit was repeated in a sequence. Subjects were asked to recall the sequence immediately; then the next trial began with a new sequence. Thus, three trials might include sequences like these:

3	9	2	1	7	4	6	5	8
4	9	3	1	8	6	7	5	2
1	6	3	5	2	9	4	8	7

Each subject received 24 trials. One can appreciate the difficulty in recalling the sequences under these conditions. There was no time for rehearsal, and there was maximum interference from preceding sequences since the same digits appeared on each trial but in different order.

In fact, one nine-digit sequence appeared every third trial—a total of eight times. Each other sequence appeared only once. This was largely unnoticed by the subjects, although some reported that there was some repetition in the list; most did not notice even that. Nonetheless, on the last two presentations of the repeated sequence, trials 21 and 24, subjects correctly recalled the sequence more than 60 percent of the time. Other sequences were recalled correctly no more than 20 percent of the time. Melton (1963) confirmed and extended this finding. One must wonder how anything but the law of exercise could explain it.

Estes (1969) carried out simple verbal association experiments, similar to those that Thorndike frequently used, and found that mere contiguous presentation of pairs of items was sufficient to form associations, independent of the law of effect. The law of exercise was sufficient. Table 2.5 provides data from Estes's experiments.

Subjects learned twelve-item lists of letter-digit pairs (for example, LF-26) under two conditions. In one condition, the experimenter presented the stimulus half of the pair (LF) and the subject supplied the response half (26). Then the S-R pair was presented (LS-26). Immediate feedback on the correctness of the response could thus be rea-

TABLE 2.5 Information (Repetition) versus Effect

Group	*Mean Trials*	*Mean Errors*
Effect (Feedback)	8.96	45.83
Information (Delay)	7.71	37.79

Estes, 1969

sonably expected to act as a satisfier and to aid the learning of the list. (The group receiving this treatment was known as the effect group.)

A second group (the information group) received quite different treatment. The experimenter presented the stimulus (LF) to the subjects, who made the response (which could have been right or wrong). The subjects in this group received no feedback: There was a pause after the subjects responded and then the next stimulus item appeared; the correct S-R pair was not shown. After going through the whole set of twelve letter-digit pairs, the experimenter presented the set of stimulus and response items while the subject just sat there looking at them. Then another name-the-response-term set of twelve was presented. One would expect that it would take this group far longer to learn the set.

As a matter of fact, all subjects continued until they made one errorless run through the set of twelve letter-digit pairs. When the mean errors were totaled, the information group had made an average of 37.8 errors, and the effect (immediate feedback) group made an average of 45.8 errors! Clearly, the mere presentation of material may be sufficient to learn it, much as Watson, Guthrie, Tolman, and (of course) Estes suggested. This does not mean that the law of effect is invalid; it merely means that it may not be as essential as Thorndike thought it to be.

Does Punishment Work? Thorndike's abandoning of the negative law of effect is similarly open to question. The *negative law of effect* is the portion of Thorndike's classic law that deals with annoyers, or punishers. Until the late 1920s, he had believed the effects of satisfiers and punishers to be about equal but opposite in effect; satisfiers strengthen connections and annoyers weaken them. By 1932 he concluded that annoyers (punishers) do not directly weaken connections. He wrote, "Punishments . . . weaken the connection which produced them, when they do weaken it, by strengthening some competing connection."

Experiment 71 was typical of the research that led to this conclusion and that convinced many educators and psychologists that punishment was not really effective. Thorndike described the experiment, "Nine subjects were given training in choosing the right meaning for a Spanish word from five in a series of two hundred." Responses were rewarded or punished by the experimenter, who announced right or wrong. After twelve or more repetitions of the list, Thorndike analyzed the effects of reward and punishment on the repetition of previous responses. He found that *right* produced a substantial effect on subsequent response choice but that *wrong* did not. In another experiment, subjects learned to match ten behaviors (open mouth wide, pull head back, and so on) with ten patterns drawn on cards. Once again, the effect of being told *right* was substantial, whereas that of *wrong* was "approximately zero."

