Factors affecting keypress responding by rats in the presence of free food*

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Rats trained to keypress 10 times per food reinforcement exhibited behavior characteristic of this schedule of reinforcement for at least 87 consecutive sessions, during which identical food was freely available. This behavior appears to be primarily a function of prior conditioning, and it varied predictably following satiation and nonreinforcement.

It has been shown that animals will continue to perform an arbitrary instrumental response for food even while identical food is freely available in the experimental chamber. Carder & Berkowitz (1970) found that this behavior depended to some extent on the work requirement, i.e., although rats would press once or twice for each food pellet, they would not press as many as 10 times per pellet in the presence of free food. Others have demonstrated, with both rats (Jensen, 1963) and pigeons (Neuringer, 1970), that this behavior is also related to the animals' prior experience in the situation.

In the earlier reports, responding in the presence of free food was either measured only once or sampled in single sessions interspersed among several days of deprivation and retraining in the absence of free food. The present study shows that rats will continue to exhibit a characteristic food-maintained pattern of behavior, established during previous training, through at least 87 successive sessions in the presence of identical freely available food. Predictable changes in this behavior were measured following changes in levels of food deprivation and following discontinuance of response-contingent reinforcement. This is apparently a heretofore little studied example of the long lasting and powerful control which conditioning can exert on behavior.

METHOD

The weights of four male Charles River rats were reduced to approximately 80% of their initial weights (mean = 180 g) by food deprivation. They were automatically trained to press a key on a multiple schedule of reinforcement in a 23 x 23 x 20 cm operant conditioning chamber (Davidson, Davis, & Cook, 1971). When the chamber was lit, responses on the key were reinforced by the delivery of a 45-mg Noyes food pellet at a fixed ratio of 10 responses per reinforcement (FR 10). Following

the delivery of each reinforcement, the chamber was darkened and a time-out period ensued, during which responses on the key were ineffective in producing food.¹ These two conditions alternated regularly until a total of 60 reinforcements was delivered to the animal. After 56 daily sessions (weekends excepted), during which the rats were maintained at a reduced body weight by limited feeding, a contact-sensitive foodcup (8.2 cm wide x 4.1 cm deep) was placed in the experimental chamber. The cup contained a measured amount (35 g) of the same pellets used to reinforce keypressing and was fixed to the floor in the corner of the chamber furthest from the key and reinforcement tray. No attempt was made to restrict the amount of food the rats could consume during an experimental session or to control their body weights from this time to the conclusion of the study. The rats were at liberty to eat free food from the foodcup or to work for food by pressing the key on the FR 10 schedule of reinforcement. The rats

were, however, kept on a 23-h food-deprivation schedule between sessions for the first two experiments described below.

RESULTS AND DISCUSSION

Section A of Fig. 1 shows the performance of these rats on the last day before free food was put in the chamber. Their keypress response rate averaged 160/min. Section B of Fig. 1 shows the performance of each of these rats in the first (a) and the 87th (b) session with free food available in the chamber. Though they responded at a lower rate, they continued to press 10 times for each reinforcement. During the first week after the introduction of free food, the rats' response rates averaged 14.6/min over the entire session, and on the 87th session it averaged 13.4/min. The decrease in overall rate, compared to their prefree food rates, was due to the occurrence of long pauses before they commenced responding on the FR 10. Once responding on the ratio began, it was maintained at a high local rate similar to that seen before the introduction of free food. Throughout these experiments each rat consumed every food reinforcement obtained by means of keypressing; however, the occurrence of long pauses is characteristic of fixed-ratio performance in partially satiated rats (Sidman & Stebbins, 1954). Over these 87 daily sessions (126 calendar days), the rats gained an average of 1.3 g/day.

Figure 2 shows a simultaneous recording of contact with the foodcup (which reflects free food consumption), water drinking, and keypressing. The record shown (Rat No. 3, 87th session with free food) is

Fig. 1. Cumulative response records showing the pattern of keypressing, during fixed ratio components, for all four rats (Nos. 1-4) in the session before the introduction of free food (Section A), the first (a) and 87th (b) free food sessions (Section B), and the final session after 8 days of continuous access to food (Section C). Slash marks indicate the delivery of food reinforcements upon completion of the response ratios. Record 2b (Section B) has been displayed downward slightly to improve graphic presentation.

