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Response modes in simultaneous and successive visual discriminations

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Modes of responding in simultaneous and successive discrimination problems were investigated using a bidirectional transfer procedure. Rats receiving training on a simultaneous discrimination problem were transferred to successive discriminations. Rats trained on a successive problem were transferred to simultaneous problems. The transfer problems were either compatible or incompatible with the response mode present during training. The results suggest that a single response mode may underlie the solution of both simultaneous and successive discrimination problem.

In a two-choice simultaneous discrimination problem, both discriminanda are present on all trials and discriminative responses are made in the presence of both discriminanda. In a two-choice successive (or conditional) discrimination, the subjects make responses in the presence of two identical stimuli representing only one value of the pair of discriminanda. On any given trial, the pair of discriminanda are not available for comaprison. This procedural difference traditionally has formed the basis for the assumption that different modes of responding are required for simultaneous and successive discrimination problems (Kimble, 1961; Nissen, 1951).

Recently, several studies (Hall, 1973; Mandler, 1966; Mandler & Hooper, 1967) have described the development of a response mode in simultaneous discrimination problems. However, Siegel (1969) has suggested that a similar response mode may occur in successive discriminations. Siegel's data showed that a response mode present in a simultaneous discrimination was readily transferable to a successive problem. However, inasmuch as Siegel's study was designed to assess the effects of overtraining, there was no attempt to determine the functional similarity of the response modes present in simultaneous and successive discriminations through the use of a bidirectional transfer between the two types of problems. In view of the long-standing assumption regarding the response modes underlying these problems, it seems especially important to determine the relationship of these modes of responding.

In earlier work in our laboratory, we observed a basic similarity in the response modes for simultaneous and successive problems. In both types of problems, we observed that rats consistently went to one side of a two-choice discrimination apparatus, regardless of the position of the S+, even during the late stages of acquisition; yet the subjects maintained a high percentage of correct responses in both cases. Figure 1A provides an illustration of the response mode we observed. During discrimination training, the subjects were required to shuttle between the two compartments of the apparatus. Each compartment contained two discriminanda placed side by side. The discriminanda were horizontal stripes (H) and vertical stripes (V), with each discriminandum occurring equally often on the left and right. In the example given, the horizontal stripes have been designated as the S+ in a simultaneous discrimination problem. In the problem, the subject exhibited an initial position preference to the right side (solid arrows). As Figure 1A shows, when the S− appeared on the preference side, the subject moved to the alternative side after first approaching the preference side. Thus, the response of moving to the alternative side is conditional upon the S− appearing on the preference side. The terminal response in this simultaneous discrimination problem is conditional upon the stimulus (S+ or S−) present on the preference side of the apparatus.

If this response mode is common to both simultaneous and successive discrimination problems, we reasoned that the mode should be a powerful source of transfer between the two problems. Figure 1B illustrates how such a transfer effect might occur for a subject showing a right position preference. The successive discrimination problem compatible with the simultaneous task is shown. The compatible successive problem consists of rewarding a response to the right side in the presence of two horizontal stimuli and rewarding a response to the left side in the presence of two vertical stimuli. The mode of responding present in the simultaneous problem (1A) should transfer positively to the compatible successive problem (1B). If the formerly

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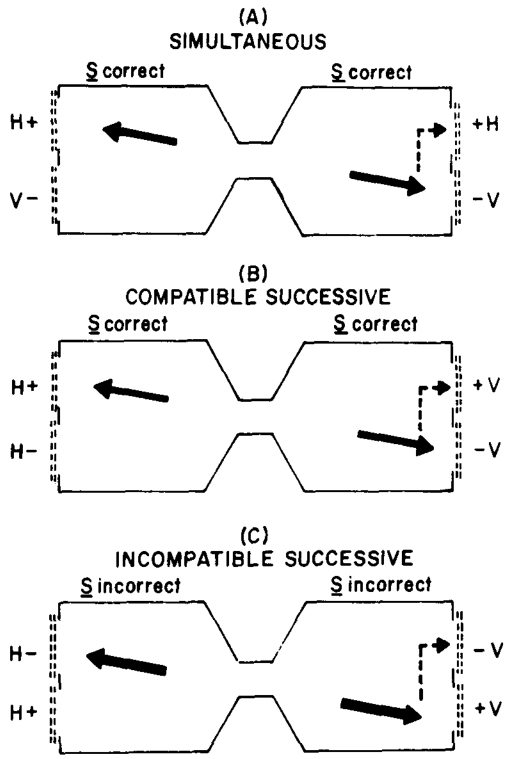