Experiments with animals seemed to Thorndike to lead to the same conclusion: Punishers do not work in a direction opposite to that of rewards. Thorndike (1932b) reported the most famous of these, in which chicks were given a choice of three paths in a maze. Two led to 30 seconds of confinement, and one led to freedom, food, and company. As was the case in the experiments with human subjects, reward led to increased repetition of the rewarded response, whereas punishment had little effect on subsequent choices.

This conclusion, coming from the inventor and popularizer of the law of effect, was quite a change to propose, especially since they came at a time when Thorndike's views had become almost institutionalized. Yet, he argued that annoyers work only insofar as they produce new responses (or awareness of wrongness) which

would then make it possible for satisfiers to act on other behaviors. Thorndike became quite extreme in his opposition to the use of annoyers, charging that the family, the school, and the church had for too long been devising new punishments, even inventing a hell after death to add more.

Thorndike's conclusion was later supported by Skinner (see Chapter 9), whose evidence was similarly meager. Despite the frailty of the evidence, it was widely believed until recently that punishment was ineffective, until overwhelming evidence to the contrary showed that punishers do appear to have a direct weakening effect on behavior. (Chapter 9 discusses these subsequent findings.) This is not to say that punishment does not involve undesirable side effects, nor does it imply that it cannot be misused. It also does not mean that punishers break S-R bonds as Thorndike's early theory had suggested. However, they do seem to work.

3. CRITICISMS OF THORNDIKE'S CONNECTIONISM

When the 24-year-old Thorndike began his professional career in 1898, psychology was almost solely concerned with the analysis of conscious experience. Even John B. Watson, who was soon to do his doctoral thesis on an analysis of conscious processes in the white rat, was not yet an advocate of behaviorism. No one in America had heard of Pavlov, and education consisted largely of the training of mental faculties, such as memory and reasoning.

Thorndike's views were radically different from the prevailing views of the time and from many current views. Over the years his theory has been criticized as too mechanistic, too simple, and/or merely a contemporary version of the ancient doctrine of hedonism, with its emphasis on pleasure and pain as determinants of behavior. Some of these criticisms apply to any serious attempt to understand the factors that determine our behavior and experience. Some arose because the critics did not fully understand Thorndike's work. Other criticisms arose because of Thorndike's extremely unfortunate choice of the terms *satisfier* and *annoyer*. Although he was not referring to sensory pleasures and pains, it is natural that such terms would be interpreted in that way. Legitimate criticism of Thorndike's position involves his emphasis on S-R connections as the basis for all learning and his emphasis on the law of effect as the key principle in understanding learning.

The Emphasis on Mechanism

It has often been charged that Thorndike's views were too mechanical, that selecting and connecting leaves out the spontaneity we all find in our behavior and experience. The premise of *mechanism* is the assumption that explanations of natural phenomena must not refer to outside agents. This is what is meant by determinism in science. It is absolutely true that Thorndike's was a deterministic view, as was Freud's. But, as a part of nature, human behavior and experience must be as orderly as we find the rest of nature to be. Given that the mind is part of nature, an understanding of what determines its workings is what gives us freedom. As Thorndike said in 1909:

> For, strange as it may sound, man is free only in a world whose every event he can understand and foresee. Only so can he guide it. We are captains of our own souls only so far as they act in perfect law so that we can understand and foresee every response which we will make to every situation. Only so can we control our own selves. (Joncich, 1968)

As discussed in Chapter 1, every scientist must be a mechanist; we have had capricious forces, demons, and magic with us for too long. A controversy about determinism seldom arises except when a particular theorist (such as Watson or Skinner) makes a point of goading the antideterminist forces.

Oversimplifying Behavior and Experience

A related criticism often raised concerns the apparent simplicity of a theory of selecting and connecting, given the great complexity of behavior and experience. William McDougall criticized what he called the "sarbon" theory (S-R bond) in an article published in the 1920s, "The Psychology They Teach in New York" (Joncich, 1968). In his view, connectionism (the sarbon theory) was a "theory of morons, by morons, and for morons." Such critics have persisted over the years and very likely arise because the most basic premise of connectionism can be stated in an overly simple way: Connectionism is the formation of S-R bonds, selecting and connecting by the law of effect.

