Extinction of stimulus elements decreases the rate of conditional discrimination learning

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Pigeons were trained on a successive discrete-trial conditional discrimination, in which either of two colors appeared on the center key and either of two forms appeared on the two side keys. Some combinations of color and form (S+ trials) were followed by food; other combinations (S- trials) were followed by no food. The colors on the center key appeared throughout the intertrial interval (ITI) preceding the trial period in which both the color and the form compound were presented or the color appeared only during the trial period in compound with the forms. Presentation of the colors during the ITI substantially degraded acquisition of two separate types of conditional discrimination. The results show that the temporal correlation of the colors with food, independent of their association with the form cues, played a substantial role in determining their availability for acquisition of the conditional discrimination.

Williams (1982) demonstrated that acquisition of a conditional discrimination may be disrupted by degrading the temporal correlation between the reinforcer and one set of stimulus elements involved in the discrimination. Pigeons were trained on a discrete-trial autoshaping procedure in which either of two colors appeared on one response key and either of two forms appeared on an adjacent key. In control conditions in which both stimuli appeared only during trial periods, the discrimination between color + form combinations that served as S+ trials and those that served as S- trials was readily learned. But when the color scheduled to appear on the next trial also was presented during the intertrial interval (ITI) preceding the trial period, all subjects failed to learn the discrimination. Instead, they never responded to the color cue, and they responded to the form key during trial periods as if no information about the colors were available. Williams (1984) extended this finding by showing that a similar effect occurred when the colors were presented alone and extinguished during separate trials in addition to the usual trials involving the stimulus compounds. These results were interpreted as showing that degrading the colors' temporal correlation with food decreased their salience, so that they became unavailable for learning of any sort.

The findings reported by Williams (1982, 1984) appear to be in conflict with those subsequently reported by Cooper (1989) using a similar procedure. In Cooper's study, subjects did learn the conditional discrimination when the colors were presented throughout the entire ITI. Moreover, when the portion of the ITI filled with the color cues was varied, faster learning occurred with greater per-

centages of ITI time filled with the colors (which he referred to as the *instructional stimulus*), a finding directly contrary to Williams (1982, see especially Experiment 3). Cooper thus concluded that conditional discrimination acquisition was positively related to the ratio of exposure time to the instructional stimulus to the trial period.

One obvious difference between Cooper's procedure and that used by Williams (1982) is the nature of the required discrimination. In Williams (1982, 1984), food delivery was contingent on different combinations of two forms and two colors. In Cooper's experiment, color cues presented on a center key signaled that food would be delivered (or not), depending on which of two side keys was illuminated with white light during the trial periods. One possible reason that this difference may be critical is that the colors in Cooper's experiment provided a cue about positional orientation that was absent in the procedure of Williams (1982). For example, consider Cooper's procedure when red on the center key signaled that food would follow illumination of the right side key but not the left side key. Because the color presentation preceded the side-key presentation, this meant that the subjects could orient toward the right key prior to its presentation. Thus, presentations of the left key on S- trials could be functionally ignored. Because the colors potentially provided information about such "observing response" contingencies, they may not have lost stimulus salience in the same fashion as they did in Williams's (1982) study, where they provided no orientational information.

The present investigation was designed to resolve the conflict between the two sets of findings. Experiment 1 provided a direct comparison of the two discrimination procedures, in both cases with the colors that served as conditional stimuli present throughout the ITIs. Experiment 2 then varied whether the colors were present in the ITI to determine if that manipulation had comparable effects on the different discriminations.

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EXPERIMENT 1

Method

Subjects

Eight experimentally naive Indian Mondian pigeons served as subjects and were maintained at 80% of their ad-lib weight. All birds received most of their food during the experimental sessions, but they were fed additional grain if necessary to maintain their weight. Unlimited water was available at all times in the home cages.

