The effects of cue salience and overtraining on extradimensional shift learning*

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Rats were first trained to criterion with either more disparate (MD) or less disparate (LD) brightness cues relevant and orientation cues irrelevant; half were then shifted to the orientation discrimination and half were overtrained prior to the shift. For nonovertrained Ss, there was a trend toward more rapid EDS learning when previous training was with the MD brightness cues. Overtraining significantly facilitated shift learning when initial training was with the LD brightness cues but slightly retarded shift learning when initial training was with the MD brightness cues, producing a significant interaction. Cue salience was concluded to be a major determiner of relative speed of EDS learning.

The present study investigated the effects of the level of initial training and of the relative salience of the cues of two dimensions upon learning rates in an extradimensional shift (EDS) task. In previous investigations, overtraining has sometimes retarded (e.g., Mackintosh, 1962) and sometimes facilitated EDS learning (e.g., Sutherland & Andelman, 1969), but more frequently has had no effect (e.g., Tighe, Brown, & Youngs, 1965). Although some of the inconsistency in previous results can be attributed to variations in design, even when similar designs are considered, some inconsistency remains. For example, with the design employed in the present study, i.e., the dimension relevant in each stage is a variable irrelevant dimension in the other, Siegel (1967), Uhl (1964), and Brookshire, Warren, & Ball (1961) found that overtraining did not affect the speed of EDS learning with rats. Brookshire et al (1961) in a replication with chicks and Schade & Bitterman (1965) with pigeons found that overtraining significantly retarded EDS learning but in each case in only one of the two shift conditions employed in the counterbalanced designs. Employing only one task order, Mackintosh (1963) also found that overtraining retarded EDS learning. These facts are consistent with the hypothesis that differential cue salience is responsible for the residual inconsistency.

This hypothesis was tested by training or overtraining separate groups on easy and difficult discriminations, respectively, and then shifting all groups to the 'same' discrimination (i.e., one having the same relevant cues for all groups). This provided a comparable shift-learning baseline against

which the influence of differential cue salience in initial learning could be measured. The cues relevant in initial learning were two sets of differential brightness cues, a more disparate (MD) set and a less disparate (LD) set; these were compounded with a single set of stripe orientation cues relevant only during shift learning. A previous study (Basden, 1969) employing techniques similar to those of Kendler, Basden, & Bruckner (1970) had established that the MD brightness cues were more salient than the orientation cues which, in turn, were more salient than the LD brightness cues. The expectation was that speed of EDS learning would be a joint function of level of training and the salience of the relevant cues in the initial discrimination.

METHOD

The 16 male hooded rats of the Long-Evans strain obtained from Simonsen Laboratories, Gilroy, California, were handled individually for 10 days prior to pretraining. Ss were maintained at 80% of normal body weight during training.

The wedge-shaped discrimination chamber was 9 in. across the front, 4 in. across the back, 16 in. from front to back, and 6 in. deep, with flat black aluminum walls and hardware cloth ceiling and flooring. In the front wall were two 3-in.-square Plexiglas panels separated by a partition that obstructed view of one panel during a response to the other. A 1-sec depression of the 2½-in.-square floor treadle located against the back wall extinguished the lights mounted beneath it and turned on the IEE readout projectors positioned behind the front panels. A push of either panel extinguished the displays and one 45-mg Noyes pellet was dispensed via a Foringer feeder into the food cup located beneath the partition when the choice was correct. At the end of the 10-sec intertrial interval the lights beneath the treadle relighted. The pretraining

chamber was similar but had only one panel.

Each stimulus display consisted of a 2½-in. o.d. by 1¼-in. i.d. circular annulus, bearing ½-in.-wide vertical or horizontal black and white stripes. The annulus framed a uniformly illuminated circle (1¼-in. diam). The GE 1414 bulbs projecting the annuli were operated at 9 V dc, and the bulbs projecting the center circles were operated at 7 and 11 V dc for the LD brightness cues, or at 4.6 and 16 V dc for the MD brightness cues. The four possible display pairs (BH-DV, DV-BH, DH-BV, BV-DH) appeared in random order across trials, subject to the restriction that no more than three successive rewards be given for a response to any irrelevant cue, including position. The single pretraining stimulus display was a 2½-in.-diam uniformly illuminated circle. Control and response recording apparatus were fully automated.

