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BEHAVIORAL CONTRAST AND RESPONSE INDEPENDENT REINFORCEMENT[1]

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Four pigeons received pre-training that included presentation of the reinforcer independently of behavior and then baseline training on a variable-interval schedule of reinforcement. With the introduction of a multiple schedule, in which the first stimulus was associated with a response contingent and a second stimulus with a response independent, 1-min variable-interval schedule, a reduction in response rate was obtained in the second component, which was not accompanied by a behavioral contrast effect in the first component. A further three pigeons were given the same pre-training and baseline training before the introduction of an otherwise identical multiple schedule, in which no reinforcement occured in the second component. Behavioral contrast was obtained from all three subjects. The results indicated that under conditions of constant reinforcement density a reduction in responding is not a sufficient condition for the occurrence of behavioral contrast.

In the experiment that first drew attention to behavioral contrast (Reynolds, 1961*a*), pigeons were first trained on a multiple, variable-interval schedule of reinforcement and then, while responses continued to be reinforced at the same rate in one component (S_1), reinforcement was discontinued in the second component (S_2). As the rate of responding declined in S_2, an increase in response rate was observed in S_1. This behavioral contrast effect in Reynolds' experiment could be attributed either to the reduction of response rate or to the reduction in reinforcement density in S_2, or to some other effect arising from these reductions. While Reynolds claimed that reduction in reinforcement density was the critical factor, Terrace (1968) suggested that a reduction of response rate in S_2 is a sufficient condition for the occurrence of behavioral contrast.

A number of experiments appear to support Terrace's view. For example, when the response rate in S_2 is reduced by the reinforcement of spaced responding, which maintains the same reinforcement density as before, contrast occurs in the S_1 component (Terrace, 1968). Similarly, when a reduction in response rate is produced by punishing responses in S_2 with shocks, whose effect is not sufficient to affect reinforcement density, contrast is again observed in the S_1 component (Brethower and Reynolds, 1962; Terrace, 1968). However, it is quite possible that in these and similar studies the occurrence of contrast is not a direct result of the reduction of responding in S_2, but of the methods used to achieve that reduction. For example, it has been argued that the addition of shock to a constant rate of positive reinforcement is equivalent to a reduction in the rate of positive reinforcement (*e.g.*, Brethower and Reynolds, 1962).

In principle, the simplest way to obtain a change in rate of responding under conditions of constant reinforcement density is to vary the correlation between responding and reinforcement. A fairly rapid decline in response rate has been obtained in a number of studies following a change under single stimulus conditions from response contingent to response independent reinforcement (*e.g.*, Skinner, 1938; Rescorla and Skucy, 1969). Discrimination between response contingent and response independent schedules appears to have been studied in only one previous study (Appel and Hiss, 1962), which established that pigeons

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were capable of such a discrimination. However, the use of fixed-interval reinforcement schedules, the absence of prior baseline conditions, and the form of presentation of the results make it impossible to draw any conclusions about contrast effects from this experiment.

The main purpose of the present experiment was to determine whether a reduction in response rate in one component (S_2) of a multiple schedule, produced by the presentation of response independent reinforcers, would be accompanied by a contrast effect in the other component (S_1) where responding is maintained by response contingent reinforcement. Since it seemed likely that under these conditions response rates in S2 might decrease only very slowly, the following measures were taken during a pretraining phase to increase the chances of obtaining a relatively rapid reduction in responding: (a) following training on a normal variable-interval schedule, all 12 subjects were given six sessions of response independent reinforcers on the same variable-interval schedule (henceforth referred to as a Free VI schedule) to provide prior experience of this kind of condition, and (b) only the eight subjects showing the greatest reduction in responding under these conditions were selected to serve in the remaining part of the study.

METHOD

Subjects

Twelve adult male homing pigeons with no prior experimental history were maintained at 80% of free-feeding weight throughout the experiment.

Apparatus

The experimental chamber measured 12 by 12 by 12 in. (30 by 30 by 30 cm). A single response key, mounted centrally above a grain hopper at a height of 8 in. (20 cm), was trans-illuminated by an in-line projector (Counting Instruments Ltd.). A white key, a blue key, or five orientations of a 5 by 15 mm white rectangle (10, 30, 50, 70, and 90 degrees to the vertical) could be displayed. The reinforcer was 3-sec access to grain. Continuous white noise was present during experimental sessions and conditions were controlled by conventional relay equipment.