Apparatus

Four identical three-key pigeon operant chambers were used for all sessions and both experiments. The inside of the chambers measured $36 \times 32 \times 35$ cm. The floor consisted of a grid made of round aluminum bars connected by a strip of clear Plexiglas at each end of the bars. The ceiling, two side walls, and the rear wall were made of opaque gray plastic, one side wall containing a clear Plexiglas viewing window (12.5×15.5 cm). The front wall was a 3-mm-thick aluminum sheet on which three translucent response keys (2.5 cm diameter) were mounted, 26 cm above the floor and 7.3 cm apart center to center. Each key required a force of approximately 0.15 N to close a microswitch and to be counted as a response. Stimuli could be projected from behind onto each key by standard IEE 28-V 12-stimulus in-line projectors. A 28-V 1-W miniature lamp was located 8.8 cm above each response key, and the center lamp provided general chamber illumination as a houselight. Directly below the center key and 9.5 cm above the floor was a 5.7×5 cm opening that provided access to a solenoid-operated grain hopper. When activated, the hopper was illuminated from above by a 28-V 1-W miniature lamp. Reinforcement consisted of a 3.5-sec access to milo, during which the houselight and all keylights were dark. A 5-cm speaker mounted above the center of the ceiling provided continuous white noise throughout all experimental sessions. The chambers were located in a sound-attenuated room with no illumination during the sessions. An IBM-compatible AST 286 computer located in an adjacent room controlled and recorded the experimental events in all chambers.

Procedure

Pretraining. Since all birds were experimentally naive, the first session involved magazine training. After the birds ate reliably from the hopper within 3 sec of operating it, autoshaping was conducted in the following manner: During an ITI of 60 sec, only the center houselight (and no keylight) was presented. At termination of the ITI, one of the three keys was lit, indicating the onset of a trial. Stimuli presented on the center key were either red or green, and stimuli presented on the left or right were either a white circle or triangle on an otherwise dark key. Each stimulus-position combination had an equal probability of presentation. A trial was terminated by a peck to a lit key or after 6 sec if no response occurred; in both cases, however, the food hopper was then raised for 3.5-sec access to grain, during which time the houselight was not lit. After reinforcement, a new ITI was initiated and the next trial cycle began. Each session lasted until 40 reinforcements were presented. In the course of four sessions, the ITI was shortened from 60 sec to 30 sec, and the stimulus duration was gradually reduced from 6 sec to 3 sec. At this point in training, pecks to all stimuli occurred reliably.

Conditional discrimination training. The general design of the experiment consisted of a response-independent conditional discrimination procedure, with S+ and S- trials randomly interspersed. Throughout a 30-sec ITI, one of the sample stimuli, either a red or green color, was presented on the center key. After the ITI had elapsed, one of two comparison stimuli, either the white triangle or circle, was presented either on the left or right side key for a trial duration of 3 sec, during which the red or green center key remained illuminated. Each trial terminated after 3 sec independently

Table 1
S+ and S- Stimulus Combinations for Each Group of Experiment 1

Reinforcement	Stimuli	
	Sample	Comparison
Position Condition		
+	Red	Tr-Left
+	Green	Ci-Right
-	Red	Ci-Right
-	Green	Tr-Left
Shape Condition		
+	Red	Tr-Left
+	Red	Tr-Right
+	Green	Ci-Left
+	Green	Ci-Right
-	Red	Ci-Left
-	Red	Ci-Right
-	Green	Tr-Left
-	Green	Tr-Right

Note—Ci = circle, Tr = triangle.

of the occurrence of a response. S+ trials always ended in the presentation of grain for 3.5 sec, after which a new trial cycle was initiated. S- trials were followed by a 3.5-sec period of completely darkened keys, and food was omitted before a new trial cycle began. The houselight remained on throughout the session except during the reinforcement/blackout following each trial. Different sample/comparison stimulus combinations for S+ or S- trials determined the two groups.

Position relevant. Four birds were randomly assigned to serve under the *position* (P) condition, which was intended to replicate the general procedure of Cooper (1989). The stimulus assignments for S+ and S- trials are shown in Table 1. For this group, triangles and circles were always presented on the left and right keys, respectively, as comparison stimuli. Position was therefore 100% correlated with shape. Trials with the red sample and the triangle comparison stimulus (always on the left key) or trials with the green sample and the circle comparison stimulus (always on the right key) were defined as S+ trials. S- trials were presentations of the circle on the right given the red sample stimulus or presentations of the triangle on the left given the green sample stimulus.

Shape relevant. The remaining 4 birds served under the *shape* (S) condition. As shown in Table 1, trials with the triangle presented on either side key given the red sample key or trials with the circle on either side key given the green sample key were defined as S+ trials. Trials with presentations of the circle given red or trials with presentations of the triangle given green were defined as S- trials. Acquisition of the conditional discrimination thus depended on discriminating the separate shapes, and the positional cues were irrelevant.

Each stimulus combination (four for the P condition and eight for the S condition) was presented with equal probability. Each session terminated after 120 trials (60 presentations of reinforcement). This condition was in effect for 35 sessions for both groups. After completion of training, the group assignment was reversed for each bird for an additional 35 sessions. Thus, each bird served in the P and S conditions at some point during the experiment, but the order for these conditions differed for the two groups.

