Analysis of the Unique Cue in Configural Discriminations

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Four experiments used an autoshaping procedure with pigeons to investigate the basis of configural discriminations. The elements of both a negative patterning \( (A^+, B^+, AB^-) \) and a conditional discrimination \( (AC^+, BD^+, AD^-, BC^-) \) were paired, in a second-order procedure with two new key lights, \( X \) and \( Y \). Responding was then tested to \( X \) and \( Y \) presented in compound with each other and with \( A \) and \( B \). The pattern of responding to compounds containing \( X \) and \( Y \) was like the pattern of responding to compounds containing their associates, \( A \) and \( B \). This suggests that \( A \) and \( B \) can be replaced by their associates without disrupting responding to their compounds. Because \( X \) and \( Y \) are physically different from \( A \) and \( B \), this in turn suggests that any unique cue controlling responding to their compounds does not depend on the physical presence of the component stimuli. Instead the unique stimulus appears to arise from the joint activation of memory representations.

A classical problem in the analysis of Pavlovian conditioning has been that of describing how associative strengths of stimuli combine when they are presented in compound. Many popular theories (e.g., Rescorla & Wagner, 1972) have adopted the simple assumption that the associative strength of a stimulus compound is some elementary combination of the strengths of its components. Especially popular has been the assumption that strengths combine in a linear, additive fashion. However, it is relatively easy to demonstrate that such elementary combination rules are inadequate, because they do not correctly anticipate the learning of certain discriminations. Two discriminations are of particular interest: negative patterning and conditional discriminations. In a negative patterning procedure, two stimuli, \( A \) and \( B \), are reinforced when presented separately but not when presented in compound. Exposure to such an \( A^+, B^+ \), \( AB^- \) procedure leads, in many preparations, to the animal's responding to \( A \) and \( B \) when presented alone while withholding responding to the \( AB \) compound (see Kehoe & Gormezano, 1980). That pattern is quite different from the one observed if the animals receive training only with \( A^+ \) and \( B^+ \); under those circumstances the response to the \( AB \) compound is commonly greater than that to the elements. Even if the levels of responding to \( A \) and \( B \) are matched in the two training procedures, responding is quite different to the \( AB \) compound in those animals having \( AB^- \) trials than in animals lacking those trials (e.g., Rescorla, 1972; Whitlow & Wagner, 1972). However, no single-valued combination rule will map common levels of associative strength to \( A \) and \( B \) into different levels of strength to the \( AB \) compound.

In a conditional discrimination, animals are typically presented with two stimulus compounds that are reinforced (\( AC^+ \) and \( BD^+ \)) and two that are nonreinforced (\( AD^- \) and \( BC^- \)). Although sometimes difficult, such discriminations can also be learned, with the animal exhibiting responding to the \( AC \) and \( BD \) compounds but not to the \( AD \) and \( BC \) compounds (e.g., Saavedra, 1975). As it is commonly carried out, this procedure reinforces each of the elements on half of its occurrences. Consequently, we may anticipate similar levels of associative strength to the various elements. Yet some combinations of elements produce responding, but others do not. Again, it is difficult to see how a single-

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valued combination rule could produce such different compound performances from elemental stimuli of similar strength.

One approach to this problem has been to suggest that stimulus compounds should be viewed as configurations. An extreme form of this view, according to which each compound is a unique configuration, succeeds with the data described above at the expense of failing to clearly anticipate summation in more simple situations that combine separately trained stimuli. However, a more modest proposal, that we should view an AB compound as composed of the individual A and B elements plus some “unique stimulus” present in the compound but not in either element, has enjoyed more success. According to this view, the organism adequately perceives A and B in the AB compound, but in addition the compound generates a novel stimulus of its own. Rescorla (1972, 1973) has argued that when combined with a formal theory of Pavlovian conditioning, such an assumption will allow explanation of both elementary summation data and the results of positive patterning and conditional discriminations.

The intention of the experiments reported here is to explore further the properties of such a unique stimulus. They are particularly concerned with whether that emergent stimulus should be viewed as a product of relatively primitive sensory interactions or as a result of the joint occurrence of more central representations of A and B. In the former instance the unique cue could be thought of as being like Hull’s (1943) afferent neural interaction, arising from A and B during the course of their processing as stimuli. The individual A and B stimuli are modified in the course of their perception. In the latter case, the unique cue is more like a rule in which the joint activation of representations of A and B generates a stimulus.