Procedure

After magazine training, subjects were trained to peck the white key using an autoshaping procedure (Brown and Jenkins, 1968); autoshaping was then repeated using the 50° rectangle and finally the blue key. In the subsequent pre-training phase, the key was blue an responding was maintained by a variable-interval schedule of reinforcement, whose mean inter-reinforcement interval was progressively increased to 1 min over a period of two sessions and then maintained at this value for a further six sessions. Each session consisted of 20 periods of 90-sec duration, separated by a 3-sec interval in which the chamber was dark and responses ineffective. For the next six sessions conditions remained the same, except that the reinforcer was no longer contingent on key pecking but occurred independently of the subject's behavior on the same variable-interval schedule (Free VI 1-min).

For each subject, the rate of responding during the final two Free VI sessions was expressed as a percentage of the response rate for the final two VI 1-min sessions. Within a group of six subjects the two subjects that showed the smallest decrease in responding on this measure were excluded from the rest of the experiment.

The remaining eight subjects were given non-differential training, in which responses to either the white or the 50° rectangle were reinforced on a VI 1-min schedule. Daily sessions contained twenty-four 90-sec components, separated by 3-sec blackout periods and the two stimuli occurred with equal probability and in semi-random order, with the constraint that a stimulus could not occur more than five times in succession. This training was continued until rates of responding had stabilized. Each subject had a minimum of 16 such sessions; the response rates for one subject continued to show considerable variability after 27 sessions and training was discontinued for this subject.

In the subsequent discrimination phase, stimulus scheduling, number of components per sessions and temporal parameters remained the same and responses to the white stimulus were reinforced as before, on a VI 1-min schedule for all subjects. For three subjects, reinforcement did not occur when the

50° rectangle was present (*mult* VI 1-min EXT conditions). For the other four subjects when the rectangle was present the reinforcer was presented on a VI 1-min schedule and was independent of the subject's behavior (*mult* VI 1-min Free VI 1-min). Subjects in the two groups were matched in terms of performance in the pre-training phase.

After 10 sessions of discrimination training, each subject was given a generalization test in extinction for two successive sessions. The six stimuli in the test were the uniform white stimulus and rectangles at orientations of 10, 30, 50, 70, and 90 degrees to the vertical. Each session contained twenty-four 90-sec stimulus periods, separated by 3-sec blackout periods; the 24 stimulus periods were made up of successive blocks of six, within which each stimulus occurred once in randomized order.

Throughout the experiment daily sessions were given six times per week.

RESULTS

At the end of the pre-training phase, average rates of responding in the final two sessions of Free-VI training ranged from 0 to 76%, median 23%, of the response rates in the final two sessions of VI training. For the eight subjects that continued in the experiment the median rate was 12%, range 0 to 45%.

Response rates to the two stimuli for the final five sessions of non-differential training (*mult* VI 1-min VI 1-min) and the 10 sessions of discrimination training between response contingent and non contingent reinforcers (*mult* VI 1-min Free VI 1-min) are shown in Fig. 1. For each of the four subjects, the rate of responding to the 50° rectangle declined steadily during discrimination training. At the same time response rates to the white key, maintained by contingent reinforcement, also decreased initially, but at a slower rate, to a level of 60 to 80% of the baseline rate. This baseline, shown as a broken line in Fig. 1, was the median response rate to the white stimulus in the final five sessions of non-differential training. In the case of two subjects, response rates to the white key returned to the baseline value before the end of the discrimination phase.

Figure 2 shows the corresponding results for the three subjects for which the discrimination was between contingent reinforcement and no reinforcement (*mult* VI 1-min EXT). In each case, a behavioral contrast effect was obtained, in that, with the decline of responding to the negative stimulus, response rates to the white stimulus increased and remained above the previous baseline value.

