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# Edward Thorndike

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## *Revolutionary Psychologist, Ambiguous Biologist*

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*Edward Thorndike's thesis can be considered the foundation document of modern comparative psychology. In it, Thorndike both rejected earlier anecdotal, anthropomorphic, and introspectionist approaches to the study of animal behavior and provided novel methods for studying comparative psychology that, 100 years later, are still the basis of the field. Thorndike also introduced ways of thinking about the relationship between evolutionary biology and comparative psychology that were to bedevil comparative psychologists for decades to come. Here the author discusses, from a contemporary perspective, both Thorndike's lasting methodological and empirical contributions and his more problematic approach to the relationship between the study of phylogeny and comparative psychology.*

**P**ublication in June 1898 of Edward Thorndike's doctoral thesis, the first dissertation in psychology in which animals served as subjects, marked a turning point in the history of the study of behavior in North America. There can be little question that Thorndike knew that his thesis pointed the way to a new kind of behavioral research. As he wrote to his fiancée, Beth Moulton, a few months into drafting the final document, "My thesis is a beauty . . . I've got some theories which knock the old authorities into a grease spot" (quoted in Joncich, 1968, p. 146). Indeed, the opening chapter of Thorndike's dissertation was a breath of fresh air for a field in need of resuscitation.

### **The Revolutionary Psychology of E. L. Thorndike**

#### ***Comparative Psychology in the Victorian Era***

By the end of the 19th century, the literature in comparative psychology had become a morass of questionable anecdote and insupportable anthropomorphism (Galef, 1988a). The introduction to Thorndike's (1898) thesis called for rejection of the informal naturalism that had dominated the study of the behavior of animals for the preceding 100 years (Barber, 1980) and that was largely responsible for the disappointing state of comparative psychology at the turn of the century.

Throughout the 19th century, authors of volumes of natural history strove, as Charles Kingsley (1855) a successful author of the period, put it,

[to bring] out the human side of science and [to give] seemingly dry disquisitions and animals of the lowest type, by little touches of pathos and humour, that living and personal interest, to bestow which is generally the function of the poet. (p. 160)

The need to tell engaging tales, rather than to provide objective description, shaped natural history books of the day. Public success often lay, then as now, in relating amusing animal anecdotes and in attributing human motives and human-like intelligence to almost any living creature.

There was, however, an important difference between 19th- and 20th-century publications in the field of animal behavior. In the 19th century, scientific publications were almost as rich in anthropomorphic interpretations of behavioral anecdotes as were books intended for the lay public. Even such distinguished journals as *Nature* accepted for publication letters similar to that excerpted below, describing the nesting behavior of a recently parturient cat that belonged to a Mr. Bidie. Mr. Bidie had returned from a journey, thus displacing from his quarters two young gentlemen who had been residing there in his absence and who had the nasty habit of teasing Mr. Bidie's recently parturient cat. Shortly after Mr. Bidie's return, the cat moved her kittens from a concealed nest to his dressing room. Mr. Bidie (1879) wrote to *Nature* to express his opinion that his cat's "train of reasoning seems to have been the following 'now that my master has returned, there is no risk of the kittens being injured . . . so I will take them out for my protector to see and admire'" (p. 96). Apparently, both Mr. Bidie and the editors of *Nature* took it for granted that progress in understanding the behavior of animals depended on chance observation of intriguing bits of behavior, putting one's self in the place of the animal, and then introspecting to discover the mental processes that might have led the animal to behave as it did. There was, initially, a scientific motivation for this anecdotalism and anthropo-

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morphism. The debate between deists and evolutionists as to the origins of human mental faculties appeared to some participants to justify introspective interpretation of questionable evidence (Romanes, 1884). The rich intellectual and emotional lives thus attributed to animals provided a link between the minds of extant animals and humans that Darwin's theory of evolution appeared at the time to require. However, things had gone very far.

### **The Critique**

It is against this background of anecdotalism, anthropomorphism, introspectionism, and inference of motive and intelligence from informal observation that the first pages of Thorndike's (1898) thesis must be read. Even his title, "Animal intelligence," contains an implicit criticism of his contemporaries, Wesley Mills (1898), George Romanes (1882), and C. L. Morgan (1890), whose similarly titled books Thorndike (1898) ridiculed in the opening pages of his monograph.