Any other theory, if stated in terms of its most basic assumptions, also would seem overly simple, whether the theory be Freud's, Piaget's, or anyone's. Over the years, connectionism has been presented in the form of a bare-bones caricature, a never-failing simple formula expressed in terms of stimuli, responses, and consequences. And that is often followed by criticisms of the theory as if the caricature were all that need be mentioned.

But what *is* the "sarbon theory"? Does it require that we be able to take any individual, present what we call a stimulus, reward whatever behavior occurs with food, money, praise, or another arbitrary satisfier, and then rest assured that the behavior and the stimulus have been connected? This is hardly what Thorndike meant. In reality, an individual comes to a situation with a variety of response tendencies (including ideas) as the result of previous experiences: Behavior is in no sense random. The individual brings attitudes, dispositions, and preadjustments depending upon prior instructions, bodily states, and other factors, including prior experience in such situations. All aspects of the situation are not equally effective; prior experience and species membership mean that some clues will be noticed and that others will be ignored (perhaps including what we are calling the stimulus). Finally, the more a new situation resembles those encountered in the past, the more similar will be the individual's behavior to that shown in the past. In addition to all of this, selecting and connecting will occur only if the intended satisfier is on that occasion a satisfier. Recall the law of readiness: No event is a satisfier or an annoyer for all organisms at all times.

Note that the modifying conditions mentioned in the preceding paragraphs paraphrase Thorndike's subsidiary laws, which were clearly discernible in his earliest writings, such as *Human Nature Club*, 1900. But critics often failed to notice this, preferring to attack the caricature. One of the most famous early critics was Wolfgang Köhler, whose evidence for insight in apes has often been cited as evidence against Thorndike's theories.

Insight versus Trial and Error

The Gestalt psychologist Wolfgang Köhler (see Figure 2.3) spent the years from 1913 to 1920 as director of the German primate research center on the island of Tenerife, in the Canary Islands off the west coast of Africa. He was impressed with what seemed to be insightful problem solving by chimpanzees, and in 1925 his classic observations were published, translated as *The Mentality of Apes*.

In evaluating Köhler's findings, it is important to note that he had little knowledge of the learning theories of the time, including Thorndike's. He interpreted Thorndike's trial and error learning as no more than random and blind fumbling, with consequences mechanically stamping in S-R connections. We have seen that this is not a fair characterization of Thorndike's views, but Köhler was not alone in believing that it was.

Gestaltists, such as Köhler, believe that problem solving, perceiving, learning, and thinking require viewing relevant parts of the environment in a particular way. The Gestaltists stressed insight, rather than trial and error, in learning. *Insight*, as Köhler defined it in 1925, is "the appearance of a complete solution with reference

FIGURE 2.3 Wolfgang Köhler, 1887–1967. Kohler played a key role in the development of Gestalt psychology. Köhler's work stressed the role of insight in learning. *Photo courtesy of Clark University Press*

to the whole layout of the field." Let us look more closely to see what Köhler meant by this.

Consider a typical problem, in which two sticks may be joined and a piece of fruit may then be retrieved from outside the bars of a cage. In another situation, an obstructing box must be moved before the subject can reach a banana. A typical chimpanzee exhibited plenty of behaviors described as "crude stupidities," but the moment of insight eventually came. In one case, Köhler wrote that "it did not dawn on Tschego for hours to push the obstructing box out of the way."

Köhler believed that his animals' errors could be characterized as "good errors," "errors caused by lack of comprehension of the conditions of the task," and "the crude stupidities arising from habit." The latter errors were extremely annoying. "It almost makes one angry."