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Fig. 2. Representative simultaneous recording of free feeding (FF), water consumption (H₂O), schedule component (SC), fixed-ratio responses (FR), and time-out responses (TO) in the 87th session for Rat No. 3 (3b, Fig. 1). Stippled portions of FF tracing indicate foodcup contacts, heavy portions of SC tracing indicate FR 10 components. The complete record was divided into three sections (top to bottom). See text for further explanation.

representative of the behavior patterns of all four rats in the presence of free food. Except for the very beginning of the session, when they usually ate free food (a) for varying lengths of time while the FR component was in effect (b), almost all of the free food consumed was obtained during time-out components. The rats consumed most of their free food during the early part of the session, although regular presentation of time-out periods throughout the session provided ample opportunity for more evenly spaced free feeding. In the record shown in Fig. 2, the rat was in contact with the foodcup for 5.9, 5.1, and 2.7 min in each successive third of the session. Neuringer (1970) described a similar intrasession decrease in free feeding by pigeons. This recording also illustrates (c) that, in general, the rats stopped responding and ate from the foodcup almost immediately after the reinforcement was delivered and the FR stimulus terminated and stopped free feeding soon after the onset of the stimulus associated with the FR component. They then resumed responding for food on the key. Drinking periods were interspersed throughout the entire session, generally during the time-out periods, and lasted for varying lengths of time. During some portion of every session, each rat

worked through several successive FR components without eating food from the free foodcup (e.g., d), even early in the session before they stopped free feeding. Instances in which rats interrupted a ratio to eat free food, or, if not already eating, began to eat free food after a ratio component had begun, were relatively rare and brief (e).

Since the rats' fixed-ratio patterns resembled those seen in partially satiated rats and decreases in free food consumption were seen during the course of each session, the response-contingent delivery of food pellets was discontinued (extinction) to determine whether the delivery of food pellets was necessary for the maintenance of keypressing or whether the rats were responding because of other unidentified reinforcers associated with keypressing. Every 10th keypress during the FR components of the 13th session operated an empty food magazine; all other conditions were the same as before. After the first 2-6 ratios, response rates decreased rapidly. Over the entire session, the average response rate was 2.3/min (range = 1.5-3.7), as compared to an average of 13.9/min (range = 6.8-27.0) on the three preceding days, and all rats exhibited frequent breaks in the ratio pattern. The rats completed an

average of 19.5 ratios (range = 14-29), as compared to an average of 55.9 (range = 49-60) on the preceding days. This experiment indicates that the rats do not press the key merely for the sake of pressing it. The food reinforcement is a critical part of the general stimulus complex controlling this behavior, and other unidentified reinforcers are inadequate for maintaining keypress behavior in the absence of food reinforcement.

Prefeeding an organism with some portion of its usual food intake produces a reduction in subsequent food intake approximately equivalent to the amount prefed (Berkun, Kessen, & Miller, 1952; Janowitz & Grossman, 1949). Prefeeding was therefore used to test the influence of satiation on subsequent keypressing and free feeding behavior. Before the 44th session, each rat was given an amount of food in its home cage equal to its average daily intake. The rats were allowed 1 h to consume the food and were tested immediately afterward. All rats ate significantly less free food than on the three preceding days (mean = -70%), which suggests that they were considerably satiated by prefeeding. One rat responded at a significantly lower rate than on the preceding days (-71%), two rats responded at the same rate, and one at a significantly higher rate (+44%). The results of this experiment indicate that for three rats, the maintenance of keypressing was independent of the short-term effects of satiation, but the results from the fourth rat provided evidence of some dependence on food motivation.

