Effects of overlearning on attention to position in concept learning

PETER W. ARNBERG and SVEN RYDBERG*
University of Stockholm, Stockholm, Sweden

Tactile observing in 48 concept learners was recorded electrically in each trial of an (over)learning-extinction-superstition sequence with changes of dimensions and position. During superstition, percent touching time on (1) the previously relevant dimension, (2) the previously relevant position, and (3) neither was studied. Position responding has been assumed to vanish as organisms develop, but here it was traced in university students. Their postexperimental hypotheses supported these duration data. Overtraining decreased attention to position. Lack of overtraining increased attention to position only if Ss were position directed in the very last trial before onset of noncontingent reinforcement.

Especially less developed organisms engaged in discrimination or concept learning seem to be crucially hindered by position habits (Zeaman & House, 1963; White, 1966; Fellows, 1968; Lovejoy, 1968; Estes, 1970). Often retardates, children, and animals suddenly stop position responding just before they begin to respond perfectly. Going on to focus attention on overlearning and reversals, we find Estes (1970, p. 178) stating that: "Increases in speed of learning with successive reversals are in some instances quite striking, even the rat being able to . . . reverse a discrimination in a single trial. However, the overlearning reversal effect has been found consistently only for *positional* discriminations . . . [our italics]."

The cited authors are only a few of those who have discussed the role of attention in such learning processes. The indicators of attention have generally been very indirect and based on inferences from the overt choice responses of the organism. Having worked with more direct attention measures for a long time, utilizing electrical recording of tactile observing responses (Rydberg, Kashdan, & Trabasso, 1966; Rydberg, 1969; Rydberg & Arnberg, 1969a, b), we have seen how intertwined problems of attention and position can be.

The cited review by Estes (1970) reawakened our interest in position-directed behavior. In order to study attention to position directly, we examined certain previously unpublished observing-behavior data collected in connection with the study by Rydberg & Arnberg (1969a) that is

especially germane to this point. In addition, we took a second look at postexperimental interview data, also from that study.

It had an acquisition-overtraining-extinction-superstition sequence (described below) with a change of positions and of some dimensions. By this paradigm we should be able to study, during superstition, for how long each S tactually explored not only (1) stimuli along a previously relevant dimension (Rydberg & Arnberg, 1969a, Fig. 2d for results), but also (2) stimuli in the previously relevant position, and (3) stimuli along the dimensions in the two remaining positions. Thus, it should be possible to study effects of overtraining and extinction on such observing behavior.

We hypothesized that with this technique, with relatively unfamiliar tactile stimuli, we would be able to find nonretarded human adults displaying tendencies toward the presumed developmentally and phylogenetically inferior position habits, possibly as a function of amount of exposure to the stimuli.

SUBJECTS

Forty-eight students (24 males and 24 females) from an introductory course in educational psychology at the University of Stockholm served as Ss.

APPARATUS

The experimental stimulus objects were contiguous to the square upper surface of blocks, 20 x 37 x 37 mm, fastened in four holes 10 mm from each other. Touch and classification responses and their durations were recorded. Rydberg et al (1966, 1969a) give more details.

STIMULI AND POSITIONS

Six types of stimuli were used, each with a clearly associated dimension: the angle (A) between two thin wires, the size of a circle (C), the depth (D) of a hole, the height (H) of a thick peg, the length (L) of the distance between two thin pegs, and the

roughness (R) of a piece of sandpaper. Each dimension could assume one of three intensity values. We call the stimulus positions a, b, c, and d.

PROCEDURE AND DESIGN

The Ss were required to try to find out which one of four tactile stimuli was relevant and to press one of three response buttons for the corresponding intensity levels within the dimension represented by that stimulus. Throughout, S was free to feel one or more of the four stimulus objects presented in each trial. Only one dimension was relevant.

Each S went through five stages: (1) Pretraining A, for familiarization and discrimination; (2) Pretraining B, for concept learning; (3) learning; (4) extinction; and (5) superstition. When S pressed a response button, a lamp at once indicated the correct response except in Stages 4 and 5. In pretraining, the positions of the stimulus dimensions varied randomly from trial to trial; thereafter they were fixed. Thus, in the three main experiments, S got to know which dimension—but not which stimulus object—he would find in each position.

The instructions and the pretraining taught S: (1) about the character of the stimuli; (2) to discriminate; (3) that only one dimension was relevant; (4) that in the relevant dimension the least intensive stimulus was the cue for the leftmost response button, No. 1, the medium one for No. 2, and the most intensive one for No. 3; and (5) to stop feeling the stimuli before responding. Further details on Stages 1-3 are given in Rydberg & Arnberg (1969a). From Stage 3 on, S was entirely unaided.

In learning, each S's relevant dimension—A, D, or C—from pretraining B, was replaced by R (irrelevant). One of the two remaining dimensions was made relevant for one-half of the Ss, the other one for the rest. This made six groups of eight Ss. The position of each dimension was fixed for each S but was varied, within each group, from S to S. This made 24 subgroups of two Ss each. The criterion for learning was 5 correct trials in a row for one S and 15 correct trials in a row for the other S in each subgroup.

