

Pavlovian vs. operant factors in nonspecific transfer of training in the pigeon

ROBERT J. NEWLIN and DAVID R. THOMAS
University of Colorado, Boulder, Colorado 80309

In Experiment 1, three groups were given 20 sessions of true discrimination (TD), single-stimulus (SS), or pseudodiscrimination (PD) training with line angles and with equal-density variable-interval (VI) and variable-time (VT) reinforcement schedules, instead of the usual VI and extinction (EXT). Subsequent transfer to a wavelength VI-EXT discrimination revealed enhanced performance by TD and retarded performance by PD groups. In Experiment 2, in an autoshaping-like paradigm, six groups were given TD, SS, or PD training with line angles using fixed-interval (FI) and fixed-time (FT) reinforcement schedules during trials. Despite almost identical responding to the two stimuli, the TD groups performed best on either of two subsequent wavelength discriminations. These results suggest that neither Pavlovian contingencies nor differential responding during training is required in order to produce the TD enhancement effect.

Successive discrimination training (TD, for true discrimination) leads to more rapid acquisition of a subsequent discrimination along an orthogonal dimension (cf. Eck, Noel, & Thomas, 1969), and nondifferential training (PD, for pseudodiscrimination) may lead to less rapid acquisition of a subsequent discrimination (cf. Newlin & Thomas, 1978) than does single-stimulus (SS) training.

In a parallel set of findings, it has been reported that TD training sharpens stimulus generalization gradients on dimensions orthogonal to those in original training (cf. Honig, 1969), whereas PD training flattens gradients (cf. Bresnahan, 1970) relative to SS training.

TD and PD groups differ in operant and Pavlovian contingencies and in behavior with respect to the training stimuli. It remains to be determined which of these differences are necessary or sufficient to produce the TD enhancement effect. In the TD condition, for example, must the stimuli be relevant signals for responding (i.e., signify an operant contingency), or is their Pavlovian function of predicting the presence or absence of a UCS sufficient? There is evidence to suggest that explicit operant contingencies are not required to produce a TD-PD difference. Tomie, Davitt, and Engberg (1976) used TD, SS, and PD autoshaping procedures in training and obtained TD gradients that were sharper than PD gradients, with SS gradients intermediate between the two. This result is particularly noteworthy, considering that autoshaping procedures necessarily involve TD

training with the dark key during intertrial intervals serving as a CS—.

If one views autoshaping in this way, there exists a somewhat analogous experiment in the transfer literature. Hall and Honig (1974) gave pigeons TD and PD training in which reinforcement was based on a variable-time (VT) schedule. In TD, red and green colored house-lights signaled VT and extinction (EXT), respectively; in PD, the stimuli and the component schedules were uncorrelated. In a subsequent orthogonal transfer task, it was shown that the TD group autoshaped more rapidly.

In the present experiment, Pavlovian contingencies were held constant between stimulus components while operant contingencies differed, in an effort to determine whether such an arrangement for a TD group would result in enhanced performance in an operant discrimination transfer task, relative to the performance of a PD group that had neither differential operant nor differential Pavlovian contingencies in their training stage.

EXPERIMENT 1

Equal density variable-interval (VI) and VT schedules were used in the training phase of this experiment. For all groups, half of the stimulus presentations were reinforced on a VI 1-min schedule and half on a VT 1-min schedule. For TD subjects the two schedules were correlated with two stimuli, for PD subjects they were uncorrelated, and for SS subjects a single stimulus was continuously present regardless of the schedule that was in effect.

With the procedure used in the present experiment, a considerable range of discriminative performances is observed in Stage 1, thus permitting the within-groups analysis of similarities in Stage 1 and Stage 2 perfor-

This research was supported by a research grant from NSF (BNS 78-01407) to David R. Thomas. It was presented at the 1979 meetings of the Midwestern Psychological Association in Chicago. The authors would like to thank Thomas B. Moyer for his assistance. Requests for reprints should be addressed to David R. Thomas, Department of Psychology, University of Colorado, Boulder, Colorado 80309.

mance. It would be useful to know whether the transfer effect seen between groups also occurs among subjects within the TD group, in which operant and Pavlovian contingencies are constant and only performance is free to vary.

