An analysis of the relationship between behavioral contrast and responding to S– in successive discrimination learning

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Ten pigeons were given extended training with VI 60-sec reinforcement contingent upon keypecking at a 555-nm stimulus in an otherwise darkened chamber with white noise present. After attainment of response rate stability, 30 sessions of successive discrimination training were run, with VI 60-sec reinforcement still signaled by the stimulus conditions indicated above, while an unilluminated response key, a houselight and a 1000-Hz tone signaled extinction. Most subjects showed little tendency to respond to S–, yet all but one subject clearly showed positive behavioral contrast. The magnitude of the contrast effect was not systematically related to either the absolute level or to the pattern of responding during the nonreinforced stimulus.

Terrace (1966, 1972) has proposed that positive behavioral contrast, an increase in response rate to the S+ in a successive discrimination relative to antecedent baseline levels, is an aftereffect of the reduction in the rate of responding to S–. In support of his position, Terrace has reported several studies in which behavioral contrast was presumably absent when a discrimination was acquired with few or no nonreinforced responses during S–. On the other hand, several studies from other laboratories, including those of Friedman and Guttman (1965), Mackintosh, Little, and Lord (1973), Reynolds (1961), Sadowsky (1973), Taus and Hearst (1970), and Vieth and Rilling (1972) have reported behavioral contrast in situations (such as the use of a blackout as S–) where presumably very little responding in S– occurred. Unfortunately, some of the aforementioned studies did not report actual response levels to S–. Some others did not employ sufficient baseline training to permit responding to the future S+ to stabilize, thereby precluding a proper basis for the determination of a contrast effect. The Sadowsky experiment avoided these problems but was based upon every few subjects. The present experiment was designed to determine whether in a situation involving relatively few responses to S– there might still be a relationship between some aspect of responding to S– and the degree of behavioral contrast observed in individual animals. For this purpose, we employed a successive discrimination procedure which entailed differentiation of S+ and S– on the basis of changes in contextual stimuli (i.e., ambient illumination and noise levels), as well as in stimuli projected onto the response key.

METHOD

Subjects
Subjects were 10 experimentally naive common pigeons obtained from a local supplier and maintained at 75% of their ad-lib weight.

Apparatus
Four standard operant chambers were used. In each chamber a translucent response key (2.5 cm in diam) was located in the middle of the magazine wall approximately 21 cm above the floor with the grain hopper opening (5.2 cm high by 6.5 cm wide) situated 10 cm directly below. In each chamber, an Industrial Electronic Engineers in-line projector (Model 10-3043-1815-L) equipped with G.E. No. 1815 bulbs was mounted behind the response key and provided a chromatic stimulus with a dominant wavelength of 555 nm (Kodak Wratten Filter No. 99). The houselight, a G.E. No. 1215 bulb, was projected onto and diffused by a strip of translucent pearl-white Plexiglas which spanned the top 5 cm of the magazine wall. Intensity of the houselights averaged 47 fL for the four chambers when measured from a position approximating that of the subjects' heads when keypecking. A 4-in. (10.24 cm) audio speaker, mounted behind the lower right quadrant of the magazine wall, was used to deliver a 1000-Hz tone at 95 dB SPL or white noise at 80 dB SPL. Three seconds of access to mixed grain served as the reinforcing event and was accompanined by illumination of a light (G.E. No. 1815 bulb) in the grain hopper opening. Manipulation of all experimental variables was programmed through standard solid state circuitry located in an adjoining room.

Procedure
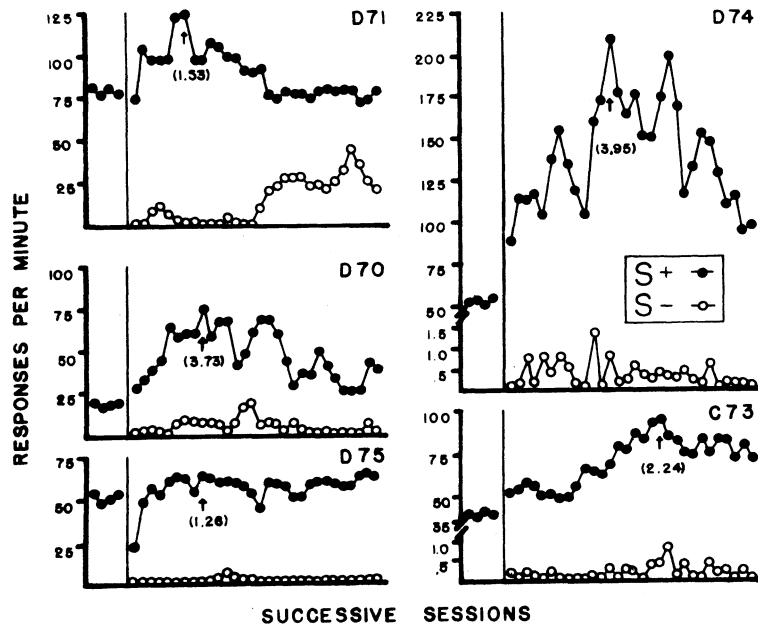During the first experimental session, subjects were magazine