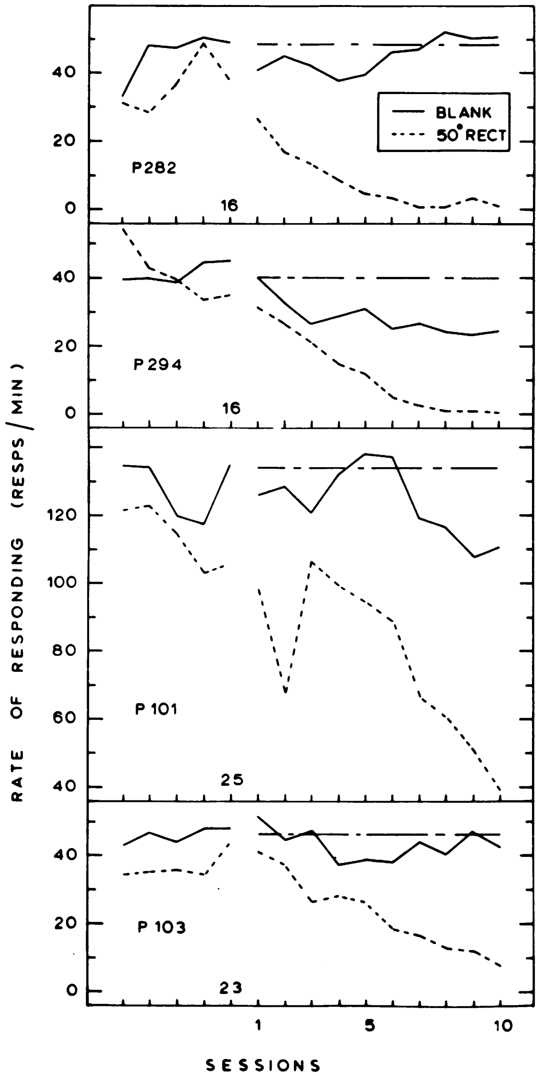

Fig. 1. Rates of responding during the final five sessions of non-differential training and the 10 sessions of discrimination training between VI 1-min (blank white stimulus) and Free VI 1-min (50° rectangle).

The rates at which responding to the 50° rectangle decreased under Free VI and under Extinction conditions can be compared in Fig. 3, where each point represents the response rate to the rectangle for a given session

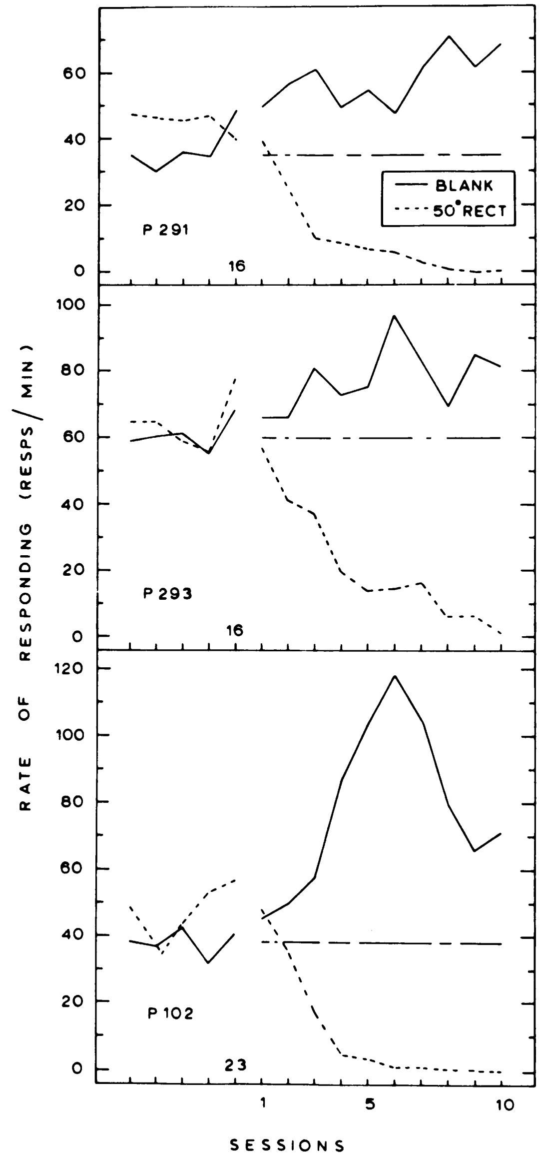

Fig. 2. Rates of responding during the final five sessions of non-differential training and the 10 sessions of discrimination training between VI 1-min (blank white stimulus) and Extinction (50° rectangle).

as a percentage of the median rate to the rectangle in the final five sessions of non-differential training. The solid lines represent the functions for Free VI subjects and the dashed lines the functions for Extinction subjects. The rates of decrease of response rates did not vary widely from subject to subject and there was no strong indication, for example, that the decrease is faster under Extinction than under Free VI conditions.