Method

Subjects. The subjects were 33 experimentally naive adult pigeons maintained at approximately 75% of their ad-lib weights.

Apparatus. Four identical single-key conditioning chambers described in Newlin and LoLordo (1976) were used. White vertical and horizontal lines .2 cm wide on a black background and chromatic stimuli of nominal peak wavelengths of 606 nm (red), 555 nm (yellow-green), and 538 nm (green) produced by Kodak Wratten filters 72B, 99, and 74, respectively, were used. Two No. 1820 pilot lamps centered behind the translucent Plexiglas ceiling served as houselights and were illuminated continuously during all sessions.

Procedure. Preliminary training. On Day 1 all subjects were trained to eat from the hopper with the key not illuminated. On Day 2 all birds were hand-shaped to peck the key illuminated by the horizontal line and reinforced on a gradually increasing VI schedule with which training continued on Day 3.

Stage 1. During Stages 1 and 2, pigeons received daily training sessions consisting of 32 1-min periods. The birds were assigned to three groups ($n = 11$). Group TD received 1-min periods of either a horizontal line reinforced on a VI 1-min schedule or a vertical line reinforced on a VT 1-min schedule. The two schedules were programmed by a single constant-probability 1-min film tape that ran continuously. The SS and PD subjects received the same pattern of reinforcement schedules as did the TD. For SS, the horizontal line was continuously present; for PD, the stimulus presentations were unrelated to reinforcement schedule. Training was continued for 20 sessions.

Stage 2. During Stage 2, all subjects received MULT VI 1-min/EXT training with yellow-green as S+ and red as S-. A few pigeons failed to begin responding immediately to the novel stimulus. Since responses are required to calculate a discrimination ratio and reinforcement is necessary before the contingency can be effective, each pigeon's first session was taken as the one on which at least 10 responses and one reinforcement occurred. Training was continued until each subject had received 10 sessions during which adequate responding had occurred.

Results and Discussion

Stage 1. The mean rate of responding to the horizontal line during the last session of Stage 1 was 53.3, 43.4, and 51.0 responses/min for the TD, SS, and PD groups, respectively ($F < 1$). Responding to the vertical line was 15.6 and 54.2 responses/min for the TD and PD groups [$F(1,20) = 24.14$, $p < .01$]. Mean discrimination ratios (percent of total responses to horizontal) on the last day of Stage 1 were 78 and 49 for TD and PD groups, respectively [$F(1,20) = 45.65$, $p < .01$].

Stage 2. Figure 1 presents the discrimination ratios for the 10 days of transfer training. On Day 1, planned orthogonal comparisons showed that TD differed from SS and PD [$F(1,30) = 4.84$, $p < .05$] and PD differed from SS [$F(1,30) = 6.68$, $p < .05$]. The mean S+ rates were approximately equal (37.8, 38.2, and 42.9 responses/min for TD, SS, and PD, respectively; $F < 1.0$), whereas mean S- rates differed, but not

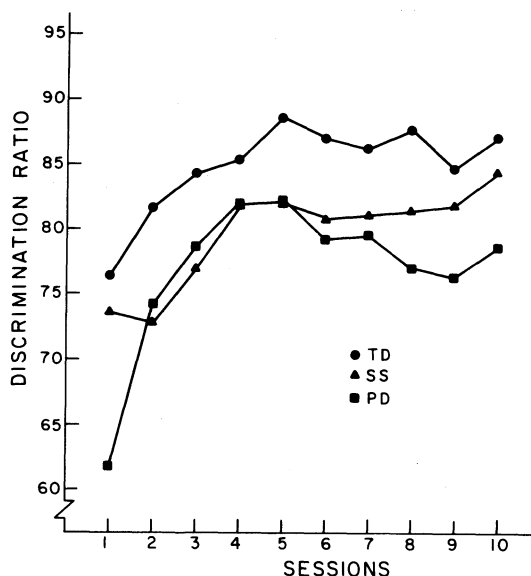


Figure 1. Discrimination ratio (mean percent of responses to S+) for the 10 sessions of Stage 2 in Experiment 1.

significantly [12.5, 18.3, and 25.7 responses/min, respectively; $F(2,30) = 2.41$, $p < .20$]. Although the differences in S- rates did not reach significance, the ordering of these rates replicates results in other studies in which TD and PD effects were mediated by differences in responding in S- (cf. Eck et al., 1969; Newlin & Thomas, 1978).

