An empirical index for ease of reversal learning¹

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Reversal learning was examined in three groups of kindergarten children receiving discrimination training to 50, 75, and 100% criterion levels. Half of each group was reversed with the former negative stimulus becoming positive; the other half received a novel positive stimulus. This manipulation produced no reliable effect. Reversal learning was related directly to degree of acquisition training as predicted by a ratio of number of rewarded trials to total number of trials (r_e).

A number of discrimination studies have shown that if the positive and negative cues are reversed while the S is responding to the stimulus no more than 50% of the time (chance), a greater number of trials are required to reach criterion (Spence, 1945; Blum & Blum, 1949; Kimble, 1961). A logical extension of this would be that further training would increase the amount of negative transfer involved. However, this is contradicted by a number of studies in which speed of reversal learning is positively correlated to degree of original discrimination learning (Capaldi & Stevenson, 1957; Reid, 1953; Birch, Ison, & Sperling, 1960). Explanation of this over-learning reversal effect (ORE) has varied from identification of the essential component as (a) development of avoidance tendencies to the S^D (D'Amato & Jagoda, 1961) to (b) over-training on the S^D , which leads S to faster extinction of response to that stimulus during reversal training (Birch et al, 1960). Mackintosh (1965) proposed two responses, viz., an attention response to the relevant dimension as well as response to the S^D , with the former lagging behind the latter and thus only reaching asymptote with over-training.

Examination of the discrimination-reversal literature indicates that most results could be described by a reversal index, such that ease of reversal is positively correlated to the value of the following fraction: the number of reinforcements of response to the positive stimulus divided by the total number of trials (reinforcements), (r_e). The closer the fraction is to

total trials
1.00, the easier the reversal learning. When there have been no previous reinforcements, r_e is equal to 0; during pre-solution when S is being rewarded no more than 50% of the time (by definition), the value of r_e is .5; during criterion training as the S learns the discrimination, r_e will increase in value approaching 1.00 with extended over-learning. Since it is predicted that as the index approaches 1.00 reversal learning should become easier, reversal learning after pre-solution period should be the most difficult, reversal after criterion learning should be next in difficulty, and reversal after over-learning should be the least difficult.

The present experiment was proposed as a test of r_e . Children were trained on a color discrimination task to three acquisition levels: 50% (still chance responding), 75% (above chance, but not perfect discrimination), and 100% (perfect discrimination over 10 consecutive trials). Predictions for reversal were as stated above. As a test of some of the explanations for ORE, half of the Ss in each group were reversed with the former S^A becoming S^D , the other half received a novel S^D . A second reversal test was conducted three weeks after the first acquisition and reversal trial. This was considered a test of the Mackintosh (1965) position on differential acquisition and extinction of the response to S^D and the attention response for the three different groups.

Method

Ss were 30 kindergarten students 5-6 years of age; each was tested individually. They were divided, on the basis of a table of random numbers, into six groups of five Ss each: same stimulus set on reversal with a 50%, 75% or 100% learning criterion, and a different stimulus set on reversal with a 50%, 75% or 100% learning criterion.

The apparatus was a large, painted cardboard box with an inserted dowel ("stick") which could be moved up or down. Stimulus cards, each with two squares, one positioned over the other, were inserted in the upper portion of the box. Each card had a black and a yellow square (acquisition-all, reversal-same) or a black and a green square (reversal-different).

Ss were told: "If you move the stick the right way, you will receive an M & M." Testing began with no cards present and Ss were rewarded for moving the stick "up." After this position habit had been established by five consecutive "up" responses, the cards were inserted and S was instructed to look at the card and to move the stick. In the acquisition stage, all Ss were rewarded with one M & M for each response in the direction of the black square (50% of the time the S^D was up and 50%, down, as determined by a Gellerman series, 1933). Training was terminated for the 50% group after 12 trials while Ss were still responding at chance level; for the 75% group when any nine of 12 consecutive trials were correct; and for the 100% group after 10 consecutive correct responses. Forty-five min. after the termination of acquisition training the first reversal test occurred. Instructions were, "Look at the card and move the stick; if you're right, you get an M & M." Second reversal occurred three weeks later. For both reversal tests, the criterion for successful reversal was eight out of 10 correct responses.