Figure 1. Schematic representation of the response mode observed in a simultaneous discrimination problem and the results of transferring to successive discrimination problems that are compatible and incompatible with the response mode.

positive stimulus (H) is present on the right side, the subject remains on this preference side and makes a correct response. If the formerly negative stimulus (V) is present on the right side, the subject moves to the alternative side and makes a correct terminal response.

The incompatible successive task (1C) consists of rewarding a response to the left side in the presence of two horizontal stimuli (H) and rewarding a response to the right side in the presence of two vertical stimuli (V). The mode of responding present in the simultaneous discrimination problem (1A) should disrupt transfer performance on the incompatible successive problem. Since the subject first approaches the right side, an incorrect response should occur when the formerly positive stimulus (H) is present on the right side. If the formerly negative stimulus (V) appears on the right side, the subject incorrectly moves to the alternative choice and makes an incorrect terminal response to the left side. Performance should be poor relative to that of the compatible transfer group.

This same mode of responding may also develop if a successive discrimination problem is administered prior to transfer to a simultaneous discrimination problem. For example, suppose an initial successive discrimination problem consists of rewarding a response to the right side in the presence of two horizontal stimuli and rewarding a response to the left side in the presence of two vertical stimuli (Figure 1B). According to our analysis, a subject showing a position preference to the right side would first approach the stimulus situated on the right. If the stimulus was vertical (V), the subject would move to the alternative left side and make a correct terminal response. If the stimulus was horizontal (H), the subject would remain on the preference side in order to make a correct response. As is the case for the simultaneous discrimination presented in Figure 1A, the response of moving to the nonpreferred side would be conditional upon the presence of a single vertical stimulus on the preference side. A simultaneous problem having horizontal as S+ and vertical as S− should then be compatible with this successive discrimination, and there should be positive transfer between the two problems. Conversely, a simultaneous discrimination having horizontal as S− and vertical as S+ should be incompatible with the successive problem, and transfer performance should be poor relative to the compatible transfer.

Half of the subjects in the present experiment were transferred from a successive problem to either a compatible or an incompatible simultaneous discrimination problem. The same predictions of transfer performance should be true for the appropriate combination of successive and simultaneous problems, preferences, and discriminanda.

METHOD

Subjects

The subjects were 51 male Long-Evans pigmented rats 55 days old upon arrival. The rats were housed individually throughout the course of the experiment.

Apparatus

The discrimination apparatus (60.9 × 22.9 × 30.5 cm high) was painted flat black and consisted of two identical choice compartments connected by a narrow passageway and covered by a transparent plastic lid. Two 8.9-cm-square transparent plastic panels, placed 2.1 cm apart and hinged individually at the top, were present in each choice compartment. In-line readout projectors were mounted behind each panel to display the discriminanda through the transparent panels. Slight pressure on either of the panels operated a microswitch and shut off the projectors. Simultaneously, the projectors at the other choice compartment were turned on. A correct response was rewarded with a small bead of water delivered automatically by a solenoid-operated water dipper through a small hole in the floor of the apparatus beneath the panels.

A second apparatus having the same basic floor plan as the discrimination apparatus was used for preliminary training. Each compartment in this apparatus had only one translucent panel, which was illuminated by a pair of miniature lamps directly outside the enclosure. A bead of water was delivered directly below the panel when a lighted panel was pressed. Simultaneously, the lamps behind the pressed panel went off and the lamps in the opposite compartment came on.

The preliminary and discrimination enclosures were housed in separate rooms apart from the programming and recording equipment. White noise was present in both rooms throughout an experimental session in order to mask any extraneous sounds.

Procedure

The subjects were given free access to dry lab chow throughout the experiment. On the day following arrival, the rats were handled individually for approximately 1 min each day for a period of 10 days. During this time, the rats were maintained on a 23.5-h water-deprivation schedule. At the onset of training, the subjects were given free access to water for approximately 20 min in their home cages immediately following a training session.