As a further test of the influence of satiety and level of deprivation, the rats were given continuous access to food in their home cages for 8 days after completing their 87th session. Free food consumption during the sessions dropped significantly from a mean of 14.9 g to less than 1 g per day after 6 days, indicating a high level of satiety. The performance of the rats after eight session (11 calendar days) under these conditions, during which they gained an average of 6.4 g/day, is shown in Section C of Fig. 1. Two rats (Nos. 3 and 4) continued to respond at rates similar to or higher than those exhibited under the 23-h deprivation regime. However, the other two rats exhibited progressive decreases in response rates, both within and between sessions, beginning on the first or second day after deprivation was discontinued. This clearly indicates that keypressing for food in the presence of free food is not completely independent of the level of food deprivation, which was suggested by the results of Neuringer's (1969) study. Neuringer housed his rats in the

experimental chamber, and responses were measured over the entire day rather than for a limited time, as in the present study. Within-day changes in levels of deprivation, related to time between meals, may have maintained responding in his study, whereas in this experiment, the session duration was less than the usual time between meals.

In the present study, the delivery of response-contingent food pellets was found to be essential to the maintenance of keypressing, yet the rats received only a small portion of their daily food intake by keypressing and could have obtained all of their food without pressing at all. They even pressed the key for food after continuous access to food for 8 days and ate all the pellets obtained by keypressing, but they ate little or no free food at all during these sessions. It is clear that the rats did not respond on the key to satisfy a nutritional need. Their regular stimulus-controlled alternation between free feeding and keypressing indicates that they also did not operate the key because of a preference for keypressing or for working. Their keypress behavior was strongly under conditioned stimulus control established during their training history. Further work is necessary to determine what other types of schedule performance persist under these conditions. In this study, the controlling stimulus could have been any or all of several elements of a stimulus complex, e.g., FR light, keypress response chain, or food delivery. This type of feeding behavior may be analogous to that seen in studies on conditioned hunger (e.g., Wright, 1965), paradoxical effects of satiation (e.g., Teel & Webb, 1951), and certain types of human obesity (e.g., Schacter, 1968).

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NOTES

1. Each time-out component terminated after a cessation of responding for 20 sec or after 1 min if no time-out interresponse time had exceeded 20 sec (but no sooner than 0.5 sec after a response).
2. Effects which deviated from the mean of each rat's performance on the three preceding control days by more than 4.3 standard deviations (2 df; $p < .05$) were considered significant.

The differential effects of omission and extinction following DRL pretraining*

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The present study attempted to compare the response-elimination efficiencies of omission and extinction training following DRL 20-sec pretraining. Results indicated that omission training produced relatively more rapid and more complete response elimination than extinction training.

Previous attempts to eliminate responding have almost exclusively utilized either extinction or punishment training, or some combination of these two techniques. In addition, omission training, in which S is reinforced for omitting a previously reinforced response, has also been shown to be a successful method of response elimination (Baer, Peterson, & Sherman, 1967; Long, 1962, 1963; Mishkin & Weiskrantz, 1959; Reynolds, 1961; Sherman, 1965). However, it has been just recently that any attempt has been made at assessing the relative efficacy of these response-elimination techniques.

Uhl & Garcia (1969) investigated the response-elimination efficiency and durability of omission training (OT) and extinction training (ET). Their results indicated that ET produced slightly more rapid response elimination but that OT resulted in more durable effects. Similarly, Uhl &

Sherman (1971) compared combinations of OT, ET, and punishment and observed that response elimination was most rapid when punishment was combined with OT and ET, as opposed to either of the latter two techniques used in isolation. In addition, OT alone yielded longer lasting effects, as compared to ET alone or combinations of OT or ET with punishment.

It should be noted that both Uhl & Garcia (1969) and Uhl & Sherman (1971) used rats as Ss and employed a variable interval (VI) 30-sec schedule in their investigations of the various response-elimination procedures. The present experiment was designed to extend the comparison of OT and ET by means of two methodological variations: (1) pigeons were used as Ss, and (2) a differential reinforcement of low rate (DRL) 20-sec schedule was utilized as the pretraining reinforcement schedule. Since DRL schedules and OT are both instances in which the S must learn to inhibit responding to produce reinforcement, it was hypothesized that this similarity might facilitate the response-elimination effectiveness of OT, as opposed to ET.

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