The strategy adopted in these experiments involves replacing the elements in a complex discrimination with other stimuli that have been associated with them. Such associates could bear an arbitrary physical relation to the original elements and yet be able to activate their representations by means of associative relations. For instance, following an A+, B+, AB− discrimination, one may associate X with A, and Y with B and then assess the response to XY. If the unique cue present in the AB compound depends on the sensory properties of A and B, then it should not be activated by a combination of X and Y; however, if the unique cue arises when the memory representations of A and B are jointly aroused, X might substitute for A, and Y for B so that XY would also activate the unique AB stimulus.

The first two experiments reported here explored this possibility for the unique cue that arises in negative patterning. The second set of experiments investigated the same question for two instances of a conditional discrimination. All experiments employed an autoshaping procedure with pigeon subjects. In that procedure the component stimuli are commonly the illuminations of key lights, and the reinforcement is food. The index of conditioning is the degree to which the birds peck at the compound and elemental stimuli when they are paired with food. Previous results (e.g., Rashotte, Griffin, & Sisk, 1977; Rescorla, 1980) demonstrate that the pairing of two key lights in an autoshaping procedure results in the sort of stimulus–stimulus learning needed for the present analysis.

Experiment 1

This experiment provided an initial examination of the unique cue in a negative patterning procedure. One group of birds learned a discrimination of the form A+, B+, AB−, in which A and B are key-light stimuli. Then two other key lights, X and Y, were paired with A and B, respectively, in a second-order conditioning paradigm. Then the birds were tested for their response to X and Y presented separately and in compound. If the unique AB cue can be activated by the associates of A and B, one would anticipate less responding to the XY compound than to its elements. To evaluate the importance of the particular negative patterning training procedure, a second group of birds was treated identically except for receiving nonreinforced presentations of another stimulus, C, instead of AB.

Method

Subjects and apparatus. The subjects were 16 female Carneaux pigeons about 1 year old, and maintained at
75% of their free-feeding weights. They had previously participated in an autoshaping experiment that used a response key and stimuli different from those employed here. Treatments in the present experiment were arranged to be orthogonal to those experimental histories.

The apparatus was four identical operant chambers, each measuring 27 × 27 × 35 cm. The metal front panel of each chamber had a 5 × 5-cm food magazine in its center, located 5 cm above the wire mesh floor. Three response keys, 2.5 cm in diameter, were located one directly above the hopper and one on either side of the center of the front wall, 20 cm above the floor. Located behind the right-hand key was an IEC inline projector that permitted the transillumination of the key with two color and two pattern stimuli. The upper half of each key could be illuminated with either a blue (B) or a yellow (Y) light; the lower half could be illuminated with either of two striped patterns, one of 1-mm lines spaced 1 mm apart and oriented 45° from the vertical, the other of 2-mm lines spaced 1 mm apart and oriented −45° from the vertical. When either colors or patterns were presented separately, the remainder of the key was black; when they were presented simultaneously, a 1-mm black line marked the boundary. In addition, the entire key could be illuminated by a uniform white stimulus (W).

These stimuli were generated by Ektachrome slides of drawings composed of Color-aid artist's paper. The remaining walls and ceiling of the chambers were composed of clear Plexiglas.

These chambers were placed in sound- and light-attenuating shells with ventilation fans providing background noise of 62 db re 20 μN/m². On the rear wall of those shells was mounted a 6-W bulb that was continuously illuminated during the session, except during the operation of the food hopper. That hopper contained Purina Pigeon grain.

Procedure. Because these birds had previously received autoshaping training in another experiment, no magazine experience was necessary. On each of the first 9 days of the experiment, the 8 animals of Group AB− were given a negative patterning procedure. Each session contained twelve 5-s reinforced presentations of each of two component stimuli, a blue key light, and the −45° stripes. Reinforcement consisted of 5-s of access to grain immediately after the stimulus. In addition the B/−45° compound was presented and nonreinforced 24 times. The 8 animals of Group C− were treated identically except that illumination of the full key with white light replaced the compound presentations of Group AB. The mean intertrial interval (ITI) was 1 min.