Preliminary training began on the 11th day following arrival. On the first day of preliminary training, the subjects were briefly shaped to press a continuously illuminated panel while restricted to one compartment of the apparatus.

The next days were devoted to training subjects to shuttle between the two compartments of the pretraining apparatus (shuttle training). During the 15-min shuttle training session, pressing a lighted panel turned off that panel and produced a water reward. Simultaneously, the panel in the opposite compartment was lighted.

Following shuttle training, 8 days of discrimination training began in the discrimination apparatus. Trials were administered in blocks of 24 on the first day of training, 48 on the second day, and 72 on each of the remaining days of the experiment. After training, the subjects were given a new discrimination problem for 3 days.

In the simultaneous discrimination problem, each trial consisted of presentation of two discriminanda (one on each panel) in one compartment of the apparatus. Pressing a panel corresponding to the discriminanda designated as S+ resulted in the presentation of a water reward. No reward was delivered for S− panel presses. An incorrect response terminated the trial. The S+ and S− appeared equally often on the left and right panels in both choice compartments.

In the successive discriminative problem, each trial consisted of the presentation of two identical stimuli (one on each panel) representing one value of the pair of discriminanda. In the presence of one value, responses to the left panel were rewarded; in the presence of the other discriminandum value, a response to the right panel was rewarded. No water reward was delivered for an incorrect response. An incorrect response terminated the trial.

Discriminanda

The discriminanda were displayed on a circular field measuring 6.35 cm in diam and consisted of three black and two white stripes, each 1.27 cm wide. In both training and transfer, the discriminanda had a value of 0 deg (horizontal) and 90 deg (vertical). For the simultaneous problem, half of the subjects had 0 deg as S+ and the other half had 90 deg as S+. In the successive problem, half of the subjects were rewarded for a response to the right panel in the presence of two 0-deg stimuli and for a response to the left panel in the presence of two 90-deg stimuli. The other half of the subjects were rewarded for pressing a right panel in the presence of two 90-deg stimuli and for pressing a left panel in the presence of two 0-deg stimuli.

Design

Position preferences were determined on the basis of performance over the entire 8 days of discrimination training. A subject who made greater than 67% of its total number of incorrect responses to the left panel was judged to have a left position preference. Similarly, subjects responding greater than 67% to the right panel were judged to have a right position preference. Nine subjects failed to exhibit a position preference according to this criterion and were discarded.

The transfer discriminations could be either compatible or incompatible with a subject's position preference, as described in the introduction. Half of the subjects received a compatible transfer and half received an incompatible transfer problem. Transfer for half of the subjects was from simultaneous to successive and for the other half was from successive to simultaneous.

Four groups of nine subjects each were used, with six subjects being discarded randomly to equalize group size. The group of subjects receiving a simultaneous discrimination problem during training and transferred to a compatible successive discrimination problem was designated Group Sim-C. The group transferred from a simultaneous problem to an incompatible successive problem was called Group Sim-I. The groups transferred from successive discrimination problems were designated as the Succ-C and Succ-I groups. Thus, the design was a 2 by 2 factorial, with Transfer Problems and Compatibility comprising the two factors.

RESULTS

The data were analyzed in terms of the mean number of correct responses for each group on the first day of transfer. A two-way analysis of variance (Transfer Problem by Compatibility) revealed that the compatible groups performed significantly better than the incompatible groups [$F(1,32) = 199$, $p < .001$]. The main effect of Transfer Problem (simultaneous or successive) was not statistically significant. However, the Transfer Problem by Compatibility interaction was significant [$F(1,32) = 5.4$, $p < .05$]. The groups transferred from a successive to a simultaneous problem produced less compatible and incompatible effects.

Figure 2 displays mean correct responses for each group across all days of the experiment. As suggested by the figure, the simultaneous and successive groups did not differ in total correct responses for the 8 training days. A one-way analysis of variance also revealed no differences among the four groups on the day prior to transfer.

DISCUSSION

The results of this study strongly support and extend the findings of Siegel (1969). Our results demonstrate that a single response mode may underlie the solution of both simultaneous and successive discrimination problems. Whether the initial problem was simultaneous or successive, rats acquired a similar positional response mode based on their position preference and a conditional visual discrimination. This response mode was a powerful source of positive and negative transfer between simultaneous and successive discrimination problems.

