LEARNING SET FORMATION AND CONCEPTUALIZATION

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Synonyms

Learning to learn, concurrent discrimination learning, deuterolearning, transfer of training, interproblem learning, object quality learning set, reversal learning

Definitions

Learning set formation (LSF) according to Harlow (1949) who originated the term is defined is as "...learning how to learn efficiently in the situations the animal frequently encounters" (p. 51). Optimal evidence for LSF is seen when animals learn successive discrimination problems progressively more quickly, often, in one trial. *Conceptualization*, as defined here, refers to a subject's ability to select correctly exemplars of a class concept using trial-unique discriminanda or responding correctly to their *first* presentations if discriminanda are presented for more than one trial; otherwise, the possibility cannot be discounted that a subject's performance was based on rote-memorization.

Theoretical Background

One of Harlow's most widely used experimental procedures, object quality learning set, involves multiple problems where two objects (one associated with a food reward) are presented for some number of trials (**n**) with six being, perhaps, most common; then, two new objects are presented for **n** trials, etc. Because the animal has no basis to know which to choose on trial 1, its choice is due to chance. If the animal "wins" on trial 1 (chooses the object with the food reward) the optimal strategy is to "stay" with that object for the remaining trials with those objects; if it "loses" on trial 1, it should "shift" to the other object for the remaining trials to maximize its food rewards. Optimal results will reflect increasing success on trial 2 as a function of the number of problems, and such successful performances have been described as learning a "win-stay, lose shift" rule or strategy. However, as discussed below, an animal might show LSF without having learned such a "rule."

Early findings comparing species on their rates of LSF seemed to confirm general impressions shared by many about the comparative intelligence of species. For example, chimpanzees attained 90-100% correct on trial 2 in about 200 problems, while rats achieved only about 55% correct on trial 2 in 1,000 problems. However, the discriminanda typically used were intended to be identified visually, namely, objects that varied in color, form, and size. This was an advantage for chimpanzees, which have human-like trichromatic color vision, compared to rats which are color blind and otherwise have poor vision. When odoriferous discriminanda were used with rats, their performances were comparable to those of chimpanzees (Bailey & Thomas, 1998).

Harlow (1959) also wrote, "...all concepts such as triangularity, middle-sizedness, redness, number, and smoothness evolve only from LS formation" (p. 510), and immediately preceding this quotation, Harlow wrote, "...insightful learning through LS formation is a generalized principle...[that]...appears in ... oddity learning..." (p. 510). If by "evolve only through LS formation" Harlow meant that multiple problems and trials with discriminanda that are exemplars of concepts may be needed to enable an animal to affirm trial-unique exemplars of the concept on a reliable basis, that part of the quotation seems reasonable. However, whether "insightful learning through LS formation" is a generalized principle in...oddity learning," raises significant questions.

Important Scientific Research and Open Questions

Thomas and colleagues (e.g., Bailey & Thomas, 1998) investigated oddity concept learning by rats using odoriferous discriminanda which were repeated for five trials (position of the odd object was randomized). A typical oddity problem involves two clearly similar or identical discriminanda and one clearly different or odd discriminandum. In two separate investigations, they found a clear distinction between learning the oddity concept versus learning to choose the odd object via LSF. If one has acquired use of the oddity concept, first trial performances using oddity problems should be better than chance, because the odd object will be obvious on the first trial. In the most extensive study, all four rats performed at chance on trial 1, but all showed increasing success on trial 2 (the four rats averaged 76% correct on trial 2 over 60 problems). Other nonhuman species such as monkeys and apes easily acquire the oddity concept. In any case, the research shows that conceptualization and LSF can be differentiated using oddity problems, which leaves open the question of how LSF relates to conceptualization.

One question, especially relevant to relative class concepts such as "oddity," is that is reasonable to suggest that if an animal is presented discriminanda concurrently where some are identical and one is different (i.e., odd), the odd discriminandum should be immediately perceptible (this general argument is applicable also to "same" vs. "different," "more" vs. "fewer," "larger vs. "smaller," etc.). What the animal is required to learn is that the odd object in any new exemplar is the object associated with reinforcement. That rats did not learn that reinforcement was associated with odd but did learn to use trial 1 information to perform well on trials 2-n, further confirms the argument that LSF without conceptualization has occurred.

