SEQUENTIAL CONTRAST EFFECTS WITH HUMAN SUBJECTS¹

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Institutionalized retardates were exposed to a multiple variable-interval: extinction schedule of reinforcement in which 5-min periods of variable-interval reinforcement and 5-min periods of extinction were presented in a random order. This schedule was found to generate sequential contrast effects: response rates during variable-interval reinforcement were higher when a variable-interval period followed an extinction period than when it followed another variable-interval period. The rate of responding within a variable-interval period also was affected by the number of extinction periods preceding a variable-interval period. As the number of successive extinction periods that preceded a variable-interval period increased, the rate of responding during that variable-interval period increased. The sequential contrast effects were transient, being most evident during the early sessions and generally disappearing by the tenth session.

Many schedules of reinforcement have been studied with laboratory animals (Ferster and Skinner, 1957; Honig, 1966). Although some schedule effects demonstrated with animals have been demonstrated with humans (Bijou and Baer, 1967; Krasner and Ullmann, 1965; Ullmann and Krasner, 1965), many others have not. One schedule effect that has not been demonstrated with humans is behavioral contrast. This effect is demonstrated with experimental conditions that successively present experimental subjects with two stimuli. The rate of responding during one stimulus is altered by changing the schedule of reinforcement during the other stimulus. This change in response rate is called behavioral contrast when the change is in a direction away from the response rate during the other stimulus (Reynolds, 1961). An effect similar to behav-

ioral contrast was first reported by Pavlov (1927) in studies of classical conditioning. He found that conditioned salivation had a shorter latency and a greater magnitude when the conditioned stimulus followed presentation of another stimulus that had been paired with non-reinforcement. Pavlov called this phenomenon positive induction. Skinner (1938) observed a similar effect in operant conditioning studies. He reported that during a discrimination problem, in which responding was reinforced during one stimulus (S+) but not during another (S-), the rate of responding increased during S+ as the rate of responding decreased during S-. Similar findings have been reported by Smith and Hoy (1954) and Herrick, Myers, and Korotkin (1959).

In recent years, behavioral contrast has been studied primarily with pigeons in two-component multiple schedules. During this procedure, two stimuli, each correlated with independent schedules of reinforcement, are presented successively. To produce behavioral contrast, pigeons' key-peck responses are first reinforced in both components according to identical schedules of reinforcement. After response rates have stabilized, reinforcement is no longer delivered in one component (S-) while the schedule of reinforcement in the second component remains the same (S+). This change in procedure results in an increased rate of responding during S+ (Bloom-

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field, 1966; Nevin and Shettleworth, 1966; Reynolds, 1961; Terrace, 1966). The increase in the response rate during S+ has been shown to be produced by rate increases within S+ components resulting from preceding S- components (Bloomfield, 1967; Boneau and Axelrod, 1962; Catania and Gill, 1964; Nevin and Shettleworth, 1966).

Terrace (1966) studied this contrast effect further by programming a multiple schedule of reinforcement in which S+ and S- components were presented in a random order rather than in alternation. This schedule programmed S+ components to occur after both S- components and other S+ components. Response rates during S+ components that followed S- components (S+/S-) were greater than response rates during S+ components that followed other S+ components (S+/S+). Terrace (1966) called this phenomenon "sequential contrast effects".

The present experiment attempted to demonstrate sequential contrast effects with human subjects. The subjects for the study were chosen from an institutionalized population so that experimental control over environmental variables could be maximized.

METHOD

Subjects

Two teenage girls living in the same building of the A. L. Bowen Children's Center in Harrisburg, Illinois served as subjects. Subject EH, age 18 and I.Q. of 77 (according to hospital records) had previous training in the experimental room on a variant of the multiple schedule programmed in this study. Subject RC, age 16 and I.Q. of 73, was experimentally naive.

Apparatus

A single room, 8 ft. by 10 ft, with a one-way mirror served as the experimental room. On top of a desk in the room were a response manipulandum, stimulus lights, and a reinforcement tray. The response manipulandum was a push-button (1-in. diameter with a 500-g force required to close its contacts) centered in the lower half of the face of a wooden box, 9 by 12 by 4 in. The face of the box was slanted for easier viewing by the subject. The stimulus lights were two jewel lights (red and green) mounted 4 in. from the back of the box

and separated by 3 in. The reinforcement tray was a rubber dish situated on the desk to the left of the box and immediately below the opening of a metal pipe extending from a hole in the wall. The pipe served to pass pennies from an adjacent room into the tray. Standard programming and recording equipment were housed in an adjacent room.

Procedure

The subjects were presented with a multiple VI 1-min extinction schedule during daily sessions. During the VI component, the red stimulus light was illuminated and pennies were delivered for responses on the average of 1 per min. During the extinction component, the green light was illuminated and no reinforcement was programmed. The components were 5 min in duration and were presented in a random sequence determined from a table of random numbers. Sequences of greater than three successive presentations of either stimulus were eliminated. Consecutive components were separated by a period of approximately 0.5 sec during which the stimulus lights were turned off.

