Notes and Comment

Are learning sets learned? A reply

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Harlow's (1949) article, clearly describing for the first time the concept of learning set formation, is one of the most widely cited articles in the animal behavior literature. Since its publication, there have been several hundred experiments concerned directly with analyzing the phenomenon itself (Bessemmer & Stollnitz, 1971; Medin, 1977; Miles, 1965) and many more in which the learning set task has been used as a tool for investigating other questions. Hence, Menzel and Juno's (1982) recent report has to be regarded as unusually significant, since it appears to demonstrate that learning set formation has been misunderstood all this time because it is essentially an artifact of standardized laboratory tests that have little applicability to everyday life. A report so critical of the basic assumptions underlying so large a research literature is well worth examining in detail. In doing so, we find many reasons to question the main conclusion of the report. We also find it necessary to point out a number of incorrect or misleading statements about learning set formation and so-called "learning-set theory."

Description of the Menzel and Juno Study

Menzel and Juno tested a social group of eight marmoset monkeys (*Saguinus fuscicollis*), using a successive (go/no-go) object discrimination procedure. Their test apparatus was a wire-mesh cage with a swinging door that was left in the animals' living cage for the duration of the experiment. During training, food (jam, honey, or some other treat) was placed in or on some household objects but not others, and the objects were placed in the apparatus. There was one 7.5-min trial each day, each trial involving a single object. During a trial, the experimenter recorded, at 15-sec intervals, which individuals were on the test apparatus just before the swinging door was opened (by means of a string), the exact order in which the animals entered the apparatus and found

food, and which animals were on or in the apparatus at each successive 15-sec interval. Menzel and Juno reported that if the animals found food on a particular object on Trial 1, on Trial 2 the next day they returned more readily to it than they did to an object that had not yielded food. They concluded that, under these conditions, the marmosets exhibited untrained one-trial visual discrimination learning, and they attributed their findings to their use of such conditions as testing in the home cage and testing in a social group—or, in general, to their choice of conditions based on considerations of the animal's natural foraging behavior.

On Learning Sets, Associative Learning, and Foraging

Our difficulties with Menzel and Juno's report begin with their interpretation of learning set formation. Learning set formation, as we understand it, refers to the fact that animals learn discrimination problems progressively more quickly, often, in the end, in one trial, when they are trained on a series of such problems. One confusing aspect of Menzel and Juno's report is their failure to distinguish between the use of the term "learning-set formation" in a strictly empirical sense, as just defined, and its use in a theoretical sense to imply some sort of process that accounts for the improving performance. The term is most widely used in the former sense, and should be because there is still disagreement about the exact nature of the process. That is the way we will use the term here.

Menzel and Juno make it appear that, according to "learning set theory," one-trial learning occurs only after training on a long series of discrimination problems. According to them, "the ability for one-trial learning" is held to emerge "as a result of [such] training, through a special process called 'learning to learn' or learning set formation" (p. 750). They state even more strongly elsewhere that the "view of learning set theory . . . [is] . . . that one-trial learning . . . requires much training" (p. 752, Reference Note 4).

The basis of learning set formation has been the subject of a good deal of speculation since Harlow (1959) first attempted to account for it in a systematic manner, although Harlow's is the only theoretical treatment that Menzel and Juno refer to when they deal with "learning set theory" or otherwise indicate what current thinking about learning sets is.¹ In any event, we know of no "learning set theory," neither Harlow's nor anyone else's, from which it automatically follows that the learning set procedure is

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a necessary condition for one-trial learning. What the learning set finding does suggest is that in many cases what appears to be quick learning, reflecting a high level of intelligence, insight, or abstraction, may in fact be the end result of a gradual learning process, that is, of learning set formation.

Menzel and Juno also state that, since they are reporting one-trial visual discrimination learning in their group of marmosets despite the fact that the animals were given no prior special training, learning set formation "is not necessarily the acquisition of a new ability and might simply be the regaining of previous levels of efficiency after the overcoming of situationally induced negative transfer" (p. 750). This is hardly a new thought in this context, since the possibility that Menzel and Juno raise was first mentioned by Harlow (1951, p. 208) and eventually came to play a prominent role in his elaboration of his error factor theory of learning set formation (Harlow, 1959). It should also be remembered that for some kinds of learning set tasks—such as discrimination reversal, object alternation, and various types of conditional discriminations—overcoming situationally induced negative transfer is an inherent aspect of the task. On the other hand, there is also firm evidence that learning set formation cannot be thought of as simply involving the overcoming of negative transfer or, as it has been put in the past, of the development of "transfer suppression" (Bessemmer & Stollnitz, 1971; Schrier, 1969; Stollnitz & Schrier, 1968).²

