FIXED RATIO AND EXTINCTION PERFORMANCE OF INFANTS IN THE SECOND YEAR OF LIFE^{1,2}

PAUL WEISBERG AND EDWARD FINK

BROWN UNIVERSITY

Five 14½- to 19½-month-old infants were trained to lever press for snacks on small fixed ratio schedules of reinforcement. Within four to nine sessions, responding under FR 10 was established for four subjects and FR 15 for the other. Each subject's last session revealed behavioral patterns similar to animal and human FR trained subjects—a high and constant ratio rate, mixed with a zero rate following reinforcements. Deviations were mostly in the form of prolonged and variable post-reinforcement pauses. These and other irregularities were probably due to the limited deprivation conditions and improper training procedures in which the ratio (for two subjects) was ascended too early and too quickly. Extinction was instituted during the last session. The degree to which extinction performance matched that of other organisms depended upon how stable and "ratio-like" performance was during conditioning.

Most attempts to control free operant performances of infants and toddlers have been made within a single experimental session, often as brief as 8 min in duration (Simmons and Lipsitt, 1961; Simmons, 1964). Where more than one session has been employed, they have frequently been separated by as long as one week (Rheingold, Stanley, and Doyle, 1964). Lack of experimental control and practical considerations, often foreign to those working with infra-humans, have sometimes determined the brevity and temporal discontinuity in infant research (*cf.*, Lipsitt, 1963). But if a functional analytic approach to infant learning is desired, procedures to generate and maintain arbitrarily chosen responses of very young children over relatively long time periods must be developed. The present study describes such a procedure for 1- to 2-yr-old infants by using a lever pressing activity reinforced by short fixed ratio (FR 10 and FR 15) schedules of food reinforcement.

Ferster and Skinner (1957) have described the behavioral pattern which develops when fixed ratio schedules come to exert strong control over the key-pecking activity of a well trained pigeon reduced to 80% of its body weight. From this description, and the experimental variables which have shown to modify characteristic FR performance—that of a high and constant ratio run followed by a brief post-reinforcement pause—have come many phylogenetic comparisons, *e.g.*, those done with the rat, cat, and monkey (Sidman and Stebbins, 1954), nursery-aged and school-aged children (Long, Hammack, May, and Campbell, 1958), and autistic and normal children (Ferster and DeMyer, 1961). A secondary aim of the present study is to add to this list the FR behavioral pattern of the human infant motivated by a relatively short period of food deprivation.

METHOD

Subjects

The infants hereafter identified by their sex and age at the start of magazine training were F 14-14 (female, 14 months, 14 days), M 16-6, M 18-21, M 19-7 and F 19-14. Except for the last three sessions of M 16-6, the experimental setting was a small interview room at an institution that provided temporary care of children waiting to be placed into foster or adoptive homes, or to be returned to parents who

¹Supported by USPHS Grant MH-08039-01 awarded to Paul Weisberg. Edward Fink was an NSF undergraduate research participant at the time of the study. Reprints may be obtained from Paul Weisberg, W. S. Hunter Lab., Brown University, Providence 12, Rhode Island.

²We thank Mrs. Jane E. Walsh and the staff of Lakeside Shelter, Warwick, Rhode Island, and Mr. Walter W. Pippit of Children's Friend and Service, Providence, Rhode Island, for their excellent cooperation.

were recuperating from illness, or who were under financial burden. M 16-6 was returned to his parents on the day an extinction session was planned; consequently he was seen at the Brown Psychology Lab for his last three sessions. The infants had been institutionalized from 13 to 105 days before participating as subjects.