Most of the books do not give us a psychology, but rather a eulogy of animals. They have all been about animal intelligence, never about animal stupidity . . . [They furnish] an illustration of the well-nigh universal tendency in human nature to find the marvelous wherever it can . . . Thousands of cats on thousands of occasions sit helplessly yowling, and no one takes thought of it . . . but let one cat claw at the knob of a door supposedly as a signal to be let out, and straightway this cat becomes the representative of the cat mind in all the books . . . [the anecdotal school] has built up a general psychology from abnormal data. It is like an anatomy written from observations on dime-show freaks. (pp. 3-4, 152)

Thorndike's attack was unrelenting. He had no patience with the telling of tales, with what he called the "the work of the anecdote school" (Thorndike, 1898, p. 29), nothing but contempt for a comparative psychology that ignored "the stupid and normal" (p. 25) and instead focused on "the intelligent and unusual" (p. 25). Thorndike was equally critical of inference from introspection as a means to understand the mental life of animals.

### **The Method**

If Thorndike had nothing to offer but criticism of his predecessors and contemporaries, he probably would (and should) have been ignored. However, Thorndike's (1898) dissertation also contained striking examples of an alternative strategy for studying not only comparative psychology but behavior generally.

Thorndike's methods are so widely used in the behavioral sciences today that it is difficult to imagine that they once needed a champion, but that they did, and their champion was Edward Thorndike. Thorndike insisted that the study of behavior be carried out in a systematic, quantitative fashion under controlled conditions so that the course of development of normal behavior in typical subjects could be described.

### **Learning by Trial and Error or by Association of Ideas**

C. L. Morgan and Alexander Bain, like Thorndike, held the view that much of what animals learned they learned

by trial and error. Late in the last century, there were even a few experiments conducted demonstrating trial-and-error learning. However, at the turn of the century, Thorndike, Romanes, Morgan, and many others believed, without experimental evidence, that animals could learn not only by trial and error but also by imitation and by having their limbs passively put through actions by a human trainer. Thorndike expected the experiments he undertook for his thesis to provide hard evidence in support of these widely held beliefs (Boakes, 1984), but he felt he "could do better than had been done" (as cited in Joncich, 1968, p. 89) in demonstrating such forms of learning.

Thorndike's methods for studying learning in animals derived from anecdotal reports by both Morgan (1894) and Romanes (1882) of dogs and cats that had learned to open garden gates. Morgan, for example, was convinced that his dog, Tony, had learned by trial and error to open the gate in Morgan's yard, though Morgan also credited animals with "intelligent inferences of wonderful accuracy and precision" when solving simple problems. Romanes (1882, p. 422) asserted that cats that had watched humans depress a latch with their thumbs and push on gates to open them were able to reason "if a hand can do it, why not a paw?" Clearly, in Romanes's view, an animal could be led to perform an act by associating the idea of the act (depressing the thumb latch and pushing the gate) with the idea of its consequences (escape from the confines of the yard). Thorndike preferred Morgan's trial-and-error learning to Romanes' association of ideas, but felt that careful experiments were needed to support either view of how animals learned to solve mechanical puzzles.

### **The Experiments**

Thorndike's now-famous puzzle boxes (Thorndike, 1898), described in detail in Burnham (1972), were designed to permit repeated measurement of the speed with which cats, dogs, and (later) monkeys could learn to escape confinement and reach food by manipulating mechanical contrivances (levers, pulleys, treadles, etc.). The devices permitting escape were analogs of the latches on garden gates that the dogs and cats in Morgan's and Romanes's anecdotes had learned to open.

Thorndike's initial studies established normal latencies for hungry dogs and cats to escape from puzzle boxes and gain access to food. The gradual decrease across trials in these latencies convinced Thorndike that such learning involved a gradual increase in frequency of production of rewarded responses rather than an insightful association of ideas concerning escape and reward.