Perhaps the most important question is whether Menzel and Juno's study has anything to do with learning sets at all? We think not. The great weight of over 30 years of evidence strongly favors the view that learning set formation involves the development or selection of an abstract rule or hypothesis most often referred to as "win-stay, lose-shift" (with respect to objects if the task is object discrimination) (Bessemmer & Stollnitz, 1971; Levine, 1965; Schrier, 1971; Schrier & Thompson, 1980). In contrast, what Menzel and Juno's animals have shown is fast associative learning to approach specific objects and to avoid other objects, a strong go/no-go tendency to specific objects. This is something that is only superficially like the win-stay, lose-shift hypothesis behavior seen at the end of learning set training. Even if Menzel and Juno prefer a theoretical view that does not restrict win-stay, lose-shift to rule-governed behavior, they further confuse the issue by defining "win-stay" and "lose-shift" so that these terms will apply to their go/no-go discriminations. This contrasts with the virtually universal use of the terms to apply to simultaneous discriminations, which are the type usually used in learning set experiments. Thus, "lose-shift" usually means a shift to a specific alternative. To what alternative are Menzel and Juno's animals shifting? With a go/no-go procedure, there is nothing to shift to, no opportunity to exhibit lose-

shift (or any other kind of specific shift behavior, such as win-shift).

Although the associative learning shown by Menzel and Juno's animals is not the same as that seen at the end of learning set training, Menzel and Juno might respond by asking, "What more do you need? What difference does how you get immediate display of 'optimal foraging behavior' make?" Here again, Menzel and Juno's terminology confuses the issue. The traditional way of referring to the behavior being studied by Menzel and Juno is "complex discrimination learning" or more generally "problem solving." Menzel and Juno choose to refer to it as "foraging behavior," presumably to call attention to another approach to studying such behavior, one which involves greater attention to the real world. However, it also has the effect of restricting the scope of the problem much more than is intended by most investigators studying problem solving. Furthermore, Menzel and Juno suggest that there is something unnatural and irrelevant about the slow rate of improvement found in the laboratory studies of learning set formation. We have a number of points to make about these issues.

To begin with, even if we restrict the problem to one of foraging, it is not at all clear that it is unnatural or maladaptive for animals to have to develop an optimal strategy gradually. Clearly, animals do not have unlimited time to find food if they are to survive. However, monkeys have a relatively long period of development under the care of adults. Presumably, they have time during this period to learn various optimal behavior strategies gradually. We note that Menzel and Juno's youngest animals were never the first to find food in their test situation. By limiting the scope of the problem to foraging, Menzel and Juno disregard discrimination learning and problem solving, major categories of behavior, to which learning set research, but not necessarily Menzel and Juno's version of foraging, is clearly relevant. It seems very unlikely that, by choosing the right set of conditions, the optimal strategy for all the kinds of problem solving situations animals face in the real world will appear immediately.

Methodological Considerations

Another basic question is whether Menzel and Juno have, in fact, shown that their results are a consequence of the factors they choose to emphasize, such as group testing and testing in the more familiar surroundings of the animals' living cage. Although these conditions were chosen on the basis of their greater "attentiveness to prior behavioral organization" (p. 752), Menzel and Juno have altered so many standard learning parameter values that it is not possible to say whether their results are a consequence of these changes or of the conditions they emphasized. How would one of their marmosets or an

individual of any other monkey species, Old World or New, do in a "standard test apparatus," such as the WGTA, if given a go/no-go discrimination instead of the usual simultaneous discrimination, one trial (or a very few) per day instead of the usual 50 to 100, a very long interval between trials instead of the usual 5 to 15 sec, a 7.5-min exposure to each object on each trial instead of the usual few seconds, repeated changes in the quality of the food reward instead of the usual constant small piece of food?³ Menzel and Juno hint, in their closing paragraph and in their Reference Note 7, that some of these factors may not matter, but we would have to see solid data before making any decisions, especially because, as we note below, we have doubts about the data already presented.

Another novel aspect of the study by Menzel and Juno was their use of "group proximity" as the dependent variable instead of the usual frequency of correct responses by an individual animal. It is one thing to test the animals in a group setting; it is quite another to use group performance as the major measure of learning. Learning by a group is certainly an interesting and important problem—it is clearly adaptive for the group to be as smart as the smartest animals—but it is hardly the only one, and it is not necessarily the most important one when the basic question is discrimination learning and problem solving. Also, if the group is as good as the best animals, it would seem important to know not only which animals were doing the discovering and leading, but, in general, when they were doing so and how their specific individual performances might have changed throughout testing. Perhaps a more complete analysis of the data of individuals than was reported would suggest more gradual development of one-trial learning than appears to be the case.