In extinction, we used the same procedure, but E told S that this was a new task, where all lamps would light up in case of a correct response. The E surreptitiously cut the lamp circuits and gave S 10 trials without reinforcement. Touch dimensions were those from learning, except that R was replaced by each S's relevant dimension from Pretraining B. The other dimension positions were changed diagonally from those in learning.

*P.A. collected the data. Address reprint requests to Sven Rydberg. We thank Professor James Greeno, University of Michigan, and Dr. Henry Reed, Princeton University, for suggestions of analyses and for editorial assistance. This paper was supported by Swedish Social Science Research Council grants.

Table 1
Relative Observing Duration Data During Superstition

Group	N	Number of Trials to Criterion		Percent Touching Time on the				Percent of Ss Touching PRP More Than PRD	t for Mean Difference PRP - PRD
				PRP		PRD			
		M	SE	M	SE	M	SE		
L	24	8.1	.4	33	6.2	22	5.7	75	
FL	8	1.9	.4	36	8.0	18	4.3	88	1.9
SL	16	11.2	.1	32	3.3	24	7.3	69	.6
O	24	6.2	.4	16	2.8	33	5.1	31	
FO	12	2.1	.4	20	4.2	21	3.4	42	-1
SO	12	10.3	.1	12	3.2	45	9.8	20	-2.7*

* $p < .05$

In superstition, E surreptitiously connected all lamp circuits and gave five trials, thus signaling "correct" regardless of the S's response; no other change was made.

In a postexperiment interview after the last superstition trial, E asked S what he had based his button pressing on in the "last part" (extinction and superstition) of the experiment.

RESULTS

All the 48 Ss mastered the main concept-learning task. They required between 0 and 25 precriterion trials, with a mean of 7.1 trials. We separated the results for fast learners, with four trials or less (Group F: $N = 20$), from those for slow learners, with six or more trials (Group S: $N = 28$). The first two columns of Table 1 show how many in each group then went through overtraining (FO and SO) and how many did not, together with the mean number of trials to criterion.

After the postexperiment interview, all Ss showed surprise when E told them that in the last part (extinction and superstition) of the experiment, E's lamp signals of "wrong" and then "correct" had not depended on their responses. In the interview, E asked for the S's rule (or cues) for "solving that last problem" (4-5) and recorded whether S based his rule on the objects in the previously relevant position (PRP; 11 Ss) or on objects along the previously relevant dimension (PRD; 8 Ss). The remaining 29 Ss did not express either type of rule, but the observing behavior could be studied in all 48 Ss.

For each trial, we quantified the observing behavior by calculating the time S spent touching the previously relevant object as a percentage of the S's total time on all four objects. During extinction, the observing behavior of all four groups (FL, SL, FO, and SO) fell back to the 25% chance level, with respect to both PRD (cf. Rydberg & Arnberg, 1969a, Fig. 2d) and the PRP. That is, they divided their touching time equally among the four dimensions. In the

postexperimental interview, many Ss said that after the first trials on the "last problem" (i.e., during extinction) their hypotheses about which dimension was relevant became less clear and fewer.

For the block of Superstition Trials 2-5, the six last columns of Table 1 show touching-duration data for the different exposure groups. (Touch behavior for Superstition Trial 1 was analyzed together with that for extinction trials because it had occurred before the onset of the noncontingent reinforcement.)

The mean percent touching time spent on the PRP was decreased with overtraining [$t(O-L) = -2.47$, $df = 46$, $p < .02$]. There was no significant effect of precriterion exposure, taken alone [$t(S-F) = -.42$, $df = 46$]. There was no significant interaction between these two types of exposure ($F < 1$).

The same pattern of results held for

the percent of Ss spending more time on the PRP than on the PRD [$\chi^2(O-L) = 8.4$, $p < .01$; $\chi^2(S-F) < 1$, $df = 1$; and χ^2 over all four groups = 8.8, $df = 3$, $p < .05$; Yates's correction].

When the mean percent time on the PRP is plotted against the percent of Ss expressing a final rule based on the PRP (see Fig. 1), the four subgroups align themselves in the same rank order (FL, SL, FO, and SO), also in these two independently recorded variables.

The remaining results pertain to possible causal relations between observing behavior during extinction and during superstition.

On the basis of the percent touching time on the PRP for the block of Superstition Trials 2-5, Ss were divided into three groups of 16 Ss having low, intermediate, and high touching times, respectively. For these groups, the mean percent time on PRP was plotted for each extinction trial. We obtained flat curves oscillating around the chance level of 25%, with one exception. The high touching time group had spent 45% time on the PRP in Superstition Trial 1, the trial at the end of which they received their first noncontingent reinforcement. Thus, the following analyses focused on that trial.

Each S's change in percent touching time on the PRP from Superstition Trial 1 to the block of Superstition Trials 2-5 was then calculated. The L group had a mean increase of 2.5% and the O group a mean decrease of 4.2%. These changes were not statistically significant. The standard deviations of

Fig. 1. Relative observing durations and tendency towards postexperimentally expressed rules implying position responding.

the difference scores were 28.7% and 15.4% for L and O groups, respectively [$F(23,23) = 3.49, p < .005$].