On each of the next 2 days the birds received posttest exposures to the key lights that would serve as second-order stimuli, yellow (Y) and the 45° stripe pattern. Each session contained twelve 5-s nonreinforced presentations of each of Y and the 45° stripes. In addition, B and the −45° stripes were presented and reinforced 12 times in each session.

On each of the next four sessions, second-order conditioning of the Y and 45° stimulus was conducted, using B and the −45° stimuli as reinforcers. Each session contained 6 trials on which Y was paired with B, and 45° was paired with −45°. On those trials no food reinforcement was given; however, each session also contained two separate presentations of B and −45° that were followed by reinforcement. During second-order conditioning the mean ITI was 2 min.

On the next day a single test session was given. That session began with two reinforced presentations each of B and −45°. Then the animals were given six presentations of the Y/45° compound intermixed with three presentations of each element given separately. All test presentations were nonreinforced and given at a mean ITI of 2 min.

Results and Discussion

Figure 1 shows the course of discrimination learning. Not surprisingly, Group C− developed differential responding more rapidly than did Group AB−. However, by the final discrimination session, the animals in Group AB− showed strong negative patterning, responding at substantially higher rates to the elements than to their compound. By the end of training, discriminative performance was not statistically superior in Group C− compared with Group AB−.

Both groups showed rapid development of second-order conditioning of Y and 45°. On

![Figure 1. Acquisition of discriminative performance in Experiment 1. (In Group AB− a compound key light was nonreinforced, whereas its individual elements were reinforced. In Group C− a plain white key light replaced the compound.)](image-url)
the final day of second-order conditioning, the rates to these stimuli were 42 and 56 responses per minute in Groups AB and C, respectively.

The data of most interest, from the test presentations of Y, 45° and their compound, are shown in Figure 2. During that test, the groups responded at similar levels to the elements, but quite differently to their compound. The animals in Group AB responded more rapidly during presentations of the elements, Wilcoxon T(7) = 1, p < .05, whereas those in Group C responded more rapidly during the compound, T(8) = 3, p < .05. Moreover, responding during the compound was more substantial in Group C than in Group AB, Mann-Whitney U(8, 8) = 4.5, p < .01.

These results suggest that the unique cue can be activated not only by the elemental stimuli composing its compound but also by associates of those stimuli. The fact that those associates, which are perceptually different from the original elements, can activate the unique cue suggests that it arises from the memory representations of the elements rather than from their actual presence.

However, there are several aspects of this first experiment that urge caution in accepting this conclusion. First, Groups AB− and C− differed not only in the treatment of the associates of the second-order stimuli but also in the degree to which they were exposed to a negative pattern discrimination. It seems possible that simple exposure to such a discrimination has a general impact on responding to key-light stimuli. The lower level of second-order conditioning of the elements shown by Group AB−, although not significant, might reflect such a general effect. Second, the particular mode of stimulus presentation in Experiment 1 might actually provide Group AB− with a physically present unique cue. When color/stripes compounds were presented, a black horizontal line separated the elements. That line was absent, however, in the nonreinforced full-key white stimulus in Group C−. Consequently, the animals in Group AB− might have learned to withhold responding when that line was present (in the B−/45° compound); the animals in Group C− could not show such learning. This could produce differential responding during test presentations of the Y/45° compound, which also contained that line. Finally, in this experiment the first- and second-order stimuli were similar to each other. Consequently, it might be that the responding to the compounds of second-order stimuli partially reflected their generalization from similar first-order stimuli. Experiment 2 used a within-subjects conditioning procedure intended to replicate the major findings of Experiment 1 while avoiding its shortcomings.

**Figure 2.** Test responding to the second-order stimuli in Experiment 1. (Responding is shown separately for the second-order stimuli presented as elements [E] and in compound [C].)

**Experiment 2**

In this experiment all animals learned a discrimination that contained a negative patterning, A+, B+, AB−. In addition, each animal received a third element, C, which was reinforced when presented either alone or in compound with A. This resulted in a
total discrimination of the form A+, B+, C+, AB−, AC+. Then some animals received second-order conditioning of X and Y using A and B as the reinforcers; others received that conditioning with A and C as the reinforcers. The question of interest is the level of responding observed when the XY compound is tested. Both groups have received the same initial discrimination that contained both reinforced and nonreinforced compounds. Moreover, B and C were counterbalanced to preclude any special similarity relations to X and Y. The groups differed only in whether the components of the XY compound had been associated with elements that composed a reinforced (AC) or nonreinforced (AB) compound.