Since the curves in Figure 1 appear to achieve asymptote after 5 days, a repeated-measures analysis of variance was performed on the first 5 days. Planned comparisons showed that the TD group differed from SS and PD, which did not differ from each other [$F(1,30) = 5.31$, $p < .05$, and $F < 1.0$, respectively]. The interaction between groups and sessions was significant [$F(8,120) = 2.86$, $p < .01$], probably due to the rapid improvement for the PD group up to the level of the SS group after Day 1.

Within the TD group, there was a significant positive correlation between discrimination ratios on the last day of Stage 1 training and 1st day of Stage 2 training ($r = .567$, $p < .05$, one-tailed test), and the correlation was maintained through Day 10 ($r = .734$, $p < .01$, on Day 10). Although it is possible that this correlation reflects only individual differences, it seems likely that a correlation accounting for more than 50% of the variance (on Day 10) reflects a transfer of learned performance.

These results, along with those of Hall and Honig (1974), indicate that either a differential response contingency or a differential reinforcement contingency with respect to stimuli is sufficient to produce positive transfer by TD subjects to a subsequent discrimination. In both of these studies, however, responding to the training stimuli was differential. In fact, if the correla-

tion found between Stage 1 and Stage 2 performances of the TD subjects reflects the same process as the difference between groups, it is possible that only performance differences in training are necessary to produce a TD-PD difference in transfer. If a procedure could be found in which TD subjects had differential contingencies without behaving differently from PD subjects at the time, positive transfer to a new discrimination problem might still be found. Although differential contingencies will probably always produce differences in behavior, procedures were employed in Experiment 2 that minimize such differences.

EXPERIMENT 2

Using the procedure of autoshaping, if two stimuli are employed, and if one stimulus signals contingent reinforcement and the other noncontingent, substantial pecking will occur to both stimuli. All subjects will learn both to respond to stimuli on the key and not to respond during the intertrial interval. Thus, all subjects will have a TD contingency between trial and intertrial interval, whereas the TD, SS, and PD contingencies are defined only with respect to trials. With this overall TD contingency in effect, it is possible that all groups might perform so well in transfer as to preclude the demonstration of group differences. For this reason, the transfer task used in Experiment 2 was the same as that in Experiment 1 (yellow-green vs. red MULT VI/EXT) for half of the subjects in each group, but a more difficult discrimination (yellow-green vs. green) was used for the other half.

Method

Subjects. The subjects were 96 experimentally naive adult pigeons, maintained as in Experiment 1.

Apparatus. The apparatus was the same as in Experiment 1.

Procedure. *Preliminary training.* On the 1st day, all birds were trained to eat from the hopper.

Stage 1. Pigeons were assigned to six groups ($n = 16$): two TD, two SS, and two PD groups, which differed in Stage 2 discriminations. Daily training sessions consisted of VT 1-min intertrial intervals with the key not illuminated and 32 8-sec presentations of a line-angle stimulus. For 16 of these presentations (fixed-interval, or FI, trials), a peck during the 7th or 8th sec resulted in an immediate hopper presentation. If no peck occurred during these 2 sec, the hopper was presented at the end of the 8-sec stimulus. For the other 16 presentations (fixed-time, or FT, trials), the hopper was presented at the end of the 6th sec, noncontingent with respect to behavior. For TD subjects, the FI trials were associated with the horizontal line and the FT trials with the vertical. For PD subjects, the stimuli were not correlated with the schedule. For SS subjects, the horizontal line was presented on both FI and FT trials. Stage 1 lasted 20 sessions.