After the Ss had been pretrained to perform the necessary response sequence (requiring an average of 7 days), four were assigned randomly to each of the four cells of the design. During initial learning, two of the Ss in each group were trained with bright as S+ and two with dim as S+; the orientation cues were irrelevant. During the shift, vertical was S+ for all Ss, and the brightness cues relevant in the first stage were present but irrelevant. Thus, the displays were identical in the two stages, with only the reward contingencies altered. During training proper, each S was run one block of 40 rerun correction trials on each of Days 1 and 2, and two consecutive blocks on each subsequent day unless the criterion (32 correct within a block) was met within the first block. S began overtraining or shift training on the day following criterion attainment. Overtraining continued for 3 days for a total of 240 trials. Shift training was continued until S again met criterion.

RESULTS

Table 1 contains the mean blocks to criterion for each group in each stage. The MD brightness discrimination was learned in fewer trial blocks than was the LD brightness discrimination $F(1,12) = 6.35$, $p < .01$, as would be expected from the salience relationships established earlier. Overtrained and nonovertrained Ss did not differ in learning ability, $F(1,12) < 1$.

Neither the set of brightness cues, $F(1,12) < 1$, nor the amount of initial training, $F(1,12) = 2.22$, $p > .05$, significantly affected the number of trial blocks required to achieve criterion on the shift discrimination; however, the interaction of these two variables was significant, $F(1,12) = 5.31$, $p < .05$. Comparison of the nonovertrained groups

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Table 1
Mean Trial Blocks to Criterion in
Initial and EDS Learning

Group	Initial Learning		Shift Learning	
	Non-OT	OT	Non-OT	OT
MD	5.6	4.5	8.8	9.5
LD	19.0	20.0	11.0	7.5

indicated that EDS learning was somewhat more rapid when prior training was with the MD brightness cues than when prior training was with the LD brightness cues, $t(12) = 1.74$, $.10 > p > .05$. Further comparisons indicated that overtraining on the MD brightness cues may have retarded shift learning, $t(12) = 1.54$, $p > .10$, and that overtraining on the LD brightness cues facilitated shift learning, $t(12) = 2.69$, $p < .02$.

DISCUSSION

On the whole, these results are consonant with those of the majority of earlier investigations in that overtraining had no overall effect on speed of extradimensional shift learning. However, as the selected contrasts indicate, this null effect was the net result of a significant facilitation for one group and a slight retardation for the other. This is, perhaps, the major finding of this study in that it emphasizes the importance of the difficulty of the initial discrimination as a determiner of the effect of overtraining on the speed of EDS learning.

The present design appears to lead to differential predictions from attentional models (e.g., Zeaman & House, 1963) and continuity models (e.g., Kendler et al, 1970). The first of these concerns speed of EDS learning for nonovertrained animals. Attentional models typically assume (cf. Lovejoy, 1968) that cues of greater salience are simply those which are more reliably attended from the outset of training. Since a shift from a more reliably attended dimension would be more difficult than a shift from a less reliably attended dimension, initial training with cues of greater salience should slow EDS learning more than initial training with cues of lesser salience. The trend toward faster EDS learning when the shift followed the MD brightness discrimination than when the shift followed the LD brightness discrimination is inconsistent with this prediction. On the other hand, this outcome is consistent with the single-stage

continuity model postulated by Kendler et al (1970) in which cue salience is assumed to be inversely related to the proportion of generalizable excitation and inhibition; learning is faster with salient or easy cues because a given difference in effective excitatory strength is established earlier in training when such cues are employed. However, since inhibitory processes mirror excitatory processes, a given difference in effective excitatory strength will also be overcome more rapidly when cues of greater salience are employed. This leads to the prediction that a shift will be accomplished in fewer trials when preceded by training with cues of greater salience than when preceded by training with cues of lesser salience.