The most famous example of insight was the retrieval of a banana hanging from the ceiling and reachable by stacking boxes underneath and climbing them. Chimpanzees were never very good at stacking two boxes, and, when they managed to do so, it was often without regard for the location of the banana! However, they were able to use a single box as a jumping platform to retrieve the banana, although only one chimpanzee, Sultan, did so without assistance. Others required demonstrations or the placement of the box under the banana before insight occurred.

We all know what it feels like to experience insight, to see things in a new way that changes things and essentially solves a problem. But is the occurrence of such rapid problem solving really damaging to Thorndike's theory? Consider the laws of selective attention, set, and response by analogy in cases of insight. Isn't it true that insight is aided when past experiences have taught us to attend to certain features of situations and to see them in new problem situations? Köhler later essentially agreed with this; he suggested that past experience helps us learn to pay attention to important features of current fields (1959). Harry Harlow showed how this might occur.

Harlow, Learning Set, and Insight

Harlow, Gluck, & Suomi (1972) reported an interesting history of the discovery of the phenomenon of *learning set*, or the "learning to learn" to efficiently solve different problems of the same class. In 1940, Harlow spent a year as a student at Columbia University and attended a seminar held by the great neurologist, Kurt Goldstein. Goldstein is known for his emphasis on the distinction between concrete and abstract thought and for his belief that only humans (with intact frontal lobes) have the capacity for abstract thought.

To demonstrate that one is capable of abstract thought, one must be able to verbalize space, set

a clock, and perform other tasks. But the most basic test for abstract thought was held to be the ability to solve the Weigl problem. This problem requires a conditional discrimination and may be illustrated with a simple version consisting of two cubes and a sphere. The sphere and one cube are white, the remaining cube is black.

The subject is asked to indicate which two objects are similar, which could be answered in terms of shape or brightness. Once the response is made, the subject is asked to specify another way of grouping them. Soldiers suffering battlefield wounds to the fronts of their heads were not capable of solving the Weigl problem and thus had lost the capacity for abstract thought.

Harlow saw the test as a challenge and set out to train rhesus monkeys and chimpanzees to solve the Weigl problem. He cheerfully conceded that they had a difficult time of it, but eventually, after posing problem after problem in a stepwise fashion, they did solve it, thereby demonstrating "abstract thought." Harlow was shocked and surprised to find that most psychologists did not care. "At least Goldstein cared," he thought. But, Goldstein aside, the discovery of learning sets seemed to solve an old problem.

Rather than interpret learning as a series of insights or as the simplified version of S-R theory that Köhler attacked, Harlow (1949) stressed the importance of learning produced by repeated exposure to problems of the same class. As he wrote:

> Our emotional, personal, and intellectual characteristics are not the mere algebraic summation of a near infinity of stimulus-response bonds. The learning of primary importance to the primates, at least, is the formation of learning sets; it is the learning how to learn efficiently in the situations the animal frequently encounters. This learning to learn transforms the creature from a creature that adapts to a changing environment by trial and error to one that adapts by seeming hypothesis and insight. (Harlow, 1949, p. 52)

The stimulus-response view he criticized was Hull's, which was popular at the time, and the "learning to learn" is the way in which insight is learned. In typical demonstrations of learning set, monkeys were presented with two stimulus objects placed over food wells. Stimulus objects could differ in shape, color, size, and other ways, and the correct stimulus could appear on the right or the left. Suppose that such a problem were presented over 50 trials and then 31 other problems (that is, each with two different stimuli) were presented successively over 50 trials each. Then 200 more problems were presented for six trials each and a final 112 problems were presented for an average of nine trials each. Figure 2.4 shows the percent of correct responses averaged over eight monkeys on the first six trials of each problem, with problems grouped in blocks varying from eight to 100. The lower curve shows the slow improvement in the initial problems; this suggests a slow trial and error process. But the last block of problems shows nearly perfect performance by the second trial. Is this "sudden solution" what is meant by *insight?* Köhler (1959) agreed that learning set may demonstrate the learning of insight. Perhaps close examination will show other cognitive processes to be the products of learning, as Thorndike suggested long ago.