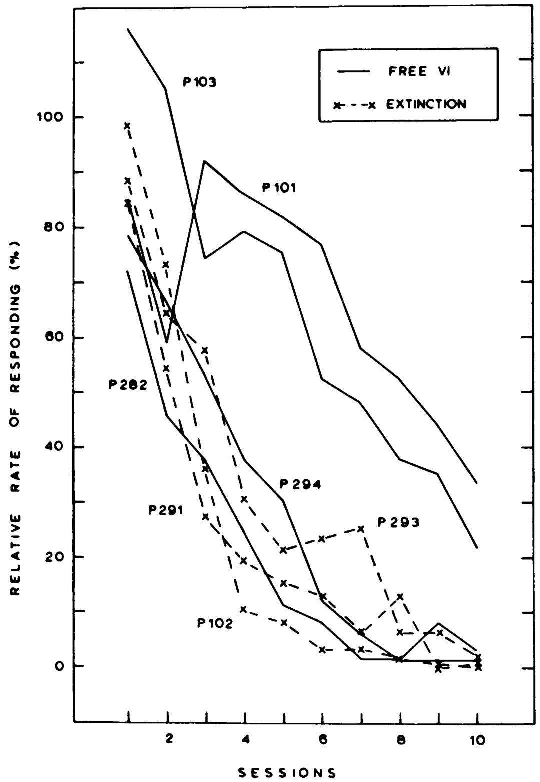

Fig. 3. Rates of responding to the 50° rectangle during discrimination training relative to prior response rates. Rates of responding are shown as percentages of the median rate to the stimulus in the final five sessions of non-differential training.

The results of the post-discrimination generalization tests are shown in Fig. 4, where each point represents the total number of responses made to a given stimulus in the two sessions. Only one subject, P 293, showed any systematic change of response rate with orientation of the rectangle.

DISCUSSION

The most important result of this experiment is that a decrease in response rate in S2 resulting from the introduction of a Free VI schedule in that component does not produce behavioral contrast in S_1. The reduction in response rate for Free VI subjects was in some cases as rapid as that shown by Extinction subjects; hence, the absence of contrast cannot be due to a slower decline of response rates with the Free VI schedule. Nor is it likely that weak contrast effects may have occurred which the present procedure was too

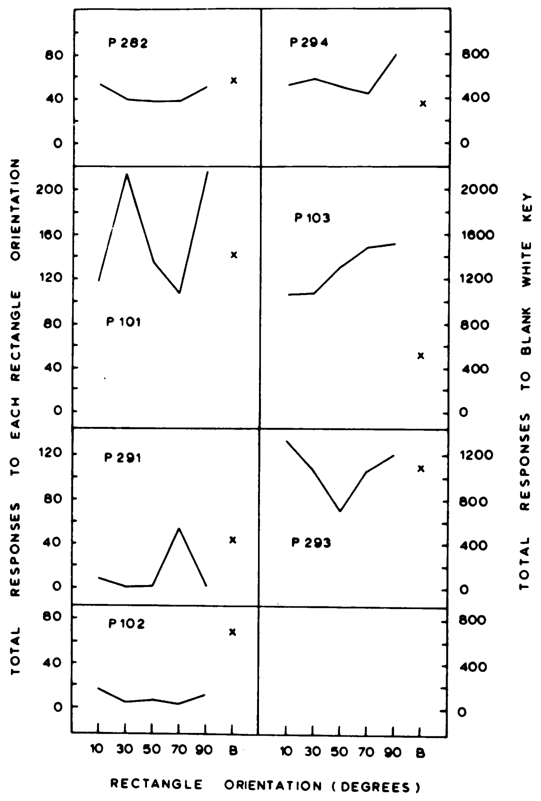

Fig. 4. Generalization gradients averaged over two test sessions. Numbers of responses to each rectangle orientation are shown on the left-hand scale and those to the blank white stimulus (indicated by crosses) on the right-hand scale. The functions in the upper half of the figure are those of the four subjects trained under Free VI conditions and those in the lower half of the three subjects under Extinction conditions.

insensitive to detect, because the changes in response rate in S_1 shown by the Free VI subjects were all in the direction of rate reduction. We conclude, therefore, that under conditions of constant reinforcement density, a reduction in the rate of responding in S_2 is not a sufficient condition for the occurrence of contrast in S_1, although it may be a necessary condition.