Figure 1. Response rates during the terminal four baseline sessions and S+ and S− periods during successive discrimination sessions for Subjects D71, D70, D75, D74, and C73. Arrows indicate the sessions in which peak behavioral contrast occurred, and peak behavioral contrast ratios are indicated within parentheses for each subject. The Y-axes have been expanded at the lower values for Subjects D74 and C73. Closed circles represent response rates during baseline and S+, whereas open circles represent response rates during S−.

trained and then trained to keypeck by the method of successive approximations. Following emission of the first response, 50 reinforcers were earned in accordance with a variable-interval 15-sec schedule (VI 15-sec). All VI schedules used in this experiment were of the constant probability type described by Catania and Reynolds (1968, P. 381). Subjects received 60 reinforcers in each of Sessions 2 and 3 according to VI 24-sec and VI 30-sec schedules, respectively.

Baseline training consisted of a minimum of 10 sessions of 30-min duration in which a VI 60-sec schedule of reinforcement was in effect. This phase of training was not terminated for individual subjects until variability in daily response rates was less than ± 5% from the mean response rate computed for four consecutive sessions. Up to this point in the experiment, the response key was illuminated with the 555-nm stimulus, the houselight was off, and white noise was present. These conditions prevailed when each subject was placed in the chamber and remained in effect until the subject was removed.

Successive discrimination training began on the session after each subject's performance met the aforementioned stability criterion. The 555-nm key stimulus presented in an otherwise dark experimental chamber and the presence of white noise continued to signal VI 60-sec reinforcement (S+). An unilluminated response key and presentation of changed contextual stimuli, i.e., houselight and tone, signaled experimental extinction (S−). These discriminative stimulus compounds were each presented for a duration of 1-min, and no blackouts were interpolated between successive stimulus presentations. Both S+ and S− values were presented 15 times in a semirandom order during the course of an experimental session with a restriction that neither stimulus occurred for more than two consecutive 1-min periods. Discrimination training was continued for a total of 30 sessions.

RESULTS

The results were analyzed in terms of rates and patterns of responding during S+ and S− stimuli (across sessions) and behavioral contrast ratios (response rate during S+ for a given session divided by mean rate of responding on the terminal four baseline sessions for the

respective subjects).

Figures 1 and 2 illustrate response rates for individual subjects during terminal baseline sessions and during S+ and S− periods of the 30 discrimination training sessions. The number of baseline sessions necessary to meet the requirements of the stability criterion ranged from 11 to 35 with a mean of 25.5. Mean response rates for the four terminal baseline sessions ranged from 20.5 to 74.4 responses per min with a mean of 49.5. Responding during S− periods occurred at very low rates for several subjects. The lower-valued portions of the Y-axes have been expanded in order to display possible systematic trends in response rates during S− for these subjects.

With the exception of D75, the rates of responding during presentations of the stimulus complex constituting S+ were substantially increased relative to those of terminal baseline sessions. Behavioral contrast ratios computed for the session in which each subject responded at maximal rate during S+ ("peak contrast," as indicated by the arrows in Figures 1 and 2) ranges from 1.26 to 3.95. These ratios reflect increments of 26% and 295% above baseline levels. Increments in response rates to maximum levels during S+ occurred very gradually across sessions for some subjects (e.g., C82 and C73) and more abruptly for others (e.g., C70 and D71). Behavioral contrast was sustained throughout discrimination training for five subjects (D72, C73, D78, C70, and C82) and appeared to dissipate with extended training for four subjects (D70, D71, D74, and D79).