Thorndike hypothesized that placing an animal in a puzzle box elicited a set of activities reflecting both inherited tendencies and previous experiences of the animal. Eventually, and by accident, the animal performed an act that allowed it to escape from the apparatus and gain access to food, thus achieving "satisfaction." Over trials,

and as the result of repeated success, the animal gradually came to associate the impulse for making a successful movement with the sensory stimuli provided by the box. The gradual decrease in latency to escape the box simply reflected the strengthening of the association between the situation of being in the box and the appropriate act. Thus, in Thorndike's view, the animal did not, as Romanes had proposed, perform an act resulting in release from constraint because it thought of the appropriate act and of the satisfaction that would result from performing that act. Rather, as the result of experiences of satisfaction following initial accidental performance of a response in a puzzle box, an animal simply came to feel like repeating that response when again placed in the same situation.

### **Implications**

Thorndike's major theoretical contribution lay in the next step he took, one that provided experimental evidence contradictory to Romanes's (1882) view that animals learned to solve problems by associating ideas of actions and rewards. Thorndike argued that, if Romanes were correct, and associating the idea of an act with the idea of its outcome sufficed to produce the act, then learning an act ought to be facilitated by giving an animal the idea both of the appropriate act and of the satisfaction it could bring.

Thorndike explored several procedures that he felt should have facilitated learning, if associating the idea of an act with the idea of its outcome sufficed to produce learning. For example, if learning depended on the association of ideas, then animals that watched others perform acts that led to satisfaction should learn to perform those acts more rapidly than animals that did not have the opportunity to learn by observation. Similarly, if a passive animal was gently put through required movements and then allowed access to reward, it should, if the association of ideas underlies learning, produce the required movements more rapidly than an animal lacking such training. In both cases, the animal was presumed to have been given the opportunity to acquire the idea of the act, as well as of the pleasure that the act could produce. Thorndike found, to the contrary, that, when placed alone in an apparatus, neither animals that had been passively led to the correct act nor those that had observed others perform the correct act learned to escape more rapidly than did animals that had to learn without such tutoring. These unexpected failures to confirm the then universal belief that higher animals could learn by both imitation and passive movement of their limbs shaped Thorndike's views on animal intelligence. The failures suggested to Thorndike that animals had a severely limited understanding of the world in which they lived. Animals might learn an association between a situation and what Thorndike called a "motor impulse." However, they learned such associations without awareness of the consequences of their acts; they could not learn to associate ideas of actions with ideas of their consequences. Occurrence of satisfying or dissatisfying events simply changed the

probability that an animal would engage in any action by strengthening or weakening the connection between a situation and various motor acts. Thus, Thorndike provided both a novel and greatly simplified view of the mental life of animals and a set of tools for studying comparative psychology that was to prove astonishingly fruitful.

### **Innovations**

In retrospect, it is hard to see the innovations in Thorndike's (1898) dissertation, because it all seems so straightforward and logical. However, at the turn of the century, Thorndike's work contained a set of methodological innovations that were to revolutionize the study of comparative psychology: A representative sample of subjects was examined in a carefully described, standardized situation. Quantitative measures of performance were made. Comparisons were made of the performance, in the standard situation, of groups of subjects that had received different treatments before testing. Interpretations of implications of different outcomes of these comparisons were arrived at before experiments were begun. Several different operations were used to address a single issue. The behavior of members of different species (dogs, cats, and monkeys) was measured in logically identical tasks. In summary, Thorndike developed a methodology suitable not only for experimental study of animal learning but for much of animal and human behavior as well.

Thorndike's views were not simply the expression of a prevailing zeitgeist. His ideas were, at first, viciously rejected by many of his contemporaries. In a lengthy review, Wesley Mills (1899) suggested that the unnatural methods Thorndike had used resulted in his studying starved, panic-stricken cats and dogs that had temporarily lost their normal wits, so that their intelligence was grossly underestimated. Linus Kline (1898–1899, p. 150) concluded a far briefer review with the suggestion that the chief value of Thorndike's thesis lay in its "testing a simple method whereby more of the facts of animal psychosis may be set forth." C. L. Morgan (1900) suggested that Thorndike's subjects would be better described as his victims. Opposition died down as the nature of Thorndike's work became better understood, and almost immediately, laboratories devoted to the experimental study of comparative psychology as advocated by Thorndike became established at Clark University, Harvard University, and the University of Chicago (Warden, 1927). Their descendants are still active today.

