Evaluation of the posttraining generalization test procedure for measuring amount of learning

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A common procedure for determining what S learns when he is trained to respond to a compound stimulus consists of giving a posttraining generalization test in which S encounters stimuli differing from the training stimulus along various physical dimensions. If S produces a sloped gradient along a given dimension, then it is concluded that he acquired information about the value of the test stimulus on that dimension during initial training; if S produces a flat gradient along a given dimension, then it is concluded that he did not acquire information about the value of the test stimulus on that dimension. The present experiment demonstrates that this procedure systematically underestimates the amount of information that has been acquired about the test stimulus.

There has been considerable theoretical interest in the question of what is learned by S when he is trained to respond to a compound stimulus (e.g., Trabasso & Bower, 1968). A common procedure for determining what has been learned consists of giving S a posttraining generalization test (PTGT) in which he encounters stimuli differing from the training stimulus (TS) along various physical dimensions (e.g., Croll, 1970; Spiker, Croll, & Miller, 1972). If S produces a sloped gradient along a given dimension, with the maximum of the gradient at the value of the TS, then it is concluded that he acquired information about the TS's value on that dimension during initial training. Alternatively, if S produces a flat gradient along a given dimension, then it is concluded that he did not acquire information about the TS's value on that dimension. The present paper is concerned with the adequacy of the PTGT procedure for determining what information has been acquired about the TS.

An experiment by Landau (1969) suggests that Ss may possess information about the TS's value on a dimension even though they produce flat gradients on that dimension during a PTGT. If this is true, then it must be concluded that the PTGT procedure systematically underestimates the amount of information that has been acquired. Landau told preschool children that they would see a series of stimuli, some of which were "vecs," and that they were to learn which ones were the vecs. He then reinforced them for saying "yes" when a 4 x 4 in. white square was presented on a black field and for saying "no" when a plain black field was presented. Following this reinforcement training, the Ss received a PTGT in which they

encountered various sizes of white squares on black fields and were instructed to identify each stimulus as a vec or as a nonvec. Many of the gradients were flat: the Ss tended to identify all white squares regardless of size as vecs. By the logic of the PTGT procedure, it would have to be concluded that these Ss had acquired no information about the size of the TS. However, some of the Ss with flat gradients were noted to verbalize spontaneously about the size of the stimuli during the PTGT. When a large square was presented, they might say, "There's a big vec," and when a small square was presented, they might say, "There's a little vec."

These spontaneous verbalizations suggest that the Ss may have possessed information about the size of the TS, even though they produced flat gradients during the PTGT. Unfortunately, the design of the Landau experiment does not permit this conclusion, since an alternative explanation is possible. Suppose that S did not acquire information about the size of the TS during training but that he began attending to size only when size began to vary—during the PTGT. After a few trials, S would have been exposed to the range of sizes being presented and might simply verbalize about the size of the squares relative to this range. A S might therefore accurately verbalize about size even if he possessed no information about the size of the vec TS.

The present experiment was designed to avoid this methodological problem and hence to assess more accurately the adequacy of the PTGT procedure. All Ss were given initial training similar to that in the Landau experiment. Half of the Ss, the vec group, then received a PTGT in which they identified the stimuli as vecs or

nonvecs, as had been done in the Landau experiment. On the basis of Landau's results, it was expected that these Ss would tend to produce flat gradients during the PTGT. The remaining Ss, the size group, were presented the same stimuli as was the vec group, but were asked to identify those stimuli which were the same size as the vec TS. Since initial training was identical for the two groups, they should not differ in information about the size of the TS. Thus, if the Ss in the size group can correctly identify the size of the TS, it would have to be concluded that Ss in the vec group possessed information about the size of the TS, even though they produced flat gradients during the PTGT.

METHOD

The Ss were 48 kindergarten children from the Lincoln, Nebraska, public schools. Each S was brought individually to the experimental room and seated before a low table. He was then told that he would be shown some pictures, some of which were vecs, and that he was to learn which ones were the vecs. He was further told that each time a picture was presented, he should say "yes" if he thought it was a vec or "no" if he thought it was not a vec.

The S then received a series of training trials, on half of which he was presented a white square on a black 10 x 10 in. card. On the remaining trials, he was presented a black 10 x 10 in. card with no white square on it. The order of presentation of these two stimuli was random, except that both stimuli occurred three times in each block of six trials and neither stimulus occurred on more than two successive trials. On each trial, E indicated to S that he was correct if he said "yes" to the white square or "no" to the plain black card, otherwise, E informed S that he was incorrect. This training continued until S made nine consecutive correct responses. During this reinforcement training phase, the white square was always the same size for a given S but different Ss had squares of different sizes. One-third had a 2.5 x 2.5 in. square, another third had a 4 x 4 in. square, and the remaining third had a 6.5 x 6.5 in. square.