Linking the Law of Effect with Hedonism

Thorndike's choice of the terms *satisfier* and *annoyer* was an extremely unfortunate one. As pointed out earlier in this chapter, he was aware that the action of consequences does not depend upon sensory pleasures and pains. Because of the belief that pleasure and pain are what he meant by satisfaction and annoyance, many critics (Chapter 4) have dismissed what they called the "law of *affect*." John B. Watson criticized the law of effect because he felt that affect (such as pleasure) was unnecessary for learning to take place. Others criticized it because it is so obvious that the bulk of our activity is not regulated by immediate pleasures and pains.

The point here is that the mistaken belief that Thorndike believed that satisfiers and annoyers must be pleasant and painful led to the perform-

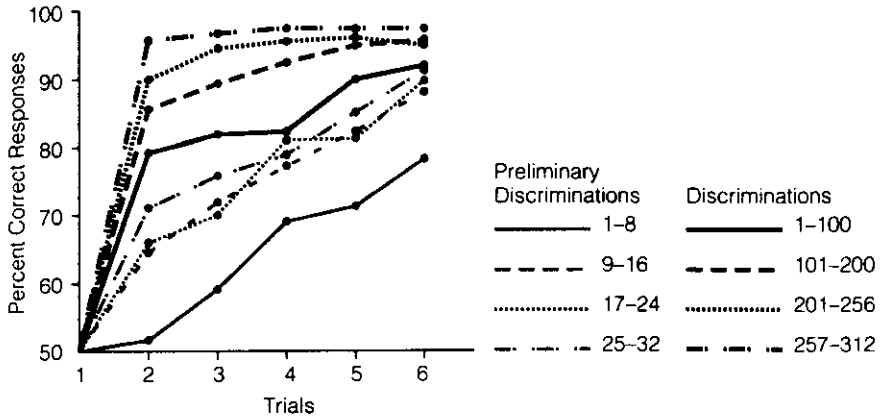


FIGURE 2.4 Data from Harlow's (1949) experiments demonstrating learning set and insight with rhesus monkeys

ing of unnecessary experiments to refute an assumption that was never made. It was inevitable, though, that Thorndike's use of the common terms *satisfier* and *annoyer* would lead to the conclusion that the law of effect was a shallow hedonism.

More Serious Criticisms

More serious are the critics who point to the deficiencies of any S-R psychology in adequately dealing with any behavior, except the most trivial. Is the world really representable in terms of discrete stimuli? Is all of our behavior and experience really represented fully by the letter "R"? Are all of the ways in which the world affects us really captured in Thorndike's laws?

Perhaps the really vulnerable part of Thorndike's theory is the emphasis placed on the law of effect. We will see that Guthrie and Watson disputed the very necessity of the law of effect, and Tolman assigned no great importance to it. And the experiments of Hebb (1961) and Estes (1969), described above, surely show that the law of effect is not necessary for learning.

But we must remember that Thorndike was truly a pioneer who was trying to provide an alternative to the views of the introspectionists in psychology and to the educators who favored the discipline method of training faculties. The law of effect seemed to offer such an alternative. Important as the law may be, it is clear that he overestimated its importance.

Even though he overstated the importance of the law of effect, Thorndike accomplished a great deal. He pointed out that animals are not as complex and mysterious as had been supposed: Much of what people and other animals do is really determined by simple factors. At the time, his news was startling, but we have probably accepted so much of Thorndike's original message into our ways of thinking that we even might wonder why he troubled to bring it to us.

4. OTHER ASPECTS OF THORNDIKE'S WORK

This book is concerned with the psychology of learning and Thorndike is thus of interest because of the impact that his views had on learning theory. But Thorndike applied the same basic point of view to a variety of other areas, from mental testing to the writing of schoolbooks and dictionaries to the testing of aptitudes and the scaling of wants and interests. The remainder of this chapter discusses how Thorndike's views influenced other areas of interest to him.