The second differential prediction concerns the interactive effects of cue salience and overtraining on the speed of EDS learning. Since attentional models assume that cues of greater salience are more reliably attended, less can be gained through overtraining with such cues than through overtraining with cues of lesser salience. This argument has been used by Mackintosh (1969) to explain why the overlearning reversal effect more frequently occurs when a difficult discrimination is employed than when an easy discrimination is employed. Within the present design, this argument leads to the prediction that overtraining with cues of greater salience will interfere less with shift learning than will overtraining with cues of lesser salience. The direction of this predicted interaction of cue salience and level of training is clearly opposite to that observed here. In the Kendler et al (1970) model, the extent to which levels of excitation and inhibition approach their maxima in establishing a given difference in effective excitatory strength varies inversely with the salience of the cues employed. Hence, overtraining produces a greater increase in the strength difference and consequently is more interfering to shift learning when prior training is with easy cues than when prior training is with difficult cues. Thus, this model predicts the direction of the observed interaction.

Neither model readily predicts the facilitation of shift learning, which was observed when overtraining was with the LD brightness cues. Of course, it is always possible that through a more comprehensive analysis of the respective

models the present results can be fully encompassed. However, it may be necessary to postulate an additional 'learning-to-learn' mechanism (e.g., Mandler, 1966), which opposes the processes considered in the present analysis. Regardless of the direction models take in the future, it is apparent that cue salience must be considered in explanations of extradimensional shift learning.

REFERENCES

- BASDEN, B. H. A nonselective model of differential cue effectiveness in discrimination learning by rats. Unpublished doctoral dissertation, University of California, Santa Barbara, 1969.
- BROOKSHIRE, K. H., WARREN, J. M., & BALL, G. G. Reversal and transfer learning following overtraining in rats and chicken. *Journal of Comparative & Physiological Psychology*, 1961, 54, 98-102.
- KENDLER, T. S., BASDEN, B. H., & BRUCKNER, J. Dimensional dominance and continuity theory. *Journal of Experimental Psychology*, 1970, 83, 309-318.
- LOVEJOY, E. P. *Attention in discrimination learning*. San Francisco: Holden-Day, 1968.
- MACKINTOSH, N. J. The effects of overtraining on a reversal and a nonreversal shift. *Journal of Comparative & Physiological Psychology*, 1962, 55, 555-559.
- MACKINTOSH, N. J. Extinction of a discrimination habit as a function of overtraining. *Journal of Comparative & Physiological Psychology*, 1963, 56, 842-847.
- MACKINTOSH, N. J. Further analysis of the overlearning reversal effect. *Journal of Comparative & Physiological Psychology*, 1969, 67, Pt. 2, 1-17.
- MANDLER, J. M. Behavior changes during overtraining and their effects on reversal and transfer. *Psychonomic Monograph Supplements*, 1966, 1, No. 6, 187-202.
- SCHADE, A. F., & BITTERMAN, M. E. The relative difficulty of reversal and dimensional shifting as a function of overlearning. *Psychonomic Science*, 1965, 3, 283-284.
- SIEGEL, S. Overtraining and transfer processes. *Journal of Comparative & Physiological Psychology*, 1967, 64, 471-477.
- SUTHERLAND, N. S., & ANDELMAN, L. Effects of overtraining on extra- and intra-dimensional shifts. *Psychonomic Science*, 1969, 15, 253-254.
- TIGHE, T. J., BROWN, P. L., & YOUNGS, E. A. The effect of overtraining on the shift behavior of albino rats. *Psychonomic Science*, 1965, 2, 141-142.
- UHL, C. N. Effects of overtraining on reversal and nonreversal discrimination shifts in a free operant situation. *Perceptual Motor Skills*, 1964, 19, 927-934.
- ZEAMAN, D., & HOUSE, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), *Handbook in mental deficiency: Psychological theory and research*. New York: McGraw-Hill, 1963. Pp. 159-223.