Results and Discussion

The results of Experiment 1 are depicted in Figure 1. Each data point is an average of the proportions of responses to the S+ shape stimuli over five sessions, calculated by dividing the sum of responses to the compari-

Figure 1. Results of Experiment 1. Shown in the top panel are the results of individual subjects trained initially with the position-relevant comparison stimuli and then switched to shape-only relevant stimuli. In the middle panel are the results of subjects trained initially with shape-only stimuli and switched to position-relevant stimuli. The bottom panel shows group averages.

son (shape) stimuli of all S+ trials by the total number of responses to the comparison stimuli of all trials. The top graph shows proportions for birds first trained on the position-relevant task (left panel), followed by the shape-relevant task (right panel). The middle graph depicts proportions for the birds serving in the two conditions in reversed order. The bottom graph shows group means ($n = 4$) for both groups under the first and second conditions.

Figure 1 shows that the discrimination was acquired more rapidly when position was correlated with the comparison stimuli than it was when position was irrelevant. Three of the 4 subjects in the position-relevant condition acquired the discrimination, whereas only 1 of the 4 subjects in the position-relevant condition (the S condition) acquired the discrimination. The subjects transferred from the position-relevant condition to shape-only condition (top panel) generally deteriorated in their performance immediately after the transfer and showed little improve-

ment thereafter. The subjects shifted to the position-relevant condition, in contrast, all substantially improved their performance.

An analysis of variance (ANOVA) was conducted on the data depicted in Figure 1. Condition was treated as a within-subject factor, since each bird served in both conditions during the experiment. Block was also treated as a within-subject factor. Order was a between-subject factor, since each bird was exposed to only one of the two orders in the experiment. The effect of order was not significant ($F < 1$). The effect of discrimination condition was statistically significant [$F(1,6) = 40.73, p < .01$]. The effect of blocks was also significant [$F(6,36) = 17.60, p < .01$], indicating that response proportions increased during training for both groups.

The graphs suggest that the magnitude of the group difference grew larger over the course of acquisition. This was supported statistically in the ANOVA by a significant condition $\times$ blocks interaction [$F(6,36) = 8.28, p < .01$]. Finally, the ANOVA also indicated a significant order $\times$ condition interaction term [$F(1,6) = 30.57, p < .01$]. In Figure 1, this reflects the fact that the subjects trained initially with the position-relevant comparison stimuli (top panel) maintained a higher level of discrimination on the shape-only comparison task than did the subjects trained initially on the shape-relevant comparison stimuli. Note also, however, that the level of performance for 3 of the 4 subjects did drop substantially with the shape-only stimuli after the change in contingencies and improved relatively little thereafter.

The distribution of pecking behavior was also of interest independent of the accuracy of the discrimination. Seven of the 8 subjects never responded more than once or twice per session to the colors, either during the trial period or during the ITI. The remaining subject (B60) responded to the colors at a low rate during the ITI but not during the trial period, both during its initial condition (P) and after the reversal in conditions (to S).

The results shown in Figure 1 generally replicate the earlier findings of Cooper (1989) and Williams (1982). The subjects trained with the comparison stimuli that allowed position to be a correlated cue generally learned the discrimination in a fashion similar to that reported by Cooper (1989, see his Group 30-30-3 in Figure 2). In contrast, the subjects trained with position irrelevant (i.e., with only shape relevant) generally failed to learn the discrimination. These results are similar to those of Williams (1982) except that, here, 1 of the 4 subjects acquired the discrimination to some extent, whereas none of the subjects of Williams (1982) acquired the discrimination. This partial replication of the earlier two studies does not, however, resolve the discrepancy between the two sets of findings. The present results could be accounted for in terms of the position-relevant discrimination being easier, since other evidence indicates that conditional discriminations involving spatial cues as choice alternatives are easier than discriminations involving nonspatial cues (e.g., Smith, 1967). Thus, any attentional deficits for the color stimuli

caused by their presentation during the ITI might simply be less evident with the easier task. Cooper, in contrast, reported that presentations of the colors *facilitated* the discrimination to the extent that larger portions of the ITI were occupied by the colors. Experiment 2 was thus intended to provide a factorial comparison in which the two types of discrimination problems were studied under each of two conditions of color presentation: (1) a replication of Experiment 1 with the colors presented throughout the ITI, and (2) a replication of the control conditions of Williams (1982) in which the colors were presented only during the trial periods.

