The effect of consistency of reward on compound-cue discrimination learning*

T. GARY WALLER

University of Waterloo, Waterloo, Ont., Canada

Rats first were trained on a compound-cue discrimination and then were transferred to a discrimination on which one of the sets of cues continued to be relevant and the other was made variable irrelevant. The rats were either consistently rewarded (CR) during both phases, partially rewarded (PR) during both phases, or received PR during acquisition and CR during transfer. CR during acquisition produced superior acquisition and transfer performance. Implications for stimulus-analyzer theory were indicated.

According to attention theories of discrimination learning (Sutherland, 1964; Lovejoy, 1968), organisms must do two things in order to learn a discrimination problem. First, they must learn to attend to appropriate cues, and, second, they must learn a correct instrumental response. If an animal receives partial reward (PR) rather than consistent reward (CR) for correct responses, the theory holds that the animal attends to many cues and attaches the instrumental response to the output of many analyzers (cf. Sutherland, 1966). Thus, in a compound-cue discrimination task, PR animals are expected to demonstrate greater breadth of learning than CR animals.

It follows that if one of the cues in a two-cue compound is dominant and the other is nondominant (i.e., one cue is clearly more likely to be attended to than the other), PR animals should learn more about the nondominant cue than CR animals. Thus, PR animals should perform better on single-dimension tests on the nondominant cue and should perform better on a transfer task in which only the nondominant cue is relevant.

The above prediction was tested by Waller (in press) with results exactly opposite to the prediction. That is, CR animals performed better on a transfer discrimination. One purpose of the research reported here was to repeat the basic design of the earlier studies with several procedural changes. Rats were first trained on a simultaneous discrimination with both texture and brightness cues relevant. Previous results (Waller, in press) indicated that brightness was the dominant cue and texture the nondominant cue. After reaching acquisition criterion, the rats were trained on either a texture

discrimination or a brightness discrimination. One group was trained with CR in both phases, while a second group received PR in acquisition and CR in transfer. In order to assess the effect of the shift from PR to CR, a third group was trained with PR in both phases. Since previous research demonstrated that texture was the nondominant cue, stimulus-analyzer theory predicts that PR animals should learn more about the texture dimension than CR animals. The present research differed from the earlier studies (1) in the inclusion of the group trained on PR throughout, (2) in the use of a noncorrection procedure rather than a modified correction procedure, and (3) in the fact that there was no interpolated CR phase at the end of discrimination training for the PR animals.

SUBJECTS

The Ss were 48 experimentally naive male albino rats supplied by the Holtzman Co. On arrival at the laboratory, average weight was approximately 290 g and average age was reported to be 90-100 days.

APPARATUS

The apparatus was described previously (Waller, in press) and was an enclosed wooden single-unit T-maze which was painted flat gray and covered with Plexiglas. Reward pellets were placed in gray foodcups behind a wooden barrier at the rear of the goalboxes. A guillotine door separated the startbox from the stem; horizontally sliding wooden doors separated the choice area from each goalbox. Stimulus inserts for the floors of the arms of the maze were cut from Masonite and were painted flat white (W) or black (B) to define a brightness dimension. For the texture dimension, a smooth floor (S) was defined as the smooth side of painted Masonite; a rough floor (R) was devised by drilling 0.5-cm holes centered every 1.25 cm over the length and breadth of the Masonite insert. Each insert extended from the center of the choice area to the foodcup.

PROCEDURE

On arrival, the rats were housed individually and placed on ad lib food and water until the fourth day, at which time all food was removed from the cages. Beginning on Day 5, the daily ration was controlled to maintain a constant 85% (± 10 g) of terminal ad lib weight throughout the experiment. Beginning on Day 5 and continuing for 8 days, 2-min prehandling sessions were given daily to each rat. During each prehandling session the rat was picked up and replaced at least three times by E, was permitted to explore the top of a large gray table, and was given access to five .045-g food pellets located in a glass dish in the center of the table.