Stage 2. For one TD, one SS, and one PD group (easy discrimination groups), the Stage 2 transfer task was the MULT VI/EXT between yellow-green and red used in Experiment 1. For the other groups (hard), the S- was green rather than red. As in Experiment 1, sessions without at least one reinforcement and 10 responses were eliminated, and Stage 2 continued until all subjects had received 10 sessions during which adequate responding had occurred.

Results and Discussion

A detailed analysis of responding on the last session of Stage 1 will be presented so that the extent of differences can be assessed. Intertrial responding was negligible (mean of 2.04 responses/min) and nondifferential with respect to group [$F(2,90) = 1.43, p > .2$]. Responding during the first 6 sec of stimulus presentations was high, averaging 120 responses/min, and not differential [$F < 1.0$]. In the FI component, 82% of all reinforcers were earned by pecking; this was not differential [$F < 1.0$].

Responding was broken down into six 1-sec intervals in each of the two stimuli for the TD and PD groups. Figure 2 presents these data (collapsed across the subsequent transfer dimension, since this showed no effect). Figure 2a shows the raw response rate across seconds. An analysis of variance including as factors hard vs. easy and TD vs. PD indicated that the rate differences were not significant (all $F_s < 1.0$). To test whether subjects distributed their responses differentially between the two stimuli, percent of total responses allocated to each stimulus was examined. This analysis (see Figure 2b) included the above factors plus horizontal vs. vertical. It indicated that subjects did not distribute responses differentially to the two stimuli (all $p_s > .10$). Finally, if subjects patterned responses differentially within a stimulus, the most sensitive measure would be percent of responses to that stimulus within a given second (see Figure 2c). The analysis of variance included the above factors, plus the additional factor of seconds. Six of the eight comparisons that are generated by this were nonsignificant ($p > .20$). The interaction between seconds and TD-PD was marginally significant [$F(5,300) = 2.19, p < .10$], and the three-way interaction between Horizontal-Vertical, Seconds, and TD-PD was significant [$F(5,300) = 3.55, p < .01$]. Inspection of the curves indicates that these interactions result from a slightly higher peak and more rapid decline in percent of responses to the vertical line (the FT stimulus) in the TD group. Variability of responding to the stimuli in both rate and pattern were also assessed and found not to be differential between TD and PD ($F < 1.0$).

In general, the patterns of behavior observed in

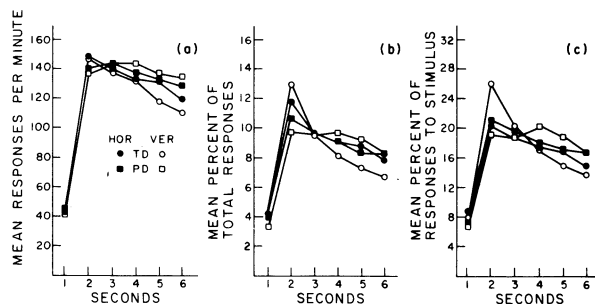


Figure 2. For horizontal and vertical line stimuli and TD and PD groups: (a) mean rate of responding, (b) mean percent of total responses, and (c) mean percent of responses to the stimulus, during the last session of Stage 1 in Experiment 2.

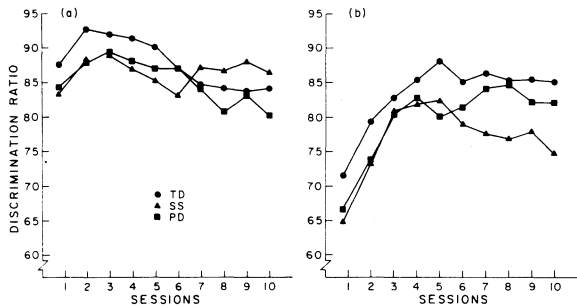


Figure 3. Discrimination ratio (mean percent of responses to S+) for the 10 sessions of Stage 2 in Experiment 2.