EXPERIMENT 2

Method

Subjects and Apparatus

In Experiment 2, the subjects were 20 White Carneau pigeons. Twelve were experimentally naive, but 8 birds (R39, R46, R57, R60, R61, R63, R66, and R104) had a history of response-dependent schedules with stimuli different from those used in the present experiment. Their 80% ad-lib weight was maintained in identical manner as in Experiment 1. All aspects of the apparatus, including the specific stimuli, were identical to those in Experiment 1.

Procedure

Pretraining for all birds was identical to Experiment 1 in that the initial few sessions presented an autoshaping procedure that generated pecks to all three keys, on which the stimuli of the subsequent conditional discrimination training were presented. The general procedure for the conditional discrimination training was also identical to that of Experiment 1, except that the trial periods were increased from 3 sec to 6 sec.

The subjects were randomly assigned to four groups, with 2 of the 8 non-naive subjects assigned to each group. Two groups were trained on the position-relevant discrimination in which the triangle/circle always appeared in the same position from trial to trial. For one of these groups, the colors that appeared during the trial period also occurred throughout the preceding ITI (P-30); for the other group, the colors, like the forms, appeared only during the trial period (P-0). The remaining two groups were trained on the position-irrelevant discrimination in which the color+form combinations defined the discrimination contingencies, irrespective of the locations of the form elements. One of these two groups received the colors throughout the ITI (S-30); the other group received the colors only during the trial period (S-0). For both groups that received the colors only during the trial periods (P-0 and S-0), the onset of the sample stimuli occurred simultaneously with the onset of the form comparison stimuli, and the ITI consisted of presentation of the houselight only. All groups were trained for 25 sessions, each of which consisted of 120 trials with equal probability of each stimulus combination, as in Experiment 1.

Results and Discussion

The findings of Experiment 2 are shown in Figure 2. The top set of four panels shows the response proportions to the S+ trials for individual birds in the four groups; group means are shown in the lower graph. One subject in Group P-30 failed to sustain responding to any of the stimuli, so only 4 subjects are shown for that condition. Response proportions were calculated in the following manner: Responses occurring during the trial period, whether to the colors or to the forms, were summed for all S+ trials,

and this value was divided by the total number of responses during trial periods across both S+ and S- trials.

The group means shown in Figure 2 indicate that both position-relevant groups displayed better discrimination performance than did either of the two shape-only groups. In addition, the groups with no presentation of the sample stimuli during the ITI (P-0 and S-0) acquired the discrimination more readily than did the corresponding groups with presentation of the sample stimuli during the ITI (P-30 and S-30).

A two-way ANOVA was conducted on the group data. Position-relevant versus shape-relevant contingencies were one between-subject factor. Presence versus absence of the colors in the ITI was a second between-subject factor. Block was a within-subject factor. The effect of type of discrimination was significant [$F(1,15) = 20.01, p < .01$]. Also significant was the effect of the colors during the ITI [$F(1,15) = 6.18, p < .05$]. The interaction between the two variables was not significant ($F < 1$). The effect of block was also significant [$F(4,60) = 34.1, p < .01$], as was the interaction between the type of discrimination and block [$F(4,60) = 5.02, p < .01$]. The interaction between ITI condition and block approached significance [$F(4,60) = 2.20, .10 > p > .05$]. The triple interaction was not significant ($F < 1$).

While group means were generally representative of performance of individual birds, there were two exceptions. First, R19 of Group P-30 did not exhibit any acquisition of the discrimination. This finding was in strong contrast to performance displayed by the other 3 birds in this group (R16, R46, and R61). The second major exception to group mean performance was the behavior of R104 in Group S-30, which was the only subject in that group to acquire the discrimination to any degree.

The distribution of pecks for the subjects with the colors presented in the ITI was similar to that in Experiment 1. Few pecks (less than five per session) occurred to the colors during the ITI for either the P-30 group or the S-30 group. Two of the 4 subjects in Group P-30 did some pecking to the colors during the trials (2% and 9% of the total pecks during the last five sessions for R46 and R61, respectively), whereas none of the remaining subjects with colors during the ITI pecked the colors during the trial periods. In contrast, the subjects without the colors during the ITIs distributed their pecks during the trial periods between the colors and forms. For Group P-0, the mean percentage of total pecks to the colors was 38.6%. For Group S-0, the corresponding percentage was 36.8%.