Apparatus

A red plastic lever (Davis Scientific) protruding from a small chassis box served as the manipulandum. The box was mounted to one side of a large wooden frame that housed a 35 bucket Gerbrands Universal Feeder. The lever was 5 in. from what was determined during magazine training to be the subject's preferred hand, and 10 in. from a collecting tray centrally mounted on the front of the feeder support. Each lever-press greater than a downward force of 26 g through 2 mm produced an audible click from the stepping motor of a cumulative recorder in the same room with the subject. Also present and hidden were counters and noiseless transistorized digital control circuitry. The feeder motor when activated produced a brief humming sound which preceded, by a fraction of a second, the delivery of a reinforcement into the collecting tray.

Procedure

Magazine training. Snacks consisting of a mixture of bite-sized pieces of cookies (Arrow-root and Nabisco Sugar Grahams) and cereal (Cheerios) were first given to the child while it played in a nursery playpen. These snacks replaced the subjects' normal daily portion. After a subject accepted and ate approximately 15 snacks from the experimenter's hand, that subject was then carried to the experimental room and offered additional snacks. It took no more than three days to get a subject willingly to accept snacks in the experimental room. Thereafter, snacks were exclusively given by the experimenter only in the experimental room and always 1½-2 hr after the subject's morning or afternoon meal. While the subject was held by the experimenter, snacks were placed one at a time into the collecting tray of the feeder. Once a subject became less apprehensive, it was secured into a high chair in front of the feeder (with the lever removed). The experimenter, now

seated beside the subject, continued to drop snacks into the tray until successive pieces were quickly retrieved and consumed. The experimenter then manually operated the feeder by a silent microswitch kept hidden from the subject.

During magazine training, responses which seemed to appear more often than others and were perhaps becoming superstitiously conditioned, were not reinforced. Hoarding was discouraged by withholding a reinforcement until the subject had consumed the previous one. This attempt was sometimes frustrated because some subjects would not eat unless they were able to "hold onto" one snack while consuming another.

As a subject repeatedly began to look at or reach into the collecting tray when the sound of the feeder motor signaled the delivery of a snack, the experimenter gradually slid his chair further away. The experimenter at first nodded or voiced approval in a perfunctory manner whenever the subject ate, but such approval gradually stopped and the session eventually ended with the experimenter stationed behind the feeder out of the subject's view. Magazine training typically lasted for one session of 25 min in which 30-40 snacks were consumed.

Training. Operant levels were taken for each subject at the start of the next session; the lever was made available and when pressed it clicked but failed to activate the feeder. Time spent under the operant level period varied among subjects (5 min for three, 3 min for M 16-6, and 7 min for M 19-7). After the operant level had been taken, each subject, without any interruption in the session, next received snacks for lever-pressing; the particular schedule of unreinforced to reinforced responses was determined by the preceding operant level. Three subjects whose mean operant level rate was one response per minute (rpm) or below were started on a CRF schedule while F 14-14 and M 19-7, whose respective mean operant level rates were 4 rpm and 16 rpm, were placed on an FR 2 and FR 3 schedule, respectively. The ratio requirement was gradually increased for some subjects in the first conditioning session and for others not until the second. No two subjects had the ratio size increased in exactly the same way. The value of the ratio requirement at the beginning of a session was reduced from the end of the pre-

ceding session. Eventually the ratio requirement during each of the last two sessions was raised to FR 10 for four subjects and FR 15 for M 19-7. During the last session, after each subject had received at least 20 reinforcements at FR 10 or FR 15, lever presses were no longer reinforced. The time spent in extinction varied from about 7 min (M 16-6) to about 20 min (F 19-14).

The number of conditioning sessions run before extinction ranged from four (M 19-7) to nine (M 16-6). Except for three instances in which two days elapsed, training sessions were always one day apart. Each session averaged 24 min, its length depending upon the subject's willingness to work. Only one session, that of F 14-14, had to be terminated because

of crying. This subject was also the only one who had to be shaped to press the lever. During shaping, five reinforcements were placed one at a time on the lever. Upon prehension of each one, the subject accidentally displaced the lever and another reinforcement was automatically delivered into the collecting tray; in all, 10 snacks were received. From then on, F 14-14's lever-presses were "self-initiated" and none of the remaining sessions was terminated because of crying.