During the initial session, each subject was seated in front of the desk and instructed as follows: "See if you can make this work." The experimenter pressed the response button once with one finger. Pause. "I will tell you when it is time to leave." The experimenter then left the room leaving the subject to respond on a VI 1-min component of the multiple schedule. Thereafter, the start of a session was signaled by the illumination of a stimulus light, which occurred after the subject entered the room and sat at the desk. Session duration ranged from 30 to 60 min. At the end of each session, the experimenter knocked on the door of the experimental room, entered, and reminded the subject of the time and day of the next session.

All responses were recorded on counters and a cumulative recorder. The reinforcement delivery was accomplished by the experimenter dropping a penny into the metal pipe, which passed the penny into the rubber dish in the experimental room. Accompanying each reinforcement was a 3-sec timeout during which the stimulus lights were turned off. Responses during the timeout were not reinforced. Pennies earned were used by the subjects to purchase various consumables and small articles at the Center's commissary.

RESULTS

Figure 1 shows the daily response rate during presentations of S+ (VI 1-min) and S- (extinction) components for Subjects EH and RC. Within every session, the response rate during S+ was greater than the response rate during S- for both subjects. Over all sessions, the response rate during S- for Subject RC averaged 50% below the response rate during S+ with a range from 27 to 66%. For Subject EH, the response rate during S- averaged 20% below the response rate during S+ and the range was from 3 to 32%. The difference between the response rate during S+ and the response rate during S- did not appear to vary in any specific pattern, although the rate difference tended to decrease over time for Subject RC.

Behavioral contrast, defined as an increase in the response rate during S+ accompanying a decrease in the response rate during S-, was not positively demonstrated in these data. Although RC showed an elevated response rate during S+ from Sessions 2 through 6, there was no accompanying decrease in the response rate during S-. EH showed neither

an increase in the response rate during S+ nor a decrease during S- over time.

Sequential contrast effects, defined as a greater response rate during S+ when S+ is preceded by an S- component than when S+ is preceded by other S+ components, were evident in both subjects, as can be seen in Fig. 2. The data presented in this figure are per cent differences between response rates during S+ components that followed S- components (S+/S-) and response rates during S+ components that followed other S+ components (S+/S+). The per cent difference was calculated by subtracting the rate for S+/S+ for each session from the rate for S+/S- for the same session and dividing the difference by the rate for S+/S+, *i.e.*,

$$\left[\frac{(S+/S-) - (S+/S+)}{S+/S+} \right].$$

This proportion was then multiplied by 100 to obtain the per cent difference in rates. A positive per cent difference indicates the occurrence of sequential contrast effects, and the magnitude of the difference indicates the magnitude of the sequential contrast effects. The per cent difference was used rather than the

Fig. 1. Responses per minute during S+ and S-. S+ was a red light during which responding was reinforced with pennies on a VI 1-min schedule, and S- was a green light during which no responses were reinforced. Five-minute components of S+ and S- were presented in a random sequence.

Fig. 2. The per cent difference between response rates during S+ components that followed S- components and response rates during S+ components that followed other S+ components. The per cent difference was calculated by subtracting the rate during S+ components that followed other S+ components from the rate during S+ components that followed S- components, and dividing the difference by the rate during S+ components that followed other S+ components. This proportion was then multiplied by 100.

difference between absolute rates because the absolute rates varied considerably between sessions.

It can be seen in Fig. 2 that the per cent difference in rates was positive for Subject EH during Sessions 1 through 9, indicating the occurrence of sequential contrast effects in each of these sessions. The magnitude of the sequential contrast effects was greatest during the early sessions, and by Session 10, the effect was absent. During Sessions 10 through 17, the per cent difference in rates was generally near or below zero, and it was positive in less than 50% of these sessions. The data for Subject RC are similar. With the exception of Session 3, the per cent difference was positive during Sessions 1 through 6. By Session 12, the per cent difference in rates was near or below zero, where it remained for the duration of the experiment.

When sequential contrast effects were obtained, the magnitude of the effect appeared to

be a function of the number of S- components that preceded an S+ component. This relationship can be seen in Fig. 3. The data presented in Fig. 3 were obtained by classifying each S+ component in terms of the components that had preceded it, *i.e.*, S+ preceded by three S- components, two S- components, one S- component, one S+ component or two S+ components. The response rate during each S+ component was converted into a percentage of the average S+ rate for the session in which it occurred. A separate analysis is presented for those sessions in which sequential contrast was present (1 to 9 for Subject EH; 1 to 12 for RC) and for those sessions in which sequential contrast was absent (10 to 17 for EH; 13 to 17 for RC).