Results

The mean acquisition trials were 12.0 (50% group), 28.8 (75% group), and 31.2 (100% group). The mean

Table 1. Mean Responses to Criterion on Reversal Trials

Acquisition level	50%		75%		100%	
Reversals	I	II	I	II	I	II
Same stimulus set	41.4	31.2	29.6	32.8	27.2	10.8
Different stimulus set	40.8	39.6	37.4	31.4	14.8	15.4

number of trials during reversals as a function of acquisition level and stimulus manipulation is presented in Table 1.

An analysis of variance of these data yielded a significant difference among the 50%, 75% and 100% groups ($F=4.53$, $df=2/24$, $p<.025$), with the respective means being 38.2, 32.8 and 17.1. No difference was demonstrated between groups relating to stimulus change on reversal or any interaction ($F_s<1.62$).

Discussion

The results of this study indicate that the r_e index adequately predicted ease of reversal, and that it in turn depended only upon the relationship of rewarded trials to total trials during acquisition. Neither changing the color of the stimulus on reversal nor using a second, later reversal trial significantly affected reversal learning.

The Spence (1936) description of discrimination learning as related to the algebraic summation of gradients of approach and avoidance tendencies does not appear to be congruent with the present data. As no difference was found in number of reversal trials when the color of the S^D was changed for half of the Ss nor on the second reversal when all Ss responded to the original set of cards, the importance of habit strength accrued to the S^Δ must be considered minimal. This also weakens the explanation of ORE posited by D'Amato & Jagoda (1961) in terms of the aversive characteristics of S^Δ .

The experiment of Birch et al (1960) used rats and the method of successive presentation. However, their interpretation, viz., that the ORE effect is dependent, primarily, upon faster extinction of responding to the previous S^D as a function of acquisition training, agrees with our findings. The proposed r_e index "extends"

their interpretation to a broader span of acquisition training as well as to more diverse stimulus conditions as shown in the present experiment.

Although Mackintosh (1965) deals more directly with reversal learning after extinction training, we might assume that at the end of the first reversal, when all Ss are responding at the 80% level, the "attention habit" is weaker than the " S^D habit" but that each is comparable across groups. In this case, one would predict similar speed of second reversal. This is not supported by our data, as Table 1 indicates there was no Group by Reversal interaction ($F=0.25$, $df=2/24$). In any case, the r_e index appears to have three advantages: (a) simplicity, (b) testability, and (c) generality across a large body of experimental findings.

References

- Birch, D., Ison, J. R., & Sperling, S. E. Reversal learning under single stimulus presentation. *J. exp. Psychol.*, 1960, 60, 36-40.
- Blum, R. A., & Blum, J. S. Factual issues in the "continuity controversy." *Psychol. Rev.*, 1949, 56, 33-50.
- Capaldi, E. J., & Stevenson, H. W. Response reversal following different amount of training. *J. comp. physiol. Psychol.*, 1957, 50, 195-198.
- D'Amato, M. R., & Jagoda, H. Analysis of the role of overlearning in discrimination reversal. *J. exp. Psychol.*, 1961, 61, 45-50.
- Gellerman, L. Chance orders of alternating stimuli in visual discrimination experiments. *J. genet. Psychol.*, 1933, 42, 207-208.
- Kimble, G. *Hilgard and Marquis' conditioning and learning*. New York: Appleton-Century-Crofts, Inc., 1961.
- Mackintosh, N. Selective attention in animal discrimination learning. *Psychol. Bull.*, 1965, 64, 124-150.
- Reid, L. The development of noncontinuity behavior through continuity learning. *J. exp. Psychol.*, 1953, 46, 107-113.
- Spence, K. The nature of discrimination learning in animals. *Psychol. Rev.*, 1936, 43, 427-449.
- Spence, K. An experimental test of the continuity and non-continuity theories of discrimination learning. *J. exp. Psychol.*, 1945, 35, 253-256.
- Turnage, T. Can one principle explain all reversal learning? Unpublished manuscript. 1962.

Note

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