In addition, Menzel and Juno's method of presenting the data does not make it clear whether there is any improvement with practice over the series of objects, a seemingly important question if they are going to claim unlearned learning set behavior. Menzel and Juno present only averaged data for all objects (except those noted by Menzel and Juno) presented in the main experimental phases of their study. Thus, it is possible that there was a significant change in performance, at least in that of the two oldest offspring, one or the other of which "nearly always" entered the test apparatus first. Perhaps behavior toward food versus nonfood objects is significantly different from that toward such objects presented later in the experiment. Menzel and Juno do indicate that the differences between food and nonfood objects were statistically significant across specific objects, but this is not the same as testing for practice effects (differences in the differences). Menzel and Juno seem to disregard possible practice effects in their preliminary phase. What effect did this phase

have on learning in their situation? They present no data on the matter. Even with practice effects present across successively presented objects, one might still argue that the learning was pretty quick, but that is quite different from immediate one-trial learning. Also, it appears that they carried out multiple statistical comparisons of data for pairs of objects, a procedure that seriously inflates the number of significant outcomes.

As a final methodological point apart from those already mentioned, we must confess to some difficulties with Menzel and Juno's group proximity measure. By claiming one-trial learning, they seem to be saying that the measure is equivalent to or provides the same information as frequency of correct choice responses by individual animals in the standard learning set tests does. Is a decrease "from trial 1 to trial 2 in the number of animals on the apparatus before the door opened" (p. 751) equivalent to one-trial learning, that is, perfect choice of the correct object on Trial 2 in the standard situation? They note that speed of finding the food was faster on Trial 3 than on Trials 1 and 2. Should there not have been zero animals in or on the apparatus by Trial 2 if there had been one-trial learning on non-food-object trials? Should not speed of finding the food have been at asymptote by Trial 2 if nothing further was to be learned?

Comparative Perspective

In several places in their report, Menzel and Juno refer either directly (see especially their Reference Note 4) or indirectly to the use of learning sets as an index of comparative intelligence of different species, doing so in a manner that suggests that it is central to "learning set theory," or at least is the general view of comparative learning psychologists. Here, again, we believe that they give a misleading impression of the current state of thinking about learning sets in order to enhance the importance of their own message. There are still a few secondary sources that follow the literature of the early 60s in dealing with this question, but it was already clear before the end of that decade (Doty, Jones, & Doty, 1967; Rumbaugh, 1970; Schrier, 1984) that performance on the standard learning set task does not vary systematically with general intelligence level, however one wants to judge it.

Summary and Conclusions

Menzel and Juno (1982) have recently reported unlearned learning set behavior, that is, immediate development of one-trial object discrimination learning, in marmoset monkeys. They attribute the slow development of one-trial learning in prior learning set studies to use of standardized test conditions that have little applicability to "everyday life." However, after examining their evidence, we conclude that they

are incorrectly equating fast associative learning with abstract hypothesis behavior. Also, Menzel and Juno altered the values of so many standard learning parameters in their experiment that they may not be correct in attributing their findings to group testing in the animals' home cage, conditions chosen on the basis of consideration of the animals' natural foraging behavior. Furthermore, their use of group proximity to the stimulus objects as a measure of learning is questionable. Menzel and Juno's study is not, in our opinion, a convincing demonstration of the applicability of a foraging model to learning set performance.

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NOTES

1. See in particular the final statement in Menzel and Juno's Reference Note 4. In that statement, they refer the reader to their Reference Note 2, which cites a chapter by Warren (1973) in addition to the one by Harlow (1959). The reference to Warren's chapter is hardly appropriate in this case, since it is a textbook review of comparative learning that includes a section on learning set formation that has no information on learning set theory. More appropriate references, in addition to the one to Harlow, would be: Bessemer and Stollnitz (1971), Levine (1959, 1965), Medin (1977), Restle (1958), and Schrier and Thompson (1980). Some of these appear in their Reference Note 6, but in connection with another point.
2. At the end of the statement that we quote about "overcoming of situationally induced negative transfer," Menzel and Juno do have three literature references, but, as far as we can tell, none of these has any direct bearing on the issue raised insofar as it relates to learning set formation or to the relevant learning set literature that we mention.
3. Although obviously not making quite the same point, Menzel and Juno themselves say, "We do not predict how the same animals would do if tested in social isolation in an unfamiliar cubicle with more customary learning set procedures" (p. 752). An unfortunate aspect of this wording is that it suggests one major difference between Menzel and Juno's conditions and the typical ones that actually does not exist. While it is true that animals are tested in social isolation in learning set studies, they are not tested in an "unfamiliar cubicle." It is standard practice in learning studies to give new animals extensive "pretraining" in the test apparatus. Schrier (1965) has described in detail a WGTA pretraining procedure that is similar to those used in many primate laboratories. This pretraining establishes the appropriate general investigative strategies in this situation, which is why, we would remind Menzel and Juno, they are taken for granted in the subsequent laboratory experiments (see their Reference Note 6, last sentence).

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