As to touching time on the PRP in Superstition Trial 1, in the O group, 9 Ss had at least 25% time and 15 Ss had less than 25%, in the L group, there were 12 Ss of each kind. The mean touching time on the PRP in the block of Superstition Trials 2-5 was 17%, 15%, 49%, and 16%, respectively, for these four groups. Thus, high touching time on the PRP in the trial just before onset of noncontingent reinforcement was followed by "more of the same" touching behavior during superstition only in the group without overtraining [interaction $F(1,32) = 9.92, p < .01$]. The remaining subgroup means were well below the chance level.

DISCUSSION

Position habits in discrimination and concept learning have been reported to change, wane, and vanish as organisms develop (White, 1966; Fellows, 1968, p. 32). Nevertheless, a learning-extinction-superstition sequence and unfamiliar stimuli succeeded in bringing out certain tendencies toward position habits—in university students. Such tendencies might be seen as remnants of position habits typically found in lower or less developed organisms (White, 1966).

In view of the literature on the "overlearning reversal effect" (ORE) for overt choice responses (Estes, 1970), we could expect that overlearning exposure during initial learning would decrease position-based observing behavior during the subsequent superstition condition. This applies to nonpositional discrimination. It would be interesting to see whether—with observing-behavior measures—overlearning reversal effects would turn up more consistently in nonpositional discrimination.

The reduction of position-based responding with longer overlearning exposure to stimuli cannot be entirely attributed to a corresponding increase in responding to the previously relevant dimension. Part of the

reduction corresponded to an increase of responding based on each S's remaining two stimulus dimensions where neither the factor of previous learning of position nor of dimension can be invoked.

One might wonder whether reverting to the position where the initially relevant dimension had been was an effect of events during the series of extinction trials. We did find a relationship here. It involved only the very last trial before the onset of noncontingent reinforcement. The Ss who had not had overtraining and were displaying above-chance position-directed observing behavior in that trial increased that position-directed behavior under the subsequent superstition condition. Lack of overtraining, as such, was not enough for this to occur. Nor could we trace any effects from earlier extinction trials.

Although there were no significant effects of length of precriterion exposure in the present study, they all point in the same direction, and it might be premature to conclude that precriterion exposure is not at all a factor here.

Further experiments should be performed to check on the quite parsimonious hypothesis (suggested by both Fig. 1 and the last column of Table 1) that exposure during acquisition and overlearning works cumulatively to decrease position-based responding. Such experiments should also take into account the findings of Lowenkron & Driessen (1971), based on overt choice responses. Their consistent and inconsistent Ss differed in acquisition performance. It would also be interesting to use observing behavior to supplement their conclusion that "it is among the inconsistent Ss ... that the ORE is demonstrated [p. 90]."

Tempone, Capehart, & Decker (1971) have recently performed a potentially germane experiment. They recorded the absolute number of eye fixations on relevant stimulus

positions in an experiment on the overtraining reversal effect. They suggested that their failure to find this effect was due to "attention reaching an asymptote [p. 131]." Now, we have unpublished results, for ages from 8 years to adult, showing a decrease in absolute touching time on relevant stimuli over the first familiarization trials, a sharp increase at the first criterion trial, and gradual decreases over overtraining trials. Thus, Tempone et al (1971) may have found artifacts. We suggest that percent (duration of) relevant fixations might have been a promising complementary variable.

REFERENCES

- ESTES, W. K. *Learning theory and mental development*. New York: Wiley, 1970.
- FELLOWS, B. J. *The discrimination process and development*. Oxford: Pergamon, 1968.
- LOVEJOY, E. *Attention in discrimination learning*. San Francisco: Holden-Day, 1968.
- LOWENKRON, B., & DRIESSEN, E. C. Solution mode in concept-identification problems and magnitude of the overlearning reversal effect. *Journal of Experimental Psychology*, 1971, 89, 85-91.
- RYDBERG, S. Concept learning: Measured selective attending changes. *Psychonomic Science*, 1969, 16, 293-295.
- RYDBERG, S., & ARNBERG, P. W. Selective attending changes during concept learning, extinction, and superstition. *Psychonomic Science*, 1969a, 17, 98-99.
- RYDBERG, S., & ARNBERG, P. W. Overlearning, extinction, and superstition effects on observing behavior in concept learning. *Psychonomic Science*, 1969b, 17, 343-344.
- RYDBERG, S., KASHDAN, R., & TRABASSO, T. Recording of tactile observing responses for the study of selective attention. *Psychonomic Science*, 1966, 6, 197-198.
- TEMPONE, V., CAPEHART, J., & DECKER, L. Attentional processes in overlearning. *Perceptual & Motor Skills*, 1971, 32, 127-132.
- WHITE, S. H. Age differences in reaction to stimulus variation. In O. J. Harvey (Ed.), *Experience, structure & adaptability*. New York: Springer, 1966. Pp. 95-122.
- ZEAMAN, D., & HOUSE, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), *Handbook of mental deficiency*. New York: McGraw-Hill, 1963. Pp. 159-223.