Method

Subjects and apparatus. The subjects were 16 female Carneaux pigeons with histories like those used in Experiment 1 and maintained in the same manner. The apparatus was that of Experiment 1. In the present experiment five stimuli were employed—the B, Y, −45°, and 45° of the previous experiment—and a plain white stimulus occupying the bottom half of the key.

Procedure. On the first 12 days of training, all animals were exposed to a negative pattern discrimination. Each day contained 12 presentations each of the B/45° and B/−45° compound, as well as 6 presentations each of B and of the stripe patterns. All presentations of the individual elements terminated in reinforcement. For half the animals the B/45° compound was reinforced and the B/−45° nonreinforced; for the remaining half the reinforcement contingencies were reversed.

On each of the next 3 days all animals received preexposure with the stimuli to be used in second-order conditioning, yellow (Y) and white (W). Each session contained six nonreinforced presentations each of Y and W, as well as six reinforced presentations each of B, 45°, and −45°. On each of the next 3 days, second-order conditioning of Y and W was conducted. For half of the animals in each discrimination condition, Y was paired with B, and W with 45°; for the other half, Y was paired with B, and W was paired with the −45° stimulus. Each session contained six second-order trials of each type, together with two reinforced presentations each of B, 45°, and −45°.

On each of the following 2 days the animals were tested with compounds of the second-order stimuli. Each session began with six presentations of each of the compounds of blue with the stripe patterns, reinforced as in initial discrimination training. The first session continued with six nonreinforced presentations each of Y, W, and YW. The second session continued with six nonreinforced presentations of Y compounded with each of the stripe patterns. The former test compared responding to YW in animals for which the associates of the elements constituted a reinforced or nonreinforced compound. The second test combined Y with two stripe patterns, one with which Y's associate (B) had been reinforced and one with which B had been nonreinforced.

Results and Discussion

Initial discrimination training proceeded unevenly, as did second-order conditioning. By the end of discrimination training, the mean levels of responding were 123, 121, and 6 responses per minute to the elements, the reinforced compound, and the nonreinforced compound, respectively. The various elements did not differ from each other in the levels of responding that they evoked. During second-order conditioning, responding to Y and W rose to a mean level of 47.5 responses per minute.

Figure 3 shows the results of the first test session, during which Y, W, and YW were presented. To the left are shown the data for

![Figure 3. Test responding to the second-order stimuli in Experiment 2. (Responding is shown separately for the second-order stimuli presented as elements [E] and in compound [C]. The second-order stimuli had been paired with stimuli that had been either reinforced or nonreinforced when presented in compound.)](image)
those animals for which the associates of Y and W had been reinforced when combined; to the right are the data from animals for which the associates of Y and W had been nonreinforced when combined. Responding to the individual Y and W elements was similar in the two groups; however, responding to the YW compound was very different. Animals in the group with reinforced associates showed greater responding to the YW compound than to its elements, \( T(8) = 0, p < .02 \), whereas animals in the group with nonreinforced associates responded less to the YW compound than to its elements, \( T(8) = 2, p < .02 \). In addition, responding to the YW compound was greater in the group for which the appropriate compound had been reinforced, \( U(8, 8) = 9.5, p < .02 \).

In a second test session the animals were given compounds consisting of the second-order Y presented together with each of the stripe patterns. The associate of Y (i.e., B) had been reinforced in conjunction with one stripe pattern and nonreinforced in conjunction with the other. During this test the mean rate of responding was 88 and 38 responses per minute when Y was presented together with the stripe pattern with which B had been reinforced and nonreinforced, respectively, \( T(16) = 15, p < .05 \).

These data support the conclusions of Experiment 1, in a design that avoids its complications. The unique cue responsible for negative patterning can apparently be activated by a combination of the associates of the stimuli originally involved in its occurrence. Moreover, it can also be activated when only one element of an original compound is replaced by its associate. That suggests that the unique cue arises whenever the representations of two stimuli are jointly activated, whether or not those stimuli are physically present.