GENERAL DISCUSSION

The results for the two groups with the colors illuminated during the ITIs (P-30 and S-30) in Experiment 2 replicate those for the corresponding conditions in Experiment 1: substantially better discrimination occurred when the comparison stimuli were correlated with response position than when position was irrelevant and the form cues alone determined the reinforcement contingencies.

Figure 2. Results of Experiment 2. The top four panels show individual subject data for the four experimental groups. Those with position-relevant comparison stimuli are shown in the top; those with shape-only stimuli are shown in the middle. Left-side panels are for subjects with colors only during trial periods; right-side panels are for subjects with colors also on during the ITIs. The bottom panel shows group means.

cies. The results of the two shape-only conditions also replicate those of Williams (1982) in showing that acquisition of the conditional discrimination was substantially impaired by having the colors illuminated during the ITI. The present results are somewhat different from the earlier findings in that 2 of the 9 subjects in the S-30 group did show substantial discrimination, whereas none of the subjects in the previous studies ever acquired the discrimination under comparable conditions. There are several potential sources of this discrepancy. First, the subjects here were pretrained to peck all stimulus elements before the conditional discrimination contingencies were imposed, whereas the earlier studies presented all stimulus elements for the first time during the discrimination itself. Second, the stimulus configuration involved three response keys in the present case, whereas only two keys were used in Williams's (1982) study. The placement of the sample colors between the two comparison-stimuli keys presumably increased the likelihood that the subjects would observe the color cues when moving between the two side keys. A third factor is the possible difference in brightness of the chambers. Williams (1982) reported that the conditional discrimination was acquired when no

houselight was used (thus converting the colors on the keys into ambient illumination of the entire chamber), which suggests that differences in the brightness of the houselight, even when illuminated, might play some role. In any event, it is clear that presentation of the colors during the ITI retarded the discrimination under the present conditions, just as was shown previously.

The results of Experiment 2 were qualitatively different from those of Cooper (1989). In his study, conditional discrimination learning was facilitated by having the colors presented for greater proportions of the ITI. For example, comparing two conditions with 60-sec ITIs and the same trial duration, a higher mean rate of discrimination accuracy was reported by Cooper for the condition in which the colors were illuminated during the entire 60 sec than was reported for the condition in which the colors were illuminated only for the last 30 sec of the ITI. In contrast, the present study showed that the illumination of the colors throughout the ITI hindered the conditional discrimination relative to when they were not presented, except during the trial periods. That is, the nonsignificant interaction between ITI condition and type of discrimination shows that the effect of illumination of the

colors during the ITI did not depend on the type of discrimination involved, but instead it hindered discrimination performance regardless of the nature or difficulty of the discrimination.

One possible account for the discrepancy between the present findings and those of Cooper (1989) is in terms of the different ranges of the ITI occupied by the samples. Here, the only assessment involved a contrast between the sample stimuli appearing during no part of the ITI or all of it, whereas in Cooper's study, they appeared either during all of the ITI or during half of it. Perhaps the function relating illumination of the conditional cues during the ITI to discrimination is nonmonotonic, such that intermediate degrees of illumination produce the worst performance. However, Williams (1982, Experiment 3) did investigate two other intermediate conditions as well, one in which the colors appeared during the last 5 sec of a 25-sec ITI and one in which the colors appeared during the last 15 sec of the same 25-sec ITI. Three of 4 subjects learned the discrimination in the 5-sec condition, whereas only 1 of 4 subjects learned it during the 15-sec condition, in contrast to no subjects learning the discrimination (in several different experiments) when the colors appeared during the entire 25-sec ITI. These data thus question whether such a nonmonotonic function occurs.

A closer examination of Cooper's study shows that its conclusion that discrimination performance varies with the percentage of the ITI filled with the colors depends critically on the results from one group that had only 3 subjects and substantial intersubject variability (Group 60-30-6 described below). Cooper ran five groups of subjects, which differed in terms of three variables: the total cycle time (C) that included the ITI+trial time, the amount of time the instructional stimulus (I) was on during the ITI, and the trial time (T). Using a cycle time of either 30 or 60 sec, and a trial time of either 3 or 6 sec, Cooper's five groups were designated as 30-30-3, 60-60-6, 30-30-6, 60-60-12, and 60-30-6 (C-I-T). The only two conditions that allow a direct comparison of the effects of the time of the instructional stimulus during the ITI were 60-60-6 versus 60-30-6: the former group had the instructional stimulus on during the entire ITI, whereas the latter had it on only during the last half of the ITI. The mean discrimination values for these groups during the last three sessions of training (from Cooper's Table 2) were .89 versus .75. Although these data are consistent with better discrimination for the group with the longer duration of the instructional stimulus, the difference was primarily due to 1 subject in Group 60-30-6 and did not approach statistical significance when separately analyzed [$F(1,5) = 1.15$].