### **Imitation Learning**

In discussing the results of his dissertation research, Thorndike (1898, pp. 76–80) described a set of "pseudo-imitative" types of social learning that might be confused with true imitation (Galef, 1988b). One hundred years later, comparative psychologists are still trying to find situations where copying of the behavior of one animal by another can be attributed unequivocally to imitation

rather than to one of the pseudo-imitative processes Thorndike described.

Thus, the results of Thorndike's (1898) thesis, as well as his methods, had sustained impact. In particular, his conclusion that animals could not learn by imitation, and its implication that animals did not learn by associating representations of acts and their consequences, were taken up as a challenge by succeeding generations of comparative psychologists. Thorndike's view provokes research to this day. Indeed, a century after Thorndike conducted his experiments on imitation learning in cats, dogs, and monkeys, the question of whether nonhuman vertebrates can truly imitate, in Thorndike's (1911, p. 173) sense of "learning to do an act from seeing it done," remains largely unanswered, though results of recent studies indicate that even parrots, Norway rats, and pigeons may be able to imitate simple acts (reviewed in Galef, 1998). Compelling demonstrations of learning by observation of complex, novel motor acts continues to elude researchers in the area (reviewed in Galef, 1998).

### **The 1911 Monograph**

During the decade following publication of Thorndike's dissertation in a *Psychological Review Monograph Supplement* in June 1898, Thorndike expanded his views on comparative psychology. In 1911 he published a new monograph on "animal intelligence," this one in book form. The book consisted of a reprinting of the 1898 thesis monograph; reprints of two other published, experimental papers; and two new essays in which Thorndike emphasized general, abstract laws of behavior derived from his experimental work. Although the principles were clear in the thesis of 1898, their first statement as general laws was in the 1911 publication.

The most enduring of Thorndike's laws, the law of effect, stated that an animal that made a response in a situation that was followed by satisfaction would be more likely to repeat that response in that situation. Conversely, an animal would be less likely to repeat responses made in a situation if those responses were followed by discomfort. This law of effect, together with the law of exercise (stating that, other things being equal, connections between situations and responses are strengthened by repetition) were to explain all learned behavior. Instinct simply provided the raw materials on which the laws of effect and exercise operated.

Thorndike argued further that, once the operations of the laws of effect and exercise were fully understood, the problem of learning would be solved: "the higher animals, including man, manifest no behavior beyond expectations from the laws of instinct, exercise and effect." (Thorndike, 1911, p. 274). By implication, experimental analysis of the effects of reward and punishment and of repetition carried out on the members of any species could yield laws of a general psychology of learning.

The central idea of the law of effect—that learning consists of the modification of response probabilities by

their consequences—became a central assumption of B. F. Skinner's (1938) approach to the study of conditioning. The law of exercise was central to Watson's behaviorism. Equally influential was Thorndike's assertion that all of learning, both human and animal, could be understood in terms of a limited number of general principles that could be studied in any convenient situation and species. An ecological or phylogenetic framework was viewed as irrelevant to the field (Jenkins, 1979). Only in the last two decades, with the decline of neo-behaviorism and the growth, first of cognitive and then of Darwinian or evolutionary psychology, has there been a weakening of the commitment of students of animal learning to the notion that experimental analyses of effects of reward and punishment in any situation can yield general laws of learning.

As I show below, by the late 1960s, the study of animal learning had become so far removed from basic biological concerns that evidence of ecologically relevant, species-specific learning mechanisms was seen as a challenge to the viability of the entire enterprise (Rozin, 1977). Thorndike's approach to comparative psychology, although both innovative and heuristic, contained the seeds of its own destruction.

## **The Ambiguous Biology of E. L. Thorndike**

### ***Thorndike, Darwin, and Spencer***

In the latter part of the 19th century, members of the scientific community entertained two incompatible views of phylogeny. According to Charles Darwin, at least in his earlier writings, speciation produced a great "tree of life" whose "green and budding twigs may represent existing species; and those produced during each former year may represent the long succession of extinct species." (Darwin, 1859, p. 120). On this view, the direct forebears of contemporary species, genera, and so on are to be found only as fossils entombed in the geological record. Extant species are related to one another not directly, as parents or grandparents are to their children and grandchildren, but as are cousins of varying degree.