Experiment 3

This experiment explored the nature of the unique cue that arises in a conditional discrimination. Birds were initially given a Pavlovian conditional discrimination of the form AC+, BD+, AD−, BC−. They then received second-order conditioning in which X and Y were either paired with A and C or with A and D. Finally, they were tested for their response to the XY compound. Despite the equivalent training of the individual elements, it was anticipated that more responding would occur when A and C, rather than A and D, had served to reinforce X and Y.

Method

Subjects and apparatus. The subjects were 16 female Carneaux pigeons with histories like those of previous experiments and maintained in the same manner. The apparatus was four operant chambers identical in all essentials to those of Experiment 1. A projector behind the right-hand key permitted the presentation of three colors—blue (B), yellow (Y), and green (G)—as well as three stripe patterns oriented vertically (V), 45°, and 45° from the vertical. These stimuli differed from those of Experiment 1 only in that compound stimuli were separated by a vertical line, with colors appearing on the right half of the key. The vertical stripe pattern was composed of 1-mm lines spaced 1 mm apart.

Procedure. Conditional discrimination training took place over 12 days. On each day the birds received 12 presentations of each of four compounds, each consisting of either B or Y and either the 45° or −45° stripe pattern. For half of the animals the B/45° and Y/−45° compounds were reinforced and the others nonreinforced. For the other half of the animals the reinforcement contingencies were reversed.

On the next day all animals received a single session in which the eventual second-order stimuli, G and V, were preexposed. That session contained 12 nonreinforced presentations each of G and V, intermixed with the presentations of the reinforced color-orientation compounds.

On each of the next 3 days second-order conditioning of G and V was conducted. Each day contained six presentations of V and six presentations of G. For half of the animals, V was followed by the 45° pattern; for the other half it was followed by the −45° pattern. Within each subgroup, half of the animals received G followed by Y, and half received G followed by B. On Days 2 and 3 of second-order conditioning, the animals were also given two separate reinforced presentations of each of the stimuli being used as reinforcers.

On the next day, all animals received a single session of their conditional discrimination. The first half of the next day continued that same discrimination; that was followed by six nonreinforced presentations of the GV compound. The rates of responding during that test constitute the data of primary interest.

Throughout the experiment all stimulus presentations were 5-s long, and the mean intertrial interval was 1 min.

Results and Discussion

The left-hand side of Figure 4 shows the course of discrimination training, with responding separated for the reinforced and nonreinforced compounds. By the end of
training, the rate of responding was substantially greater to the reinforced compounds, $T(16) = 1, p < .01$. Second-order conditioning proceeded smoothly. By the third day the mean response rate to $G$ and $V$ was 34. The right-hand side of Figure 4 shows the results of test presentations of the GV compound. Those results have been separated according to whether the associates of $G$ and $V$ were reinforced (+) or nonreinforced (−) when compounded. The former produced greater responding to the GV compound, $U(8, 8) = 12, p < .05$.

These results suggest that the unique cue involved in a conditional discrimination, like that involved in negative patterning, can be activated by associative means. Apparently, its occurrence depends more on the representations that a stimulus evokes than on the current sensory experience that a stimulus produces.

**Experiment 4**

The conditional discrimination explored in Experiment 3 involved compounds composed of comparable components; both elements were of the same duration, modality, and location. However, some instances of conditional discriminations involve an inherent asymmetry between the components. For instance, in "switching" experiments, animals are taught a discrimination of the form $A+, B−$ in one environment and the reverse $A−, B+$ discrimination in another environment (e.g., Asratyan, 1965). If the environments are viewed as components of a stimulus compound that also contains the $A$ and $B$ elements, such experiments have the logical form of a conditional discrimination. However, the environments differ from the $A$ and $B$ stimuli in being longer and more static. For that reason, some authors have described switching experiments in terms of the environments playing a different role from the discrete stimuli. For instance, the environments have been described as "setting the occasion" for the reinforcement of $A$ or $B$ (e.g., Holland, in press), as "facilitating" responding to those elements (e.g., Rescorla, 1985), or as telling the organism which contingency is in effect.

Despite this asymmetry, one can conceive of switching experiments as solved in terms of unique cues. It is then of interest to ask whether unique cues generated in this way function like those investigated above. Consequently, this experiment applied the techniques of previous experiments to a switching procedure. Birds were initially given a con-
ditional discrimination with two key lights and two longer auditory stimuli. The discrimination was such that one key light was reinforced in the presence of a white noise but not in the presence of a tone; for the other key light the reinforcement contingencies were reversed. Then the animals were given treatments that assessed the responding controlled by the individual auditory and by the individual key-light components. Then the two key lights were used to reinforce two other key lights in a second-order conditioning procedure. Finally, responding to those second-order stimuli was tested in the presence of the tone and noise.