In contrast to this simple analysis, Cooper compared combinations of groups to support his conclusion that discrimination learning improves as the duration of the instructional stimulus in the ITI increases relative to that in the trial (i.e., as the I/T ratio increases). In particular, discrimination acquisition for the first two groups listed above, with a 10:1 I/T ratio, was faster than for the latter three, which had a 5:1 ratio. However, except for the 60-

30-6 condition, the contrast is confounded by the ratio of total cycle time to trial time (C/T). Perhaps that ratio, rather than I/T ratio, is the critical variable. To test this possibility, we calculated the mean values from the raw data presented in Cooper's Table 2 in two ways: the means contrasting the high C/T versus low C/T groups, and the means contrasting the high I/T versus low I/T groups. For the former contrast, the means were .86 versus .74; for the latter contrast, they were .90 versus .75. Thus, while the difference was slightly larger for the I/T contrast, the difference between the two contrasts was so small that no clear separation of the two controlling variables is really possible. Thus, it is not clear that the present results are actually in conflict with those of Cooper because of the possibility that his effects were due to the ratio of cycle/trial time rather than due to the percent ITI time occupied by the instructional stimulus. Why the cycle/trial time should facilitate discrimination accuracy in the same way it facilitates simple Pavlovian conditioning is unclear.

Evidence in favor of the generality of the present findings comes from Rescorla (1991). He investigated the effects of intermixing separate presentations of the sample stimuli, either reinforced or extinguished, on a conditional discrimination problem similar to that used here and also on positive and negative occasion setting. In all cases, reinforcement of the sample stimulus (or "occasion setter," to use his terminology) improved discrimination learning, whereas extinction worsened it, relative to a control condition with no separate presentations of the occasion setter. Given that Williams (1984) demonstrated the functional similarity between presentations of the stimuli during the ITI and their presentations on separate extinction trials, the present findings are consistent with the results of Rescorla's extinction condition.

The issue raised by the present findings and those of Rescorla (1991) is how our findings of retardation of conditional discrimination due to separate extinction of the conditional cue is to be reconciled with previous investigations of occasion setting in which separate extinction/reinforcement of the occasion setter has little effect on the occasion-setting function (Holland, 1989b; Rescorla, 1985; Ross, 1983). On the basis of this and several other properties of occasion setting that are functionally different from simple associative learning, Holland (1989a, 1989b) has argued that it is a separate form of learning, in which the occasion setter serves the higher order function of gating the associative linkage between the target element and reinforcer.

The present findings demonstrate that the associative status of the conditional cues does in fact play a critical role in some situations, and thus undercuts at least part of the evidence that simple associative learning and occasion setting are functionally independent. However, this lack of independence does not necessarily pose a serious problem for the view that occasion setting (or conditional discrimination) is a separate higher order form of learning, because it is possible that the facilitation/interference

due to the separate reinforcement/extinction of the conditional cues does not depend on those operations' changing the associative linkages of the conditional cues themselves. Instead, as suggested by Williams (1982), those effects may be mediated by changes in the salience of the conditional cues, which makes them more or less effective for learning of all sorts. Thus, the higher order relationships involved in occasion setting and conditional discrimination could be independent of the simple associative linkages involving the conditional cues, but they would not be independent of the salience of those stimuli, which in turn depends to some extent on the same operations that determine the associative linkages. Such a view would imply that attentional learning is a separate form of learning from that involving associative relationships, as suggested by several theories (Frey & Sears, 1978; Mackintosh, 1975; Pearce & Hall, 1980). But it also should be noted that Williams (1984) demonstrated that it was not the mere extinction of the color elements that was critical for preventing conditional discrimination from occurring. This was shown by the demonstration that discrimination did readily occur when both the color and the form elements were equally degraded by both being extinguished during separate presentations. Thus, it was the relative salience of the different elements constituting the compound that was the critical variable. The generality of this finding is challenged, however, by the finding of Rescorla (1991) that separate reinforcement of the occasion setters improved discrimination performance. Thus, there appears to be an asymmetry in how reinforcement/extinction function to change the relative saliences of the different stimuli. Clearly, a great deal is yet to be learned about the determinants of salience and how it affects discrimination performance.

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