FACILITATION OF LARGE RATIO PERFORMANCE BY USE OF CONDITIONED REINFORCEMENT¹

JACK D. FINDLEY² AND JOSEPH V. BRADY

UNIVERSITY OF MARYLAND AND WALTER REED ARMY INSTITUTE OF RESEARCH

Fixed ratio performance was examined in the chimpanzee under two alternating conditions. In one, conditioned reinforcement followed successive fractions of the total ratio, and in the other it was omitted. Shorter pauses and working times, and the development of a strong preference resulted for the condition affording conditioned reinforcement.

Several conditioned reinforcement studies summarized by Kelleher and Gollub (1962) show substantial reinforcing effects obtained with stimuli that are consistently correlated with food reinforcement. In general, the reinforcing property of such stimuli may be established by simple correlation with food delivery, or by chaining procedures where, temporally, the stimuli are sometimes considerably removed from food reinforcement. Utilizing a light correlated with food delivery, recent studies by Zimmerman (1963) and by Kelleher (1964) show very clear conditioned reinforcement effects by using the stimulus as an intermittent reinforcement for other behavior. Using a similar procedure, Findley (1962) found that a light associated with food reinforcement could be effectively employed as a conditioned reinforcement for an explicit chain of behavior. He also found that several repetitions of a short chain, each followed by conditioned reinforcement, was a more effective procedure than one long chain, equivalent in number of responses and amount of food delivery, but without conditioned reinforcement. The work of several investigators, therefore, raises questions not only concerning various methods for establishing conditioned reinforcement, but also as to its potential for enhancing and sustaining otherwise weak behavior. The present experiment focuses upon the latter question and was designed to test the facilitating effect of conditioned reinforcement

upon two aspects of large fixed-ratio performance.

METHOD AND PROCEDURE

An adult male chimpanzee served as the major subject. It lived within an experimental chamber approximately 5 ft square. Conventional programming and recording equipment was employed, and the experimental program ran continuously. After a long experimental history on various fixed ratio requirements, the chimpanzee was exposed to the following procedure. In the presence of a red stimulus, 4,000 responses on a heavy push button³ automatically extinguished the red light and dropped 20, 0.67 g food pellets one at a time into a hopper illuminated with a flashing light. After the pellets were delivered and the hopper light extinguished, a green stimulus was presented. In the presence of the green stimulus, 4,000 responses were also required to produce the 20-pellet reward and the flashing hopper light; however, in this color each 400 responses toward the total requirement of 4,000 produced a 0.5-sec illumination of the hopper. Nine such flashes, therefore, preceded the delivery of the 20 pellets and the (30-sec) hopper light while the pellets were being dispensed. The red and green stimulus and their respective conditions were alternated with each completion of the total ratio requirement. The 0.5-sec flashes of the hopper light were presented in the green since the experimental history of the animal had favored the red condition. The chimp was exposed to this

¹Supported in part by Grant NsG 189-61 from the National Aeronautics and Space Administration.

²Reprints may be obtained from Jack D. Findley, Institute for Behavioral Research, 2426 Linden Lane, Silver Spring, Md.

³Cuttler-Hammer, oil tight, industrial push button switch. Series #10250T.

procedure for 31 days during which all food was earned via the experimental program. The performance was recorded by automatic equipment and measurements in each color were made of the time before commencing the ratio following the onset of a given color, and the time required to complete the ratio once be-

RESULTS

following the onset of a given color, and time required to complete the ratio once begun.

ratio (in the red stimulus) were shorter, as was expected in view of the subject's history of greater amounts of reward in this color. After approximately 30 reinforcements, the pauses before working were found to be shortest in the green condition (which presented the flashes of the hopper light after each 400 responses). It was also found that the time to complete the ratio once begun had shown a similar shift, with the shortest work times now found in the green. Figure 1 shows frequency distributions of both these measures

Fig. 1. Frequency distributions comparing pause length and working time in red and green stimulus. Green condition provided conditioned reinforcement.

comparing the performance in red and green during the last 60 reinforcements of a 31-day training period. It can be observed that the pauses before starting the ratio are clearly shorter in the green and that a similar difference, although less dramatic, is found in the working times. In these distributions the longest intervals are of particular significance since no restriction was placed upon the number of reinforcements that could be obtained and the experiment was programmed continuously. These intervals, therefore, include the periods during which the animal did not work at all and was most probably asleep. During the initial phases of training long pauses of 12-18 hr occurred in both red and green. Their complete absence in green during the last 60 reinforcements, as shown in Fig. 1, is yet another indication of the controlling importance of the conditioned reinforcement.