Books and Other Publications

During his 43-year career and his 10 years of retirement Thorndike published some 450 books, articles, and monographs. His *Arithmetics*, in which he tried to substitute what was known of the psychology of learning for the rote drill of previous books, sold in the neighborhood of five million copies in the 1920s. The *Thorndike Century Junior Dictionary*, published in 1935, sold approximately a million copies by 1940. Needless to say, the royalties from these and other books eased the hardships of the depression for the Thorndikes.

Education: Nature versus Nurture

Thorndike's career was spent at Teachers College of Columbia University, an institution devoted to the training of teachers. Yet, Thorndike's attitudes toward teaching were not what one would expect. He felt that his own education, especially at Wesleyan, would have been improved if unlimited cuts had been allowed; as it was, he spent his time in class at the back of the room doing other things. He was not known as an exceptionally good teacher himself and he often commented that courses were generally a waste of time for all concerned. If this was the case, why the emphasis on proper methods of teaching, on selecting and connecting?

For Thorndike (e.g., 1898), the "most and the best" learning comes from reading books and doing things for oneself, rather than from hearing lectures. This being the case, Thorndike frequently used his lecture notes from a new course as the basis for a textbook, so that future students could rely on his printed words rather than on his less reliable spoken words.

Because of the crudeness of the distinction between environmentalists and hereditarians, Thorndike is often presented as an extreme environmentalist, stressing the importance of experience, rather than heredity, in learning. This seems natural, since his connectionism seems to imply that experience may mold us into infinite forms, depending on what connections are formed. In fact, however, Thorndike viewed the power of education as severely limited by innate endowment; the laws of his connectionism work within the bounds of some 80 percent domination by heredity! This view was apparent early in his career, as it was in the first volume of his *Educational Psychology* (1913), in which he said:

> The physician should know whether original nature lets a child eat too much and chew it not enough; the criminologist should know the relative shares of nature and nurture in the production of assault or theft. (p. 41)

Later, after examining data from 409 pairs of brothers, he said: "The more one looks, the more one is confronted by failures of the environment to do what is expected of it" (Thorndike, 1942, p. 87).

Despite the limits which Thorndike felt were imposed by heredity, society expects its children to be educated, Thorndike noted. The principles of connectionism still provide the best guide for achieving this, although one should not expect too much of any method.

Wants, Interests, and Attitudes

In 1949, the last year of his life, Thorndike wrote that *The Psychology of Wants, Interests, and Attitudes* (1935) was one of his best works. He undoubtedly felt that he had applied the methods of science to a particularly difficult area. Here are some examples of the studies he discussed.

Thorndike showed that interest in learning some facts is greater than that in learning others. For example, subjects learn birth dates of eminent people better than those of nonentities. The truth of a fact makes little difference in whether it is easily learned. Learners remember false birth dates of eminent people, false meanings of rare words, and false biographies of historical figures as well (or better than) they learn the truth, even if they know from the start that what they are learning is untrue.

Other studies (Thorndike, 1949) consisted of questionnaires assessing valuations placed on various activities or events. For example, in one

TABLE 2.6 The following question was asked of 60 employed and 39 unemployed professionals: "For how much money would you suffer each of the following?" Their answers are shown in dollar figures below.

Hardship	*Employed*	*Unemployed*
Have one upper front tooth pulled	$ 5,000	$ 4,500
Have all the hair of your eyebrows fall out	100,000	25,000
Become unable to smell	300,000	150,000
Fall into a trance or hibernating state throughout March of every year	400,000	200,000
Be temporarily insane throughout July of every year (would have to be put in an insane asylum)	NO SUM	2,500,000
Have nothing to eat but bread, milk, spinach, and yeast cakes for a year	25,000	10,000
Have to live the rest of your life in Boston	100,000	50,000
Spit on a picture of Charles Darwin	20	10
Lose all hope of life after death	6,500	50
Eat a live beetle one inch long	50,000	25,000

Thorndike, 1949, pp. 252–254

study, groups of employed psychologists and unemployed professionals were asked to rate the goodness of various activities for a specified individual. In one example, respondents were asked to rate activities that a forty-year-old chemist might engage in during three hours off on a Thursday afternoon. The activities included studying chemistry, reading literature of the Mormon church, writing unsigned defamatory letters to several men about their wives, and teasing the monkeys in the zoo. His subjects had no trouble ranking such activities.