RESULTS AND DISCUSSION

Figure 1 shows each subject's last session of operant reinforcement. During this same session the feeder was made inoperative and ex-

Fig. 1. Responding in extinction (E) of five infants following fixed-ratio acquisition. Numbers in parentheses represent the session in which these records were taken.

tion started at E. M 19-7 began the fourth and final session immediately on FR 15, although the three previous sessions all began on shorter ratios. All other subjects started their final conditioning session at ratio values smaller than their terminal ratios of FR 10.

A feature common to all records in Fig. 1 is the rather abrupt shift from a period of no responding, usually following a reinforcement, to one in which the level of responding is high and sustained. M 19-7 most clearly exemplifies this bi-valued mode of responding; his ratios are run off at a fairly steady response rate of about 2.5 responses per sec and most pauses come after reinforcements. Although instances of departure from the normal FR pattern are seen in all the conditioning records, *e.g.*, rates of intermediate size throughout the performances of F 19-14 and M 16-6, interrupted or "split" ratios for M 18-21 and M 19-14, and running past the reinforcement as for M 19-7, F 14-14, and M 18-21, the most outstanding disruption is in the length of the post-reinforcement pause. Extended and variable pause durations are most marked in the records of F 14-14, M 18-21, and M 16-6. This characteristic is not surprising in view of the rather limited conditions of food deprivation (less than 2 hr). Sidman and Stebbins (1954) found that partially satiated FR trained animals showed extreme post-reinforcement pauses, but that responding when it occurred was almost always at the terminal rate. Increases in pause length without a corresponding loss in the local running rate has also been observed by Ferster and Skinner (1957) with pigeons whose weight was close to or above their inactive weight. This is also reminiscent of the first session performance of some older children who, with high response rates under the control of short FR schedules of trinket reinforcements, rapidly accumulated these stimuli. The major result was a prolongation of the post-reinforcement pause (Long *et al.*, 1958).

Another variable to consider is the way in which the ratio was progressed for each subject. Starting M 19-7 on an FR 15 and moving F 19-14 up to a FR 10 after some reinforced experience with FR 3 and FR 7 did not seem to disrupt their over-all response rates. In retrospect, however, the ratio change to FR 10 for F 14-14, M 18-21, and M 16-6 probably should have awaited further exposure to lower ratios or, upon noticing a deterioration in

performance after FR 10, they should have been shifted to a lower ratio and the behavioral effect assessed before the possible reinstatement of FR 10. At any rate, the most probable result of such ratio "strain", however small, was to lengthen periods of nonresponding (Skinner, 1953).

Considering the conditions of limited deprivation, the premature move for some subjects to "higher" ratios and the relatively small number of previous training sessions, the performances are as good as could be expected. They compare rather favorably with human subjects of limited behavioral repertoires, such as autistic children (Ferster and DeMyer, 1961) and low IQ adults (Ellis, Barnett, and Ayer, 1960) similarly trained under short fixed ratio schedules.

During the session previous to that shown in Fig. 1, the subjects received at least 25 reinforcements either at FR 10, or for M 19-7, at FR 15. The difference in the over-all response rates when subjects were reinforced at their highest ratio during the next-to-last and last sessions revealed an increase in rate for all, except M 16-6. M 16-6 went from 24 rpm during session eight to 19 rpm during session nine (Fig. 1) while on FR 10, and M 18-21 showed the greatest intersession increase, from 34 rpm to 45 rpm (Fig. 1) while on FR 10. The ordering of subjects with respect to the over-all response rate at the terminal ratio during the last two sessions remained the same. The over-all response rate for the other subjects on the last conditioning day while on their highest ratios were: M 19-7, 61 rpm; F 14-14, 30 rpm; and F 19-14, 54 rpm. These values represented an increase of no more than 15% in over-all rate over the previous session's performance.