Method

Subjects and apparatus. The subjects were 14 female Carneaux pigeons with histories like those of previous experiments and maintained in the same manner. The apparatus was that of Experiment 1. The left-most response key was employed and could be illuminated with five stimuli: blue (B) light on the full key, either red (R) or yellow (Y) light on the left-hand side of the key, and either a horizontal (H) or vertical (V) stripe pattern on the right-hand side of the key. In addition, two auditory stimuli—a white noise or an 1800 Hz square-wave tone—could be presented. These had intensities of about 76 dB and 81 dB (SPL), respectively.

Procedure. During discrimination training each bird was exposed to four different auditory-visual compounds. Each presentation consisted of a 15-sec white noise or tone, the last 5 sec of which contained either the blue or the red key light. Eight subjects were taught a B+—R—discrimination during the noise and an B—,—R + discrimination during the tone. The remaining 6 subjects had the same treatment with the reinforcement contingencies interchanged. Each of 48 days contained 12 presentations of each compound, presented in a randomized order at a mean intertrial interval of 1 min.

The discrimination session on the next day was extended so that after the 48 training trials each bird received two nonreinforced presentations of each key light both alone and in the presence of each auditory stimulus. The intention of this session was to assess the conditioned strength of the key lights themselves.

The birds were then given a procedure intended to assess the status of the auditory contexts. This test consisted of the presentation of another key light during each auditory stimulus. This procedure began with 15 additional discrimination sessions, the last 12 of which contained nonreinforced pretest presentations of the yellow key light. The first 4 days each contained four presentations of yellow, the last 8 days each contained eight presentations of yellow. Then on each of the next 2 days the birds were tested with four presentations of yellow alone and four in the last 5 sec of each of the auditory stimuli. On the first day all presentations of yellow were nonreinforced; on the second day half of each of the trials types was reinforced. The question of interest is the degree to which the auditory stimuli can modulate responding to a key light other than the key lights used during training (cf. Rescorla, 1985).

Next the birds were given a pretest sequence with the H and V stimuli later to receive second-order conditioning by B and R. This sequence began with 8 days of continued discrimination training during which H and V were rested both alone and in the presence of the auditory stimuli. On the first 2 days, only discrimination training occurred. On the next 3 days, eight nonreinforced 3-s presentations of H and V were intermixed with that discrimination training. On the final day, two nonreinforced presentations of H and V in conjunction with each of the auditory stimuli were intermixed with discrimination trials.

The subjects then received 3 days of second-order conditioning in which H and V were reinforced by 5-s presentations of R and B. Half the subjects received pairings of H with B and of V with R; half received the converse pairings. The assignment was orthogonal to the prior discrimination training treatments. On each day the birds received six second-order trials of each type, intermixed with two reinforced presentations each of R and B. Trials were presented in balanced order with a mean ITI of 2 min. On the next day the birds were given a single retraining session on the conditional discrimination.

Finally, all birds received a single test session during which four nonreinforced presentations of H and V were each given in the presence of the white noise and tone. Those presentations were intermixed with continued discrimination training. It is the performance during these test trials that constitutes the data of primary interest. Because B and R each show differential responding during the auditory stimuli, the question is whether their H and V associates will evoke a similar pattern of differential responding.

Results

Figure 5 shows the course of discrimination training, separated according to the auditory components of the compounds. It is clear that discriminative performance emerged slowly. However, by the end of training there was a substantial difference in responding to the reinforced and nonreinforced compounds. Responding was greater to the reinforced (+) than the nonreinforced (−) key light during both the noise, Wilcoxon T(14) = 11, p < .01, and the tone, T(14) = 3, p < .01. This level of discriminative performance was maintained throughout the remainder of the experiment.

During the next session the key lights were presented alone and in compound with the auditory stimuli. During that test the mean rates of responding were 102 and 38 responses per minute when the key light was presented in its reinforced and nonreinforced com-
of the auditory stimuli to augment responding to yellow suggests that they are no longer neutral. They apparently have either excitatory or facilitatory properties (see Rescorla, 1985).