In a similar study, the same two types of groups were asked to put a dollar value on suffering various hardships, including having the hair in their eyebrows fall out; falling into a hibernating state throughout March of every year; being temporarily insane during July of every year; eating a live beetle; having nothing to eat but bread, milk, spinach, and yeast cakes for a year; and losing all hope of life after death. In general, the unemployed professionals were willing to accept the hardships for much less money. For example, they were willing to lose all hope of life after death for a mere $50, on average. The employed professionals wanted $6,500 on average for such a hardship! Table 2.6 presents additional data from this study. It may seem that the gain in our knowledge produced by such studies is questionable. However, these were pioneering efforts that helped to convince a great many people that there was no aspect of human behavior or experience that could not be treated scientifically.

SUMMARY

Thorndike saw his contribution largely as having provided an alternative to the mentalism of his (and our) day. He showed that the seemingly complex behavior of cats in the problem box could be simply explained as the stamping in and out of connections between situations and responses through the action of satisfiers and annoyers. Throughout his career he argued that the same

principles could account for a great deal of our behavior, including our thoughts and interests.

The law of effect proves to be more complicated than it appears at first sight when one asks why satisfiers and annoyers work as they do. They have no necessary connection with pleasure and pain. Some satisfiers and annoyers are innately determined, but most are not. As a general principle, a state of affairs will act as a satisfier or an annoyer depending on the readiness of the individual for particular consequences. Once a behavior series is begun, satisfaction depends on its successful operation, which is defined in terms of the readiness of conduction units to operate. One may not arbitrarily apply satisfiers and expect them to work invariably.

The law of effect is thus more limited in usefulness than is sometimes believed, but its use by Thorndike called attention to the need to be specific when we seek to alter behavior. Selecting and connecting requires that we specify precisely what behaviors we want to attach to what situations. We must consider, for example, exactly what we mean when we say that we want to teach patriotism or reasoning skills.

The law of effect is further tempered by a set of subsidiary laws. The law of multiple response points out that the learner brings a set of behaviors to new situations, which determine what responses will initially be made. The learner also brings attitudes (also known as dispositions, preadjustments, and sets)—conditions of the learner which determine what will act as a satisfier or an annoyer. The learner will attend to what similar past experience has led him or her to see as salient aspects of a situation (the law of piecemeal activity or selective response), and his or her performance will be greatly affected by the similarity of present and past situations, expressed as the law of response by analogy. A special case of this last principle, associative shifting, refers to what was later called classical conditioning and stimulus fading.

In the early 1930s, Thorndike altered his views somewhat, dropping the law of exercise and the negative law of effect. The opinion that annoyers (punishers) work only indirectly was widely believed for many years, until later evidence clarified the effects of punishment. Critics of Thorndike's connectionism chiefly object to what seems a mechanical conception of humanity, an oversimplification of behavior and experience, and a restatement of the simple hedonistic view of centuries past. Some reflection shows that such criticisms are applicable only to a grossly oversimplified concept of connectionism. Clearly, any model of behavior and experience similarly caricatured would be subject to similar criticisms.

The Gestaltists emphasized the importance of insight but were little concerned with the learning experience that makes insight possible. Harlow demonstrated the phenomenon of learning set, or "learning to learn," thus showing what kind of experience is necessary for sudden solutions to occur.

Thorndike considered himself a basic scientist all his life, though a good deal of his work was aimed at practical application. He was a strong advocate of the influence of heredity, a factor that he felt placed great limits on education, whether carried out using connectionist methods or not. His work in assessing attitudes, wants, and interests seems primitive by modern standards but probably contributed greatly to the belief that such mental entities are subject to precise measurement.

GLOSSARY

Annoyer Thorndike's term for punisher. An annoyer is a state of affairs that stamps out the association between a situation and a response. In Thorndike's pre-1930 theory, a response followed by an annoyer will be less likely to occur in that situation in the future.