The results also clearly demonstrate that Siegel's (1969) findings were not related to the fact that he used an apparatus which prevented his subjects from viewing both discriminanda at the same time. In our apparatus both discriminanda were presented side by side, thus insuring that the subjects had the opportunity to view the discriminanda at the same time.

The present results seriously question studies based

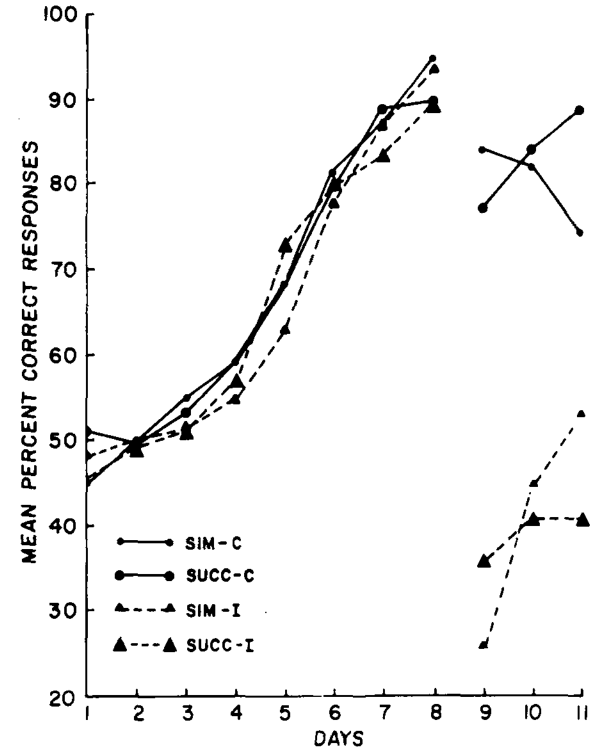

Figure 2. Mean percent correct responses for each group across both training and transfer.

on the assumption that different response modes underlie simultaneous and successive discrimination problems. Both Lawrence (1949) and Mackintosh (1965) made such an assumption in studies supporting the role of attentional processes in discrimination learning. Siegel (1969) made this argument previously in offering evidence that the transfer of overt response modes provided a better account of the overtraining reversal effect than did covert attentional processes. Similarly, the results of the present study emphasize the importance of studying overt response modes in discrimination learning. Differences in discrimination procedures do not insure different modes of responding.

The positional response mode described in this study appeared to be composed of two separate response units: (1) orientation on the basis of a prior position preference and (2) a conditional visual discrimination. Evidence for the independent nature of these response units comes from two sources. First, studies with both rats and rhesus monkeys indicate that position preferences do not retard discrimination learning and are present even after a high degree of learning has been achieved (Riopelle, 1953; Siegel, 1969). Furthermore, studies on learning sets with rhesus monkeys have shown that positional habits and object discriminations may be acquired concurrently (Riopelle & McChinn, 1961). Second, Siegel (1969) found that, after an incompatible transfer from a simultaneous to a successive discrimination problem, his rats learned the transfer problem in one of two ways. According to Siegel, half of the rats retained their original position preference while reversing their conditional responses associated with the conditional visual discrimination. The other half of the rats retained the conditioned responses of the conditional discrimination and reversed their position preference.

Position preference have historically been viewed as sources of error or as, typically incorrect, hypotheses (Harlow, 1949; Krechevsky, 1932). Position preferences, however, need not be sources of error and may actually underlie successful modes of responding. The present study suggests that rats may use a prior position preferences to provide a single unique solution to two different discrimination problems. In such cases, a position preference may be incorporated into a response mode rather than be a source of error to be extinguished.

Finally, it is of some concern that nine subjects were discarded in the present experiment for failing to exhibit a position preference according to the criterion employed. These subjects typically did exhibit what appeared to be a position preference during the early stages of training, but as training progressed, it appeared that in the majority of cases their preference side changed. As a result, the number of incorrect responses to the left and right sides tended to be equalized and a position preference could not be determined according to the criterion. Since the position preference is a basic component in the observed response mode, it is important that any future studies in this area give careful consideration to the method employed in defining a position preference.

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