EDWARD THORNDIKE AND THE LAW OF EFFECT

Darwin's theory of evolution implies that there is no sharp line of demarcation between humans and other animals, either in their gross physical structures or in the fine structure of the nervous system that control their behavior. If humans are able to solve problems in intelligent ways, we would expect at least the rudiments of such capabilities in other animals as well. Of the many who set out to investigate this possibility experimentally, Edward Thorndike was one of the earliest and most influential.

Edward Lee Thorndike (1874–1949) was born in Williamsburg, Massachusetts. After taking his B.A. at Wesleyan University 1895, he developed an interest in psychology from reading William James's *Principles of Psychology*, so he went to Harvard to study with James, taking a second B.A. in 1896. He set about studying the learning abilities of animals, beginning with chicks, which he incubated and hatched in his room in Cambridge. Unfortunately, as anyone who has worked with chicks knows, their tiny bodies can generate a formidable amount of sound. Thorndike's landlady could not tolerate the noise they made. So James took Thorndike, chicks and all, into the cellar of his own home, "much to the glee of the James children" (Boring, 1950, p. 562).

Shortly after that, Thorndike was offered a fellowship at Columbia under the auspices of James M. Cattell, a student of Wundt. So Thorndike and some of his more educated chicks moved to New York. There, dogs and cats could be accommodated, though Thorndike also continued to test the learning ability of chicks, using mazes made of books stood on end. Thorndike began a series of studies that were published in the year he got his degree, 1898. What he found was that animals were indeed able to solve the problems that he set them, doing things that would be called intelligent if humans did them. So he titled his book *Animal Intelligence.*

After taking his degree, Thorndike taught for a year at Western Reserve, then returned to Columbia in 1899, then joined the faculty at the Teachers College, where he remained until his retirement in 1940.

For his most famous animal experiments, Thorndike invented what he called a *problem box*. A cat might be confined uncomfortably in a little box, from which it could escape by making some response that was designated as correct—pulling a loop of string, for example, that would trip a latch, allowing a door to fall open so that the cat could escape confinement and, as a bonus, collect a bit of f
placed outside the door. (Or it could just take off, and have to be recaptured for the next trial.)

Thorndike measured the *latency* of the correct response—that is, from the time the door was closed on the cat, how long did it take the cat to make the correct response and escape from the box? What typically happened was that, when confronted with the problem for the first time, the cat would flounder around aimlessly, scratching and grooming and exploring, until by chance it happened to perform the act that was correct. Then, on successive trials, the response was likely to appear more and more promptly until the cat had mastered the task, and would make the correct response immediately upon being shut up in the box.

By measuring these latencies, Thorndike was able to plot learning curves, showing how long it took the cat to escape on the first trial, the second trial, and so on. Latency gradually declined over successive trials—that is, the correct response occurred more and more promptly. What struck Thorndike about these data was the *gradualness* of the change. We might expect that after an initial period of confusion, the cat would suddenly "make the connection," understand what it had to do to escape the box, and do it promptly thereafter. There should, in other words, be a sudden drop in its latency that should remain low thereafter. But that is not what happened. Instead, the time to escape diminished slowly and gradually over many trials.

It was as if the correct response were *gradually being strengthened* by the *reward* of escape from confinement (and fish). Unrewarded responses gradually dropped out. This was Thorndike's view, and he laid it down in his famous *law of effect*. Rewarded responses are gradually "stamped in," becoming stronger and stronger with successive rewards. We need not talk about what the animal "knows" or "comes to realize," but only about the *effect* that its action has in bringing about reward. Thorndike saw this as a process of forming and strengthening a connection between the stimulus situation *(S)* and the response *(R)*. As he put it, a response that is followed by a pleasant or satisfying consequence becomes more strongly connected to the situation in which it occurs. The more often the response is rewarded in that situation, the stronger the connection becomes.

He also stated the converse—if a response is followed by an unpleasant consequence, its connection to the situation is weakened—but he later discarded this idea. Finally, there was his *law of exercise*, to account for the effects of practice: the more often a response occurs in a situation, the more strongly it is connected to that situation. "Practice makes perfect," we say, but Thorndike would have corrected us: No, practice makes *habits*—that is, connections. It may be better, far better, not to practice at all than to practice wrong responses.