Herbert Spencer (1855) proposed, as did Darwin, that life began on earth with a few simple forms. However, to Spencer, as to Lamarck before him, evolution meant steady linear progress from the simplest unicellular organisms to man. Gradual increase in physiological and neuroanatomical complexity as one ascended this *scala naturae* was a fundamental law of nature, and the increase in morphological complexity was reflected in increased sophistication of mind and behavior. "From the lowest to the highest forms of life, the increasing adjustment of inner to outer relations is one indivisible progression" (Spencer, 1855, p. 387).

The central problem with Spencer's (1855) approach is that it does not take into account the fact that extant species are not direct descendants of one another and, therefore, that any ranking with respect to complexity (whether of behavior or neuroanatomy) does not re-

flect historical relationships. The idea of ordering extant animals in terms of the complexity of their nervous systems and behavior surely did not originate with Spencer, but he was among those who provided a scientific, rather than theological, rationale for constructing a *scala naturae* or Great Chain of Being.

The distinction between Darwin's (1859) and Spencer's (1855) views of phylogeny is clear to the modern reader. It seems to have been less important to many working at the turn of the century.

Boakes (1984) reported that, while an undergraduate student at Wesleyan, Thorndike "was taught some psychology, read a great deal of Spencer and became inspired by James's Principles" (p. 68). Boakes does not, however, mention Thorndike's exposure to Darwin's thought. Boakes, I, and numerous others have read Thorndike as a proponent of Spencer's views. Clearly, the impression conveyed in Thorndike's 1911 monograph, which is far more accessible today than is Thorndike's 1898 publication in the *Psychological Review Monograph Supplement*, is that Thorndike had incorporated Spencer's (1855) rather than Darwin's (1859) view of phylogeny into his theorizing. For example, Thorndike (1911) wrote,

there is, as we pass from the early vertebrates down to man, a progress in the evolution of the general associative process. . . . It may be that the evolution of intellect has no breaks, that its progress is continuous from its first appearance to its present condition. . . . As we follow the development of animals in time, we find the capacity to select impulses growing. We find the associations thus made between situation and act growing in number, being formed more quickly, lasting longer and becoming more complex and more delicate. (pp. 285–287)

However, both Thorndike's (1898) thesis and some of his less frequently cited, early publications (1900, 1909) are far more Darwinian in flavor than is his 1911 monograph. The early papers make clear that Thorndike was widely read in Darwin's work and understood and accepted Darwin's views on phylogeny. As Thorndike (1898) stated in criticism of the views of a contemporary, "Since Hübner has shown how early the primate stock split off, it seems far-fetched to call a dog-mind and cat-mind an ancestor in any sense of the human" (p. 520). Similarly, in his thesis, Thorndike's thinking about phylogeny is clearly Darwinian rather than Spencerian. For example, Thorndike (1898, in Thorndike 1911) speculated, first that "the present anthropoid primates may be mentally degenerate;" second that "their chattering is a relic of something like language, not a beginning of such;" and third, that "comparative psychology should use the phenomenon of the monkey-mind of to-day to find out what the primitive mind from which man's sprung off was like" (p. 151).

Something changed Thorndike's thinking about phylogeny between 1898 and 1911. During the intervening years, Thorndike the animal psychologist became Thorndike the pedagogist, and Thorndike the Darwinian became Thorndike the Spencerian. In summary, in the end,

Spencer's view of phylogeny eventually prevailed in Thorndike's thinking and led both Thorndike and many other comparative psychologists out of the mainstream of evolutionary thinking.

### Consequences

Thorndike's influence on later animal psychologists, particularly those interested in behavioral plasticity, shaped the future of much of the field. Thorndike (1911, pp. 286–287) wrote that his research with various animals showed a Spencerian progress in the general associative process that reflected a progressive increase in the "delicacy and complexity" of the "neurones" and the connections between them as "we pass from the early vertebrates down to man."