Figure 2 shows two sample records which illustrate the performance differences de-

scribed. In this figure, each of the daily records is complete except for one long pause in the red condition which has been omitted. The green condition is indicated by a pen deflection after each 400 responses.

After finding that the presence of conditioned reinforcement resulted in shorter pause and working times and even controlled the stimulus conditions under which the animal would sleep, it seemed likely that the reinforcing properties of the two conditions were considerably different and would, therefore, be reflected in the animal's preference between the two. The experimental conditions were then altered to allow a single switch from red to green or green to red after each food reinforcement until the first ratio response was made in a given color. Switching was provided by an illuminated push button which became active with the onset of a new color. Since the colors always alternated after each completed ratio, it was possible to limit any resulting

Fig. 2. Two daily cumulative response records illustrating the differential performance. From both records one long pause in red has been omitted. The green condition is indicated by event pen deflection each 400 responses.

preference to 90 per cent by not illuminating the switching button on two successive ratios out of 10. This insured continued exposure to each stimulus condition.

On the first day of these new procedures, a single forced trial was presented in red and green. Once the switching procedure had been introduced, the chimpanzee selected the green condition and continued to do so at every available opportunity for the next 13 days. On the 13th day the colors were reversed; the red condition now included the flashes of the hopper light and the green did not. After one exposure to each color, the preference immediately switched to red and remained for 27 days. The colors were then returned to the original condition for 21 additional days, where again a rapid and complete reversal was found. It was concluded that the chimpanzee showed a strong and consistent preference for the conditioned reinforcement procedure.

Not available in this experiment was a control condition to present stimuli similar to the hopper light, but uncorrelated with the presentation of food. The magnitude of the effects found, however, together with negative control experiments, reported by Kelleher (1964) strongly suggest that the stimulus effects shown here are a function of the pairing with food reinforcement and not related to any inherent properties of a flashing light. In another experiment, with a second chimpanzee and much larger total ratios, the reinforcing and stimulus control developed by such a pairing procedure was convincingly confirmed. Shown in Fig. 3 is a portion of a record in which this chimpanzee sustained performance on a total ratio of 120,000 responses. Each 4000 responses toward the total requirement produced a brief illumination of a meter which remained on and was correlated with almost unlimited access to food once the total ratio

Fig. 3. Sample record illustrating pauses produced by conditioned reinforcement within a large ratio requirement.

was completed. Of significance here are the pauses following the flash of the meter after each 4000 responses. These pauses parallel one of the effects normally found with food reinforcement and illustrate the degree of control possible with conditioned reinforcement.

Unanswered by the present work is the extent to which the use of conditioned reinforcement is necessary to establish large fixed ratio performance. That its use is facilitative is clear. This result suggests that such facilitating effects might also be possible in many other situations and raises anew the need for greater clarification of the discriminative and reinforcing aspects of conditioned reinforcement.

REFERENCES

- Findley, J. D. An experimental outline for building and exploring multi-operant behavior repertoires. *J. exp. Anal. Behav.*, 1962, 5, 113-166.
- Kelleher, R. T. and Gollub, L. R. A review of positive conditioned reinforcement. Monograph Supplement, *J. exp. Anal. Behav.*, 1962, 5, 543-597.
- Kelleher, R. T. *Chaining and conditioned reinforcement in Operant Behavior in Psychology*, ed. by W. Honig. New York: Appleton-Century-Crofts, in press, 1964.
- Zimmerman, J. Technique for sustaining behavior with conditioned reinforcement. *Science*, 1963, 142, 682.

Received September 11, 1964