To consider further the relationship between LSF and conceptualization, a conceptual framework is needed. Building from work by Gagné (1970) and Borne (1970), Thomas proposed an eight-level hierarchy of intellectual or cognitive abilities suitable for all species that included *all of the fundamental types of learning abilities.* Any learning task or product, no included *all of the fundamental types of learning abilities.* Any learning task or product, no matter how complex, can be reduced to these fundamental learning or cognitive abilities; see Bailey, McDaniel, and Thomas (2007) for references, examples, and additional explanations of each of the levels. The fundamental learning abilities (see schema below) ranged from the lowest level (Level 1) habituation and sensitization, complementary processes which appear to be within the capabilities of single-celled organisms, to the two highest levels which involve using class concepts in conjunctive, disjunctive, conditional (level 7), or biconditional (level 8) relationships. Nonhuman primates have been shown to have some degree of capability at level 7, but only humans have been shown to be capable at level 8. Generally (with possibly minor exceptions), that the abilities are hierarchical is due to lower levels being prerequisites for higher levels. Any animal's (including human's) general intellectual or cognitive capability depends on how many types of learning abilities from the hierarchy are within its capabilities. It is recognized that most intellectual/cognitive tasks may involve an animal using several of its abilities concurrently, in series and in parallel.

A Hierarchy of the Fundamental Types of Learning Upon Which Intelligence and Most Cognitive Abilities Are Based
8. Using Class Concepts in Biconditional Relationships as Defined by Symbolic Logic
7. Using Class Concepts in Conjunctive, Disjunctive, or Conditional Relationships as Defined by Symbolic Logic
6. Using Absolute and Relative Class Concepts
5. Multiple Discrimination Learning: Concurrent Discrimination Learning or Learning Set Formation
4. Chaining Units of Stimulus-Response Learning
3. Stimulus-Response Learning (i.e., Instrumental or Operant Conditioning)
2. Signal Learning (i.e., Pavlovian or Classical Conditioning)
1. Habituation and Sensitization

Thomas and colleagues have also considered the question of where LSF fits within the hierarchy (Bailey *et al.*, 2007). The schema shows that concept learning begins with class concept learning at level 6, and that LSF is deemed to be at level 5. Class concept learning is discriminanda that serve as exemplars of absolute class concepts are inherent in each discriminandum, such as, an exemplar of “flower,” “chair,” “triangularity,” etc., but identifying features of discriminanda associated with relative class concepts require comparing discriminanda such as those used to manifest “oddity”, “same” (a pair of clearly similar or identical objects) versus “different” (a pair of clearly different objects) “more” versus “fewer,” etc. Evidence for conceptualization requires successful responses to exemplars of class concepts using *trial-unique* discriminanda or successful *first-trial* performances when discriminanda are presented more than once. LSF cannot involve conceptualization as defined here because first-trial successes can occur only by chance. Placing LSF formation at a prerequisite level for concept learning as was done here also appears to be consistent with Harlow’s earlier assertion that “all concepts…evolve only from LS formation.” In this regard it may be noted that Concurrent Discrimination Learning, which involves learning multiple discrimination problems concurrently and presented in random order, is also at level 5 and that some students of LSF have considered Concurrent Discrimination Learning to be a type of LSF.

One interpretation for successful LSF might be that the subject relatively passively acquires an efficient strategy for rote-learning and working memory that can be applied to each new pair of discriminanda. It is reasonable to conceptualize successful performances on trials 2-n in terms of concurrent rote learning of two simple associations. For example, by chance an animal might choose object A and receive food reinforcement and then simply associate A with reinforcement on trials 2-n, or, alternatively and following an initial nonreinforced choice of B, it might simply associate A with reinforcement on trials 2-n. The animal need never use mediational "rules" such as "avoid B" and "choose A" nor one such as "win-stay, lose-shift."

Nevertheless, some may consider it to be an open question whether to agree with Thomas and colleagues, and many who study concept learning in animals, regarding (a) what “conceptualization” means or (b) that the necessary evidence for conceptualization requires that the subject respond correctly to trial-unique or first trials with new exemplars of the concept. For example, one might argue that learning a strategy or "rule" such as that which humans might verbalize as "win-stay, lose shift" involves a kind of conceptualization. However, it must also be recognized that with animals it is unlikely that they learn anything akin to such verbalizations of a rule or strategy, not to overlook that it is unlikely that an experimenter could provide unequivocal evidence that they did. It might only involve a kind of passive learning, as described above, where, through extensive experience, they acquire a habit or response pattern that serves them well in acquiring rote-learning strategies to use when performing tasks such as object quality learning set.

Cross-References

→ Abstract concept learning in animals

→ Analogical reasoning in animals

→ Animal learning and intelligence
→ Associative learning
→ Behavioral capacity limits
→ Complex learning
→ Complex problem solving
→ Concept learning
→ Conditional reasoning
→ Conditions of learning
→ Conditions of learning – Robert M. Gagné
→ Deuterolearning
→ Discrimination learning model
→ Evolution of learning
→ Human learning
→ Laboratory learning
→ Learning about learning
→ Logical reasoning and learning
→ Problem solving
→ Rote memorization
→ Rule formation

→ Working memory

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