Pretesting of H and V prior to second-order conditioning confirmed this conclusion. The mean rates of responding were 9 and 22 responses per minute, $T(12) = 12, p < .05$ during the stripe patterns alone and in compound with the auditory stimuli, respectively. Over the course of second-order conditioning, responding to H and V increased from a rate of 26.5 to one of 55.5 responses per minute from the first four to the last four conditioning trials, $T(13) = 4.5, p < .01$. This substantial level of second-order conditioning confirms the excitatory strength of R and B.

Although the original discriminations were reasonably well maintained on the test day in both the noise and tone, 2 of the subjects responded more to a training key light when it was presented in its negative, rather than in its positive, compound. Because the second-order conditioning test presupposes maintenance of the original discrimination, the data from these 2 subjects were not included in the subsequent analysis.

Figure 6 shows the level of responding to the second-order stimuli during the test. The results are presented in blocks of two test trials, separated according to whether those stimuli were presented alone or in compound with the auditory stimuli in which their associate had been reinforced (+) or nonreinforced (−). Responding to the second-order stimuli in the auditory contexts reflected the treatment of their associates. During the second test block there was more responding to H and V when they were presented in a stimulus during which their associates had been reinforced than when they were presented in a context in which their associates had been nonreinforced, $T(9) = 3, p < .05$. During that same block, responding to the patterns was higher in the reinforced context than when they were presented alone, $T(10) = 7, p < .05$. There was no difference in responding to the patterns when presented alone or in the nonreinforced context.

These results suggest that the bird could substitute the associate of a key light for the
Figure 6. Performance to the second-order key lights of Experiment 4 before and after second-order conditioning. (The data are separated for presentations of these stimuli alone [A] and in compound with the auditory stimulus during which their first-order reinforcers had been either reinforced [+] or nonreinforced [-].)

key light itself within the auditory-visual compound without eliminating discriminative performance.

General Discussion

These experiments suggest that the basis for the learning of configural discriminations does not lie in perceptual interactions that depend on the actual physical presence of the component stimuli. Once a discrimination that depends on the joint occurrence of two stimuli has been learned, either or both of those stimuli can be replaced with other stimuli associated with them without totally disrupting performance. This result occurred with two different configural discrimination paradigms and under circumstances where the component stimuli were of similar or different duration or modality. Those results suggest that the evaluation of that joint occurrence takes place at the level of memory representations rather than that of peripheral perceptual processing.

Previously reported results (e.g., Rescorla, 1972, 1973) demonstrate the value of viewing this joint occurrence in terms of a stimulus that it generates. With this assumption, one can account for most of the available data on configural discriminations in Pavlovian conditioning. Moreover, this assumption permits a variety of novel predictions that have received some substantiation. If one adopts the position that these discriminations are learned in terms of a stimulus unique to a stimulus compound, the present results suggest that this stimulus is generated at a reasonably advanced stage of processing. That conclusion makes this a more attractive theoretical alternative. However, whatever explanation of configural conditioning one adopts, the results reported here suggest that the animal is sensitive to conjunction of representations of multiple stimuli whether those conjunctions are activated by the stimuli themselves or associatively.

The present results also provide evidence on the nature of the associations formed in second-order Pavlovian conditioning. They support the position that second-order auto-shaping results in a reasonably detailed encoding of the elements of the association (Rashotte, Griffin, & Sisk, 1977; Rescorla, 1980). The results reported here could be obtained only if the organism had quite accurate information about which stimuli had been paired. It is only then that a stimulus could serve as an adequate replacement for one, rather than another, component of a compound. Indeed, the ability of one stimulus to temporarily control the strength of another target stimulus might be used as a tool to investigate the associates of that target stimulus.

These results expand the range of circumstances under which associatively aroused representations have been shown to substitute for stimuli themselves in governing Pavlovian learning and performance. Holland (1983) has noted that stimulus representations aroused by an associate act like the stimulus itself in promoting responding, interfering with or potentiating learning and performance to other stimuli, entering into new associations, or extinguishing previously learned associations. The present results suggest that an aroused representation can substitute for a stimulus member of a compound to yield a unique compound stimulus. Apparently
under some circumstances, the signal for a stimulus stands sufficiently well for that stimulus as to have many of its functional properties.

References


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