In a number of studies, DRO schedules have been introduced in the S_2 component. With such a schedule, the occurrence of the reinforcer is conditional on the absence of responses during some specified interval. In general, the introduction of a DRO schedule leads to changes in reinforcement density. It has been shown that, if this increases substantially, then either no contrast will appear in S_1 (Reynolds, 1961*b*) or there will be a decrease in the rate of responding in S_1, *i.e.*, negative induction (Nevin, 1968). However, by continuously adjusting the DRO schedule during the development of the discrimination, Weisman (1970*a*) was able to keep reinforcement density in S_2 constant, under these conditions contrast occurred.

In both this experiment by Weisman and in the present experiment, a reduction in response rate was obtained in S_2, while the overall reinforcement density was held constant. The occurrence of contrast in one experiment, but not in the other, may be because of possible differences in the actual distribution of reinforcements or, more probably, because of the negative correlation between responding and reinforcement that exists for a DRO schedule but not for a Free VI schedule, where there is no correlation. Weisman (1970*b*) suggested that contrast occurs when there is a negative correlation between responding and reinforcement. This hypothesis would account for the contrast found with the introduction of spaced responding (Terrace, 1968; Weisman, 1969) or DRO (Weisman, 1970*a*) schedules and also for the lack of contrast in the present experiment. But, in the standard behavioral contrast paradigm, where S_2 is associated with Extinction, there is no negative correlation between responding and reinforcement; yet, contrast occurs. Thus, Weisman's hypothesis does not account for this basic case.

Weisman's hypothesis, like that of Reynolds, is an attempt to account for contrast by identifying some unique feature of schedules, which when introduced in S_2, produce contrast in S_1. The evidence so far has failed to reveal any such feature, since neither reduction in reinforcement density nor negative correlations between responding and reinforcement uniquely specify those schedules that result in contrast. An alternative approach is to suppose that contrast is a by-product of the effects on an animal that can follow certain changes of conditions. One example of this is Terrace's hypothesis of response-rate reduction. The present experiment showed that this particular effect is not the critical one. However, this may be the correct approach so that one should look for some other common effect, which might well be described as inhibition (Terrace, 1966) or frustration (Scull, Davies, and Amsel, 1970). In this connection it is unfortunate that the present results from the generalization tests provided inconclusive evidence on inhibitory gradients.

There are clear indications of reductions in S_1 response rates with the introduction of the Free VI schedule in S_2. This induction has been observed in other experiments (*e.g.*, Nevin, 1968). This phenomenon is not well understood, but it might be expected that, in the absence of factors giving rise to contrast, some generalization might take place from S_2 to S_1.

Performance under Free VI schedules of reinforcement is of interest, apart from the relevance to behavioral contrast, as part of the general problem of extinction processes. Rescorla and Skucy (1969) suggested that experimental extinction can be described as the removal of a response-reinforcer relationship and that the normal extinction procedure, that of removing reinforcement, is but one example of a large class of procedures. In their comparison of the effects of introducing Extinction and Free VI conditions after variable-interval reinforcement of bar pressing by rats they found that response rates fell slightly more slowly and to a higher asymptotic level under Free VI conditions. On the basis of a series of experiments they concluded that this difference was not due to occasional accidental reinforcement of bar pressing, as originally suggested by Skinner (1938), but partly to the food acting as a discriminative stimulus for responding and partly to the maintenance of general activity in the neighborhood of the bar. It should be noted that these conclusions were based on variable-interval schedules and that, when reinforcers occur independently of behavior at fixed intervals, there is evidence in the form of scalloping for the maintenance of responding by accidental reinforcement (Appel and Hiss, 1962; Zeiler, 1968), presumably because fixed-interval schedules produce an accidental correlation between responding and reinforcement. The present experiment shows that the conclusion reached by Rescorla and Skucy, that the differences between removing a response-reinforcement relationship and removing reinforcement altogether are confined to relatively minor effects, is incorrect, in that the two procedures differ substantially in the way that they interact with response contingent schedules.

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