When reinforcement was omitted at E, the ensuing level of responding in extinction was related to the response output during conditioning. M 19-7 and F 19-14 continued to show high and sustained rates with most of their responding confined to the initial state of extinction. While F 14-14 and M 16-6 extinguished much faster, most of their responses were also emitted early in extinction, as is typical of organisms undergoing extinction after fixed-ratio reinforcement (*e.g.*, Ferster and Skinner, 1957; Ferster and DeMyer, 1961; and Hutchinson and Azrin, 1961). The negative curvature which developed during extinction, as seen in the records of M 19-7,

F 14-14, and F 19-14, was due to increasingly longer periods of nonresponsiveness; this feature is yet another characteristic of FR extinction (Ferster and Skinner, 1957). Of these three subjects only F 14-14 continually responded in an all-or-none manner with most running rates equal to her local rates during FR 10. The running rates during the early stages of extinction for the other two subjects were mixed in size. Toward the end of extinction more response runs were at the previous ratio and a two-valued rate of responding was developed.

Unusual characteristics of FR extinction are seen in the records of M 18-21 and M 16-6; for example, the lack of a well-defined period of steady responding when extinction begins (M 18-21), prolonged pauses quite early in extinction (M 18-21 and M 16-6), a preponderance of small response bursts at intermediate rates throughout extinction (M 18-21), and a rather sudden and early cessation of responding (M 16-6). These irregularities are probably related to the subjects' prior unstable FR pattern, as reflected by their unduly long and variable pause durations during conditioning. Worth mentioning in this connection is the statement by Ferster and Skinner (1957) that "a ratio-type extinction curve requires a well-developed fixed-ratio performance." (p. 61).

The inverse relationship obtained between number of training sessions and resistance to extinction was due to the fact that the most stable performance and highest response rates belonged to those subjects who, with little difficulty, progressed to high ratios fairly early in training. Had M 18-21 and M 16-6 received additional conditioning sessions with perhaps

more stable FR 10 performance emerging, then an even greater inversion between number of sessions and extinction rate would have resulted.

REFERENCES

- Ellis, N. R., Barnett, C. D., and Pryer, M. W. Operant behavior in mental defectives: Exploratory studies. *J. exp. Anal. Behav.*, 1960, **3**, 63-69.
- Ferster, C. B. and DeMyer, M. K. The development of performances in autistic children in an automatically controlled environment. *J. chronic Dis.*, 1961, **13**, 312-345.
- Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Hutchinson, R. R. and Azrin, N. H. Conditioning of mental-hospital patients to fixed-ratio schedules of reinforcement. *J. exp. Anal. Behav.*, 1961, **4**, 87-95.
- Lipsitt, L. P. Learning in the first year of life. In L. P. Lipsitt and C. C. Spiker (Eds.), *Advances in child development and behavior*. Vol. I. New York: Academic Press, 1963.
- Long, E. R., Hammack, J. T., May, F., and Campbell, B. J. Intermittent reinforcement of operant behavior in children. *J. exp. Anal. Behav.*, 1958, **1**, 315-339.
- Rheingold, H. L., Stanley, W. C., and Doyle, G. A. Visual and auditory reinforcement of a manipulatory response in the young child. *J. exp. child Psychol.*, 1964, **1**, 316-326.
- Sidman, M. and Stebbins, W. B. Satiation effects under fixed-ratio schedules of reinforcement. *J. comp. physiol. Psychol.*, 1954, **47**, 114-116.
- Simmons, M. W. Operant discrimination learning in human infants. *Child Developm.*, 1964, **35**, 737-748.
- Simmons, M. W. and Lipsitt, L. P. An operant-discrimination apparatus for infants. *J. exp. Anal. Behav.*, 1961, **4**, 233-235.
- Skinner, B. F. *Science and human behavior*. New York: Macmillan, 1953.

Received April 19, 1965