Acquisition

Beginning on Day 13, each rat was given acquisition training on a simultaneous discrimination in which brightness and texture were relevant and redundant cues. No attempt was made to counterbalance completely for positive cue (cf. Sutherland & Holgate, 1966), in that all rats were rewarded for choosing the white floor. For a randomly selected half of the rats, the white-smooth (WS) floor was positive (S+) and black-rough (BR) was negative (S-); for the other half, WR was S+ and BS was S-. Training was with a noncorrection procedure, and the right-left position of S+ was determined by randomly selected Gellermann series. Each rat received 16 trials/day to a criterion of 15 correct responses on any 16 consecutive trials. When appropriate, correct responses were rewarded with five .045-g Noyes pellets. Errors were never rewarded, but the foodcup was always present in the incorrect goalbox. The within-day intertrial interval was approximately 10 sec. Rats in Group CC were rewarded for every correct response; rats in Groups PC and PP were rewarded for a randomly selected 50% of the correct responses in every block of 10, except that the first two correct responses were rewarded for every rat.

Transfer

On the day after each S reached acquisition criterion, it was shifted to a discrimination in which one of the acquisition dimensions continued to be relevant and S+ on that dimension was unchanged. The other previously relevant dimension was changed to variable-between irrelevant such that only one value of the irrelevant dimension was present on any single trial. For example, if S+ was WS and S- was BR during acquisition, S was shifted to either (1) a brightness discrimination in which WS-BS appeared on half the trials, WR-BR appeared on the other half, and WS and WR were S+, or (2) a texture discrimination in which WS-WR or

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BS-BR appeared equally often and S+ was WS and BS. Rats in Groups CC and PC were rewarded for every correct response during transfer; those in Group PP were rewarded for a randomly selected 50% of the correct responses. All other procedures were the same as in acquisition.

RESULTS AND DISCUSSION

Mean trials to acquisition criterion for Groups CC, PC, and PP were 68.25, 117.31, and 115.81, respectively; mean errors for white-smooth positive and white-rough positive were 81.75 and 119.17, respectively. Analysis of variance indicated that the effect of reward condition was significant ($F = 5.36$, $df = 2/42$, $p < .01$) and that learning was faster with smooth positive ($F = 7.22$, $df = 1/42$, $p < .025$), but that the interaction of reward condition with positive cue was not significant ($F < 1.0$). Individual comparisons by the Newman-Keuls procedure (Winer, 1962) indicated that Group CC learned faster than Group PC ($q = 5.76$, $df = 3/42$, $p < .01$) or Group PP ($q = 5.58$, $df = 2/42$, $p < .01$), but that Groups PC and PP did not differ significantly during acquisition ($q < 1.0$). The acquisition data confirm the essential aspect of earlier results (Waller, in press; Cranford & Clayton, 1970; Erlebacher, 1963) in demonstrating that CR produces superior performance to PR during acquisition of a simultaneous discrimination task.

Mean trials to transfer criterion as a function of reward condition and relevant dimension during transfer are shown in Table 1. Group CC learned fastest, followed by Groups PC and PP, and performance was superior on

Percentage of Reward During Acquisition and Transfer	Relevant Dimension During Transfer	
	Brightness	Texture
Consistent-Consistent	15.38	24.12
Partial-Consistent	19.00	44.37
Partial-Partial	22.88	57.75