Stage 1 were remarkably similar between TD and PD groups, as well as between stimuli within groups. Both TD and PD groups responded very little in the intertrial interval and substantially during trials. Whereas the PD group responded equivalently to the vertical and horizontal training stimuli, the TD group responded differentially to them, indicating a sensitivity to the different response contingencies they signaled. Note, however, that this difference in responding was subtle and small. The difference consisted of a slightly different pattern of responding within the 6-sec stimulus presentation interval. Furthermore, the within-trial differences in responding in TD subjects were minuscule compared with the differences for all subjects between trial and intertrial interval responding.

Stage 2. Figure 3 shows the discrimination ratios obtained during Stage 2. Easy groups are presented in Panel a and hard groups, in Panel b. As in Experiment 1, the first 5 days were used in the analysis of variance. There was a large effect for difficulty [$F(1,90) = 36.11, p < .01$], and this interacted with sessions [$F(4,90) = 10.13, p < .01$]. As expected, the easy groups all performed substantially better than even the TD group in Experiment 1. Planned orthogonal comparisons indicated that TD differed from SS and PD [$F(1,90) = 6.082, p < .05$], which did not differ from each other [$F < 1.0$]. TD-SS-PD did not interact with sessions or difficulty [$F_s < 1.0$], confirming that the group difference developed within the first session (as in Experiment 1) and was not a function of the difficulty of the discrimination. As in Experiment 1, there were no significant differences or interactions in S+ rates, other than the effect for sessions. Both the differences in difficulty [$F(1,90) = 7.17, p < .01$] and Difficulty by Sessions [$F(4,90) = 4.01, p < .01$] were reflected

in differential suppression during S- periods. The TD-SS-PD difference was also reflected in rates to S-; planned comparisons showed that TD rates to S- were significantly lower than SS and PD rates [$F(1,90) = 5.04, p < .05$], which did not differ from each other [$F < 1.0$].

Although it is possible that the TD enhancement effect found in this experiment was a direct transfer of the slight performance differences found in training, a more plausible explanation is that enhancement was due to the fact that in TD groups the two stimuli were associated with different operant contingencies, whereas in PD they were not. Again, it is possible that this differential contingency was in the slightly different delays of reinforcement yielded by FI 6 sec and FT 6 sec, but a more likely source of the difference was the operant contingency itself. Transfer of learned performance is seen here in the superiority of all the easy groups when compared with the groups in Experiment 1.

In summary, the present experiments suggest that the TD enhancement effect is a product of the transfer of differential behavior and/or of experience with stimuli associated with differential contingencies.

REFERENCES

- BRESNAHAN, E. L. Effects of extradimensional pseudodiscrimination training upon stimulus control. *Journal of Experimental Psychology*, 1970, **85**, 155-156.
- ECK, K. L., NOEL, R. C., & THOMAS, D. R. Discrimination learning as a function of prior discrimination and nondifferential training. *Journal of Experimental Psychology*, 1969, **82**, 156-162.
- HALL, G., & HONIG, W. K. Stimulus control after extradimensional training in pigeons: A comparison of response contingent and noncontingent training procedures. *Journal of Comparative and Physiological Psychology*, 1974, **87**, 945-952.
- HONIG, W. K. Attentional factors governing the slope of the generalization gradient. In R. M. Gilbert & N. S. Sutherland (Eds.), *Animal discrimination learning*. London: Academic Press, 1969.
- NEWLIN, R. J., & LoLORDO, V. M. A comparison of pecking generated by serial, delay and trace autoshaping procedures. *Journal of the Experimental Analysis of Behavior*, 1976, **25**, 227-241.
- NEWLIN, R. J., & THOMAS, D. R. Nondifferential training retards acquisition of subsequent discriminations involving other stimuli. *Animal Learning & Behavior*, 1978, **6**, 385-390.
- TOMIE, A., DAVITT, G. A., & ENGBERG, L. A. Stimulus generalization of autoshaped key-pecking following interdimensional and extradimensional training. *Learning and Motivation*, 1976, **7**, 240-253.

(Received for publication July 1, 1980.)