The upper section of Fig. 3 shows that for Subject RC, the rate of responding during S+ is an increasing function of the number of S- components preceding S+. The response rate during S+ also appears to be a slightly de-

Fig. 3. Average rate of responding for S+ components as a function of the nature of the preceding components. The response rates are expressed as percentages of the average S+ rate of the session in which they occurred. The upper graph indicates the response rates when sequential contrast effects were recorded (Sessions 1 to 9 for EH; 1 to 12 for RC); the lower graph indicates the response rates when sequential contrast effects were absent (Sessions 10 to 17 for EH; 13 to 17 for RC).

creasing function of the number of consecutive S+ components that preceded it. The data are similar for Subject EH, with the exception of the unusually high response rate during S+ preceded by two S- components.

The lower section of Fig. 3 shows that this relationship does not exist for those sessions in which sequential contrast effects were absent.

This relationship was also analyzed within sessions by calculating the rate of responding for each category within a session and comparing that rate with the rate for the next lowest category. If the comparison was not in the expected direction, the comparison was labeled a reversal. (For sessions in which a category was not represented, the comparison was made with the next lowest category that did occur in the session.)

Only one reversal occurred in 25 comparisons for Subject EH during sessions in which sequential contrast occurred (1 to 9); however, 10 reversals in 26 comparisons occurred during sessions in which sequential contrast was absent (10 to 17). The data for RC are similar. Three reversals occurred in 20 comparisons during sessions in which sequential contrast was present (1 to 6); however, 13 reversals occurred in 31 comparisons during sessions in which sequential contrast was absent (7 to 17).

DISCUSSION

This study demonstrated sequential contrast effects with humans, and the effects were remarkably similar to the effects with pigeons as reported by Terrace (1966). The increase in the response rate during S+ following the presentation of an S-, although relatively small, was highly reliable during the early sessions, for both humans in the present study and pigeons in Terrace's study. The increase was greatest during early sessions and became smaller in later sessions for both studies. The increase was transient, disappearing in 9 to 12 sessions with the humans in the present study and in 12 to 40 sessions with the pigeons in the Terrace study.

The present study also demonstrated stimulus control over rate of responding. For all sessions, response rates during S+ were greater than response rates during S-. However, the S- (extinction) component of the multiple schedule did not result in as low a response rate as is generally seen in laboratory animals (Ferster and Skinner, 1957). The possibility that S+ responding would increase as S- responding decreased (behavioral contrast) could not be evaluated since S- responding did not decrease. The existence of this type of contrast might be suggested in the data for Subject RC who did show an elevated response rate during S+ in Sessions 1 through 6. Subject EH, however, did not show a similar increase.

It was also found that the response rate during S+ increased as more S- components preceded the S+, suggesting that the duration of a prior exposure to S- affected the response rate during the following S+ component: the greater the prior exposure to extinction, the greater the increase in the response rate during the following S+.

Although the effects of preceding periods of S+ on the rate of responding in the following S+ component were very slight, they were highly reliable, as evidenced by the few reversals that occurred in the within-session analysis. The finding suggests the possibility that the duration of a prior exposure to S+ may also have an effect on the following S+ response rate: the greater the prior exposure to S+, the greater the decrease in the response rate during the following S+.

REFERENCES

- Ayllon, T. and Azrin, N. H. *A motivating environment for therapy and rehabilitation*. New York: Appleton-Century-Crofts, in press.
- Bijou, S. W. and Baer, D. M. *Child development: readings in experimental analysis*. New York: Appleton-Century-Crofts, 1967.
- Bloomfield, T. M. Two types of behavioral contrast in discrimination learning. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 155-161.
- Bloomfield, T. M. Some temporal properties of behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1967, 10, 159-164.
- Boneau, C. A. and Axelrod, S. Work decrement and reminiscence in pigeon operant responding. *Journal of Experimental Psychology*, 1962, 64, 352-354.
- Catania, A. C. and Gill, C. A. Inhibition and behavioral contrast. *Psychonomic Science*, 1964, 1, 257-258.
- Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Herrick, R. M., Myers, J. L., and Korotkin, A. L. Changes in S^D and S⁺ rates during the development of an operant discrimination. *Journal of Comparative and Physiological Psychology*, 1959, 52, 359-364.
- Honig, W. K. (Ed.) *Operant behavior: areas of research and applications*. New York: Appleton-Century-Crofts, 1966.
- Krasner, L. and Ullmann, L. P. (Ed.) *Research in behavior modification: new developments and implications*. New York: Holt, Rinehart & Winston, Inc., 1965.
- Nevin, J. A. and Shettleworth, S. J. An analysis of contrast effects in multiple schedules. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 305-315.
- Pavlov, I. P. *Conditioned reflexes: an investigation of the physiological activity of the cerebral cortex*. New York: Dover Publications, Inc., 1927.
- Reynolds, G. S. Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 57-71.
- Skinner, B. F. *The behavior of organisms*. New York: Appleton-Century-Crofts, 1938.
- Smith, H. M. and Hoy, W. J. Rate of response during operant discrimination. *Journal of Experimental Psychology*, 1954, 48, 259-264.
- Terrace, H. S. Stimulus control. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 271-344.
- Ullmann, L. P. and Krasner, L. (Ed.) *Case studies in behavior modification*. New York: Holt, Rinehart & Winston, Inc., 1965.

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