The law of effect, which we now call the *reinforcement principle*, has been either a fundamental principle or a target of intense criticism ever since Thorndike's day. Some behaviorists objected to it on the grounds that it speaks of subjective states such as satisfaction or annoyance, but Thorndike was careful to define these terms behaviorally: a satisfying state of affairs is one that an animal will work to bring

about, and an annoying state of affairs is one that the animal will work to terminate.

Then, however, we encounter another difficulty: The principle begins to sound circular. Why will the animal work to achieve this or that? Because it is a reward. How do we know it's a reward? Why, because the animal works to achieve it! However, we can escape the circularity this way: if we identify an event as a reward in one experiment, we can predict that it will be a reward in another one as well. Thus, if we show that food for a hungry animal will reinforce, say, latch pulling in one situation, we can predict it will reinforce lever pressing in a different situation. Unfortunately, all this turns out not always to be true (chapter 24), but that became clear only much later.

These difficulties, however, did not seriously deter the acceptance of Thorndike's law of effect, at least by second-generation behaviorists. That actions are sensitive to their *rewarding and punishing consequences* is so clearly evident that it seems perverse not to accept it. But how does it work? And how important is it? Does it apply only to cats in boxes or chicks in mazes?

Thorndike titled his monograph *Animal Intelligence*. However, looking over his interpretation of his experiments, we see that he is really not assigning his animals much intelligence at all. A cat, while "learning" to escape from a problem box, is not really *doing* anything except making responses. It is the environment—the rewarding consequence of action—that "stamps in" the correct response over successive trials.

What then of the continuity between animal and human, the question with which we began? There would seem to be two possibilities: *(a)* perhaps animals are more intelligent than Thorndike gave them credit for, which was the view of Köhler (chapter 21) and Tolman (chapter 22); or *(b)* perhaps the human mind is simpler than we have supposed. "Connections" between situations and responses sound very much like the "associations" of Ebbinghaus (chapter 29) and, for that matter, of John Locke (chapter 2). Perhaps the human mind looks complicated only because there are so many associations, formed by experience of various situations, responses, and consequences. Its actual workings might be quite simple. Indeed, what we call intelligence in humans might actually be *measured* by the richness of connections with which the adult human is equipped. This was Thorndike's view. It put him in opposition with other students of intelligence, such as Charles Spearman, who contended that there was something like a faculty, or capability, that ran through a very wide variety of specific tasks. That controversy is still with us (Sternberg, 1999).

When Thorndike joined the faculty at Columbia in 1899, he began applying his ideas to education. An enormously influential paper, in collaboration with Robert S. Woodworth, challenged a popular view of education—the concept of *formal discipline*. The idea was that the mind had "faculties" that could, like muscles, be strengthened by exercise. Schoolchildren memorized poetry, for example, in order to strengthen their memories; they studied mathematics not for its own value, but to strengthen their faculties for logical analysis. Thorndike and Woodworth performed a series of experiments asking whether practice at one sort of problem would transfer to other problems. They concluded that this could indeed happen, but if it did, it was not because a general "faculty" had been strengthened. Rather, it was because the new problems had elements in common with the old ones. Now, the

notion of an *element*—a small part of a complex whole—again recalls the Lockean conception of mind in which complex ideas (and cognitive capabilities) are made up of smaller ones, connected to each other. Then, if a new problem has elements in common with an old one, this simply means that some connections required by the new problem have already been formed, through practice and rewarded success, with the old one. If this is so, then the notion of strengthening this or that "faculty" is unnecessary. What one strengthens are connections.

That controversy, too, remains alive today. Does training in statistics, for example, lead to a more logical approach to data and problem solving in general? Results have been somewhat disappointing, just as Thorndike would have predicted.

"Thorndike retired in 1940 after four decades of service to Teachers College, but he kept working. In 1942 he went back to Harvard as William James Lecturer, honoring the memory of the great man who had lent him his cellar for his chicks forty-four years before" (Boring, 1950, pp. 563–564).

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