the brightness discrimination for all reward conditions. Analysis of variance of trials to criterion indicated that the effect of reward condition was significant ($F = 3.33$, $df = 2/36$, $p < .05$), as was the effect of relevant dimension ($F = 12.36$, $df = 1/36$, $p < .01$), but that neither the interaction of reward condition with relevant dimension ($F = 1.35$, $df = 2/36$) nor any effects involving positive cue (all $F < 1.0$) were significant. Individual comparisons with the Newman-Keuls procedure showed that Group CC learned faster than Group PC ($q = 4.12$, $df = 2/36$, $p < .01$) or Group PP ($q = 7.22$, $df = 3/36$, $p < .01$) and that Group PC learned faster than Group PP ($q = 3.09$, $df = 2/36$, $p < .05$). Although the interaction of reward condition with relevant dimension was not significant, previous research indicated that reward conditions would differentially affect the two transfer tasks, so the simple effects of reward condition for each relevant dimension were evaluated. Reward conditions did not significantly affect performance on the brightness task ($F < 1.0$) but did have a significant effect on the texture task ($F = 4.42$, $df = 2/36$, $p < .05$). Individual comparisons on the texture task indicated that Group CC performed better than Group PC ($q = 3.56$, $df = 2/36$, $p < .05$) or Group PP ($q = 5.90$, $df = 3/36$, $p < .01$) but that Groups PC and PP were not reliably different from each other ($q = 2.35$, $df = 2/36$).

The transfer results substantiated earlier research (Waller, in press) in demonstrating that (1) the brightness discrimination was easier than the texture discrimination, (2) transfer performance on the easier brightness task was affected only slightly, if at all, by percentage of reward during acquisition, and (3) transfer performance on the more difficult texture discrimination was significantly retarded by PR during acquisition of the compound-cue discrimination. The impetus for the research previously reported and for the research reported here was a prediction from stimulus-analyzer theory of discrimination learning (Sutherland, 1964, 1966; Lovejoy, 1968), i.e., that in a discrimination situation where one of two compound cues is dominant (brightness) and one

is nondominant (texture), PR animals should learn more about the nondominant cue than would CR animals, and, on transfer to a discrimination which retained the nondominant texture cues, the PR animals should perform better than the CR animals. That is, Group PC should perform better in transfer than Group CC. A significant effect in the opposite direction was observed, thus confirming the previous lack of support for the above prediction. One possible explanation of the earlier result, where a period of CR was given to PR animals at the end of acquisition on the compound cues, was that the interpolated CR phase served as overtraining. Sutherland & Holgate (1966) showed that overtraining with CR on a compound-cue task with a dominant and nondominant cue increased the amount learned about the less salient cue. Thus, in the earlier research the superiority of CR animals on the texture discrimination possibly could be attributed to overtraining on the compound. However, there was no interpolated CR in the research reported here and performance on texture transfer was superior for CR animals.

The present research demonstrated that the shift from PR to CR (Group PC) did not produce discrimination performance equal to performance for rats trained on CR in both phases (Group CC). While Group PC showed some improvement as compared to Group PP, the improvement was not statistically reliable. Thus the results are not in agreement with performance in the runway, where it has been shown (Theios & McGinnis, 1967) that rats shifted from PR to CR perform under CR as well as rats trained throughout under CR. The failure on the part of Group PC to perform as well as Group CC on the second discrimination task indicates that performance on discrimination tasks is subject to the influence of previous reward contingencies. The effect of PR during acquisition on transfer performance is at least partly attributable to the effect of inconsistent reward on lengths of error runs. The percentage of error runs that were of lengths 1, 2, or greater than 2 are shown in Fig. 1 for all three groups.

The lengths of error runs were

Fig. 1. Observed percentage of error runs of Lengths 1, 2, or greater than 2 for Groups CC, PC, and PP.

dependent upon reward conditions ($\chi^2 = 21.64$, $df = 4$, $p < .01$) in that animals receiving CR during acquisition made fewer error runs of lengths greater than 1, and animals receiving PR during acquisition made more error runs of lengths greater than 1. While the tendency to make longer error runs was less for Group PC than for Group PP, both groups PC and PP made more long runs of errors than did Group CC. The tendency for PR animals to make more of the longer error runs suggests that nonreward provided less information or had less value as a cue for PR animals (Groups

CP and PP) than for CR animals.

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