Despite the fact that nine of the ten subjects showed clear evidence of behavioral contrast, no consistent patterns in S− response rates are evident across subjects. Five subjects (C73, D79, C82, D72, and D78) rarely emitted S− responses at a rate exceeding .5 responses
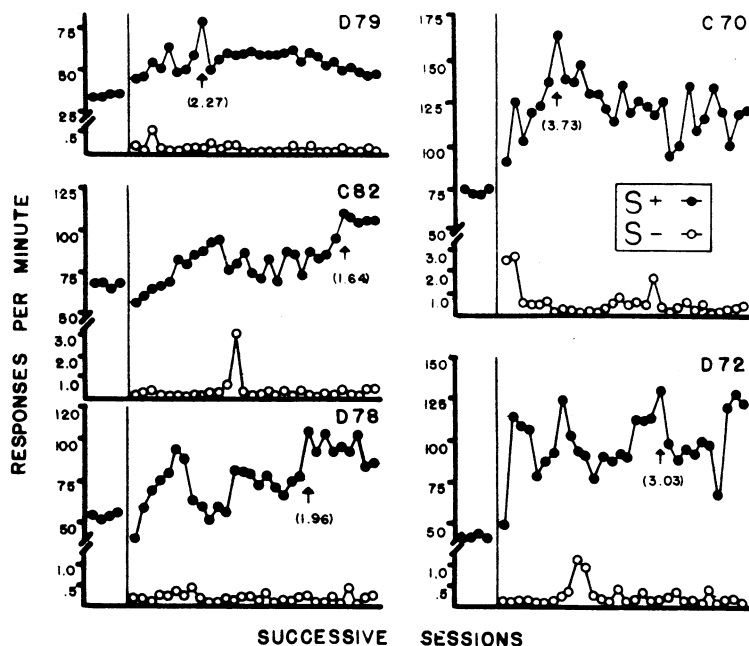
Figure 2. Response rates during the terminal four baseline sessions and S+ and S– periods during successive discrimination sessions for Subjects D79, C82, D78, C70, and D72. Arrows indicate the sessions in which peak behavioral contrast occurred, and peak behavioral contrast ratios are indicated within the parentheses for each subject. They Y-axes have been expanded (at the lower values) for all subject. Closed circles represent response rates during baseline and S+ whereas open circles represent response rates during S–.

per minute. Thus substantial responding to S– during discrimination training is clearly not a prerequisite for obtaining behavioral contrast. Neither can response rate *reduction* be a prerequisite since response rates to S– were initially very low, allowing no substantial rate reduction.

The determination of whether or not response rate *reduction* to S– has taken place requires the specification of a baseline level for purposes of comparison. Since the S– stimulus was first introduced at the time discrimination was initiated in this study, no prediscrimination baseline is available. The rate of responding to S– on the first discrimination training session may be used as a baseline. If some response rate reduction to S– had occurred during Session 1, a lower rate would be expected during Session 2, but this generally did not occur.

An obvious reduction in S– response rate across several of the initial discrimination sessions is evident for only one subject (C70), and there is a tendency for S– response rates to increase with extended training for some subjects (e.g., D70 and D71). It is, of course, possible that response rate reduction to S–, although not required, might contribute to the magnitude of behavioral contrast observed. There is, however, no evidence for this. Subject C70 showed no greater contrast effect than did Subjects D74 and D70, who showed no S– response rate reductions.

For purposes of correlational analysis, the peak behavioral contrast ratio was employed. There was no apparent correlation between the magnitude of peak behavioral contrast and: (1) the total number of responses emitted during S– up to and including that session, or (2) the number of responses emitted to S–

during that session. Pearson product moment correlation values of R = +.11 (t = .31, df = 8, p < .50) and r = +.40 (t = 1.24, df = 8, p > .01) were obtained for the former and latter comparisons, respectively.

DISCUSSION

Sadowsky's (1973) study had included a condition in which the houselight remained on and only the key light was darkened during S–. Only two birds were run under this condition, however, both of which showed behavioral contrast whereas only one had responded to S–. In a sense, then, the present study may be viewed as an extension of the Sadowsky experiment with the addition of an auditory and a houselight cue, and with enough subjects to permit a correlational answer to the question: "Is the magnitude of behavioral contrast related to either prior or present levels of responding to the S–?" Both questions were answered in the negative.

Gonzales and Champlin (1974) and Mackintosh, Little, and Lord (1972) have reported data suggesting that, despite our use of a rigorous stability criterion, response rate to S+ probably would have continued to gradually increase throughout the course of the experiment even if discrimination training had not been introduced. Thus, the magnitude of behavioral contrast reported here is probably an overestimate; however, it should be clear that this would not have affected any of our conclusions, since they were based upon relative amounts of contrast among the different animals in the experiment.

In the present experiment, highly efficient discrimination performance was based upon a change in the entire stimulus complex which denoted S+, including the key stimulus, the dark chamber, and the white noise. This suggests a practical procedure for making discrimination learning more efficient, i.e., the S+ and S– should be viewed as stimulus compounds and the more elements which differ between the two compounds, the more rapidly the discrimination is likely to proceed. The role of contextual stimuli in classical conditioning has been emphasized by Rescorla and Wagner (1972), but their function in operant conditioning is not generally recognized. The present study, in

addition to an earlier one by Welker, Tomie, Davitt, and Thomas (1973), represents a step in this direction.

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