The notion that, as we move along the vertebrate series, associations are learned more rapidly and more lastingly because the brain is more complex is not without heuristic value. It underlies the work of Hebb (1949) and of Jerison (1973), both of whom hypothesized a relationship between various aspects of brain size or complexity and behavior. Hebb pointed to the change in the ratio of the volume of association areas and primary sensory areas as one moves from "lower" to "higher." He assumed that this change in relative size of brain areas was responsible for "the greater speed with which the 'lower' species could learn to respond selectively to the environment, and to the comparative simplicity of their behavior when it is fully developed" (p. 126). Jerison used mathematical techniques to demonstrate a progressive enlargement of the brain as one moves from lower to higher vertebrates, even when the corresponding general increase in body weight is taken into account. Bitterman's (1965, p. 408) demonstration of different patterns of learning as we "ascend the phyletic scale" also reflects the Spencer–Thorndike tradition in psychology.

The problem, of course, with all such work on progressive evolution of brain or behavior is, as Hodos and Campbell (1969) pointed out,

the concept that all living creatures can be arranged along a continuous phylogenetic scale . . . is inconsistent with contemporary views of animal evolution . . . . The widespread failure of comparative psychologists to take into account the zoological model of animal evolution when selecting animals for study and when interpreting behavioral similarities and differences has greatly hampered the development of generalizations with any predictive value. (p. 337)

Although the doctrine of "levels" in the psychological capacities of animals (Schneirla, 1949) is evolutionary or comparative in the broadest sense of those terms, it is not historical, and for that reason it fails to make contact with much of mainstream biology.

Many comparative psychologists looked, as Thorndike (1911) seemed to be doing in his later work, for similarities and discontinuities in the mental abilities of distantly related species. However, those working, albeit some decades later, in what became the mainstream of

biology were interested in comparisons of homologous characteristics in closely related species, and thus in tracing the actual phylogeny of behavior. This divergence in the approach of psychologists and biologists to the study of comparative behavior led one biologist, Konrad Lorenz, to remark in 1950 that there is "an American journal masquerad[ing] under the title of 'comparative' psychology, although, to the best of my knowledge, no really comparative paper ever has been published in it" (p. 240).

It is hard to imagine the extent to which important parts of animal psychology became divorced from other biological disciplines (see Dewsbury, 1984, for counterexamples). Examination of the indexes of texts used to teach me animal psychology some 30 years ago, when I was a graduate student, make the point. Maier and Schneirla's (1935) classic, *Principles of Animal Psychology* (of which I have the fondest memories), does not mention either Darwin or natural selection. The book does not contain a definition of *adaptation* in the biological sense; the term *evolution* appears only twice in 480 pages of text, and it is not used in a biological sense in either case. In Koch's (1959) edited text, *Psychology: A Study of a Science*, evolution is mentioned only in Hinde's (1959) chapter on ethology. Keller and Schoenfeld's (1950) *Principles of Psychology* never mentions Darwin, evolution, or adaptation, and Kimble's (1961) edition of *Hilgard and Marquis' Conditioning and Learning* gives Darwin only a paragraph and a footnote. By mid-century, the disassociation between the study of the psychology of animals derived from Thorndike's work and Darwinian biology was essentially complete. Large and very visible parts of comparative psychology had become abiological.

The pernicious effects of the disassociation of mainstream study of comparative psychology from mainstream evolutionary theory would not become apparent until the 1970s. However, the breach between animal psychology and biology played an important role in the eventual crisis of confidence in animal psychology (Beach, 1950; Lockard, 1971; Hirsch, 1987). Lack of an evolutionary perspective permitted various biological subdisciplines (e.g., behavioral ecology, sociobiology, Darwinian psychology) to become dominant in areas that were once the sole province of comparative psychologists.

### Conclusion

As a consequence of Thorndike's influence, those trained in comparative psychology are still among the most experimentally sophisticated of animal behaviorists. As a second, though less desirable consequence of that same influence, many comparative psychologists have concentrated inordinately on problems of steadily diminishing interest to the larger community of animal behaviorists. The challenge is to preserve the first of Thorndike's legacies while breaking with the second.

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