Associative shifting One of Thorndike's subsidiary laws corresponding to what was later called classical conditioning.

Attitudes/dispositions/preadjustments/sets Four terms treated as synonymous and referring to the effect of preparation of the learner on the effectiveness of satisfiers and annoyers, as well as on other effects of a new situation on performance.

Conduction unit Used by Thorndike to illustrate the

law of readiness. Depending upon its readiness to fire, the firing or not firing of a conduction unit constitutes satisfaction or annoyance.

Connectionism Thorndike's term for his theory of learning. Learning consists of the connecting of stimuli and responses.

Discipline method Method of education in which drill exercises are used to develop a general mental faculty. For example, the memorizing of poetry was used to develop the general faculty of memory.

Faculties Mental powers that act semiautonomously. Attention, memory, judgment, perception, and imagery are often proposed as faculties.

Hedonism The ancient doctrine popularized in British empiricism, which assumes that pleasure and pain are the essential determinants of conduct.

Insight Term used by Köhler to describe the sudden solutions to problems he observed in his primate subjects (1925). Insight involves the apprehension of relationships in a problem situation, which Köhler contrasted with "blind fumbling" and the action of the law of effect; this was his view of Thorndike's theory. Readers of Köhler's accounts of insight in apes may disagree with his interpretations. Like other Gestalt psychologists, Köhler downplayed the effects of experience in promoting insight. In 1959 he said that, although he had been confused on the issue in the past, he realized that only sudden solutions without prior experience represented true instances of insight. Thus defined, insight may be a relatively rare event.

Law of effect Thorndike's doctrine that held that responses were connected to or disconnected from situations depending upon the effect produced by the response (satisfaction or annoyance).

Law of exercise Thorndike's pre-1929 principle that referred to the connecting of a response and a situation simply because they frequently occurred together.

Law of readiness Also called the law of instinct. Thorndike's law refers to the conditions that determine satisfaction and annoyance. Present stimuli produce a readiness for certain types of consequences.

Mechanism The assumption that explanations must not refer to outside agents, such as demons or life forces.

Mentalism The belief that mental phenomena are different in kind from physical phenomena and that mental events may cause physical events.

Multiple response One of Thorndike's subsidiary laws. This law refers to the behaviors that an individual brings to a learning situation and that determine what behaviors will occur.

Negative law of effect The portion of the pre-1929 law of effect that refers to the effect of annoyers, or punishers.

Original behavior series Thorndike's term for a sequence of activities that are determined innately and that constitute satisfaction when completed.

Partial or piecemeal activity One of Thorndike's subsidiary laws, which referred to the selective nature of perception. We react only to a small subset of the elements of a situation.

Problem box A crude device used by Thorndike and other animal researchers to study problem solving. Typically, a subject placed in such a box could escape by operating a release mechanism, such as a lever or a pull cord.

Response by analogy Thorndike's principle of transfer. We respond to a new situation in the same way that we responded to similar situations in the past.

Satisfier A state of affairs that acts to connect a response with the situation in which it occurred and thus form an S-R bond. Any more precise definition of a satisfier becomes difficult.

Selecting and connecting Term used by Thorndike to describe his theory. Responses are selected by the fact that they produce satisfiers, which also connect them to the situation in which they occurred.

Stamping in or out Term used by Thorndike to describe the connecting or weakening of an S-R association.

Successful operation Term used by Thorndike to specify the conditions for satisfaction. Successful operation refers to the unimpeded completion of an original behavior series.

RECOMMENDED READINGS

Joncich, G. (1968). *The sane positivist*. Middletown, CT: Wesleyan University Press.

This is nominally a biography of Thorndike, but it is much more than that. It is an excellent history of the development of education and psychology in this country, from the nineteenth century onward, with Thorndike's life the thread that runs through it.

Thorndike, E. L. (1949). *Selected writings from a connectionist's psychology*. New York: Appleton.

This is a collection of Thorndike's own papers that he considered most important. Their variety testifies to the considerable range of his interests.