Following reinforcement training, the Ss were assigned to either the vec group or the size group. Assignment was random, except that half of the Ss who had been trained on a given stimulus size were assigned to the vec group and the other half were assigned to the size group. The Ss in the vec group received a PTGT in which each of the three sizes of squares was presented 30 times. The order of presentation of the three test stimuli was random, except that each stimulus

Table 1
Mean Log Trials to Criterion

	Size of Training Stimulus					
	2.5		4		6.5	
	Mean	SD	Mean	SD	Mean	SD
Vec Group	1.10	0.22	0.97	0.03	1.03	0.13
Size Group	1.10	0.11	1.19	0.27	0.98	0.05

Table 2
Mean p_1 and p_2 for the Size Group

	Size of Training Stimulus					
	2.5		4		6.5	
	Mean	SD	Mean	SD	Mean	SD
p_1	.65	.43	.42	.46	.48	.48
p_2	.05	.07	.25	.23	.24	.26

occurred three times in each block of nine trials. Just prior to the PTGT, these Ss were told that they would be shown more pictures, that they were to continue saying "yes" and "no," and that since they now knew what a vec was, E would no longer tell them when they were correct or incorrect. The Ss in the size group were presented the same stimuli as were the Ss in the vec group but were explicitly instructed to classify the stimuli on the basis of whether they were the same size as the TS. They were told that they would see more pictures, that they should indicate which ones were the same size as vec, and that E would no longer tell them when they were correct or incorrect.

RESULTS Training Phase

A preliminary analysis was conducted on the data from the training phase. Since the trials to criterion scores were positively skewed, they were subjected to a logarithmic transformation (Winer, 1962, p. 221). These log scores, which are given in Table 1, were then entered into an analysis of variance in which the factors were: (1) size of the TS (2.5, 4, 6.5 in.), and (2) type of test to be received (vec instructions or size instructions). Neither the effect of test stimulus, $F(2,42) = 1.65$, nor the effect of test type, $F(1,42) = 1.56$, was significant. The interaction of these two variables was also not significant, $F(2,42) = 3.29$. (The significance level in this analysis and in all subsequent analyses was .01.) An analogous analysis of variance conducted upon the untransformed trials to criterion scores also yielded no significant effects.

Test Phase

No S in the vec group produced a

sloped gradient: 22 of the Ss identified all stimuli as vecs and two Ss identified all stimuli as nonvecs. Of these latter two Ss, one was trained with the 4-in. TS, while the other was trained with the 6.5-in. TS.

In order to determine whether the Ss in the size group did in fact possess information about the size of the TS, two probabilities were calculated for each S: p_1 = the probability of identifying a stimulus as being the same size as the TS, given that it in fact was the same size as the TS, p_2 = the probability of identifying a stimulus as being the same size as the TS, given that it was not the same size as the TS. If the Ss did possess information about the size of the TS, then the mean value of p_1 should exceed the mean value of p_2 . The mean p_1 was .518, and the mean p_2 was .182. A *t* test for related observations indicated that the difference between these means is significant, $t(23) = 4.22$. The means and standard deviations of the p_1 and p_2 values are given in Table 2 for each of the subgroups trained on different-sized stimuli.

DISCUSSION

No S in the vec group produced a slope gradient during the PTGT, which, by the logic of the PTGT procedure, entails that no S in this group learned anything about the size of the TS during training. In contradiction to this, p_1 was significantly greater than p_2 for Ss in the size group. Since at least some Ss in the size group clearly possessed information about the size of the TS, it must be concluded that some Ss in the vec group also possessed this information and that, therefore, the PTGT procedure underestimates the

amount of information that has been acquired.

This demonstrated inadequacy of the PTGT procedure appears related to the distinction between attention and utilization of information (Trabasso & Bower, 1968). That is, Ss may attend to certain properties of the TS yet not utilize this information in a given transfer task. Thus, in order to measure accurately the amount of information that has been acquired, it is first necessary to ensure that S utilizes all of the information he possesses. With articulate humans, this is easily accomplished through instructions. With very young children and infrahumans, this is, however, not possible; at present, there appears to be no satisfactory method of measuring the amount of information acquired by such Ss. Measures obtained for these Ss by the PTGT procedure must be considered conservative, since the Ss may well have learned more than the PTGT indicates.

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