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An examination of various deprivation-reward combinations in the barpressing vs freeloading phenomenon in rats*

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In a choice situation in which rats could obtain rewards by barpressing or freely, an examination was made of the following seven deprivation-reward groups: food-food, food-water, food-sucrose, food-saccharin, water-water, water-sucrose, and water-saccharin. The food-food, food-sucrose, water-water, and water-sucrose groups preferred to obtain the rewards by barpressing. The water-saccharin group preferred the free reward. The remaining two groups did not learn to press the bar. Implications for the theory that barpressing has an intrinsic attractiveness for rats are discussed.

A number of studies in recent years have indicated that after having been trained to respond instrumentally for food, a rat or pigeon will continue to "work" for a reinforcer even when identical reinforcers are freely available (Jensen, 1963; Neuringer, 1969, 1970; Carder & Berkowitz, 1970; Singh, 1970; Tarte Snyder, 1972, 1973). Carder (1972) designed a study in which he examined a possible explanation for this phenomenon. He felt that since a certain amount of manipulation is integrated with the rat's consummatory pattern, the barpressing response would enable the rat to engage in a more complete, and therefore preferable, sequence of consummatory behavior than by merely eating free food. It would follow that this preference for manipulation would be especially true in the case of a liquid reinforcer that could not be manipulated by the rat. Since the manipulation of such a reinforcer would be reduced, the effect of the manipulation of the bar would increase. He found that when a 10% solution of sucrose in water was used as a reinforcer, the rats barpressed for 83% of their total intake in the choice situation. When plain water was used as the reinforcer, however, the rats only barpressed for 26% of the total amount consumed. Carder concluded that the preference for earned 10% sucrose was due to the fact that the sucrose, as a food substance, is more strongly reinforcing in the presence of food-related consummatory patterns such as food or lever manipulation, than it is in their absence. Water, having no food value, would not have manipulation as part of its consummatory pattern, thus accounting for the low percentage of earned water.

Several questions were generated by Carder's findings. If sucrose is reinforcing because of its nutritive value, how would animals which were water deprived respond in the choice situation with sucrose as the reinforcer? And further, how would animals respond with saccharin as a reinforcer, saccharin being sweet but having no food value? Sheffield and Roby (1950) found that rats preferred saccharin to water in situations involving a choice between the two freely available reinforcers.

The purpose of this study, therefore, was threefold: (1) to replicate the findings of Carder (1972); (2) to examine sucrose as a sweet reinforcer with nutritive value vs saccharin as a sweet reinforcer with no food value; and (3) to examine possible interactions between seven deprivation-reward combinations, and to determine the percentage of intake via barpressing for each of the combinations in a choice situation. If Carder's conclusion was correct, the amount of earned sucrose for water deprived animals should approximate the amount of water earned for water deprived animals. It should also follow that the amount of earned sucrose should be significantly higher than the amount of earned saccharin for food deprived animals.

METHOD

Subjects

The Ss consisted of 28 female adult albino rats. They were randomly assigned to one of the following seven deprivation-reward groups: food-food, food-water, food-sucrose, food-saccharin, water-water, water-sucrose, and water-saccharin.

Apparatus

All testing took place in Lehigh Valley operant chambers. Liquid reinforcers were administered freely during the free and choice days from a bottle attached at the left rear portion of the chamber. A .1-cc dipper feeder was located in the front middle portion of the chamber. The sucrose was presented as a 10% solution in water, and the saccharin concentration was equivalent in sweetness, using the manufacturer's recommendation as a standard. Food as a reinforcer was available in the form of 45-mg Noyes pellets during the free and choice days from a metal dish containing 300 pellets located in the left rear portion of the chamber.

Procedure

All animals were placed on a deprivation schedule under which they received 1 h of food or water per day for 7 days prior to testing. Following the Carder (1970, 1972) design, during the first 3 days of the experiment the appropriate reward was freely available to the animals in the operant chambers for 1 h, with the bars removed from the chambers. The following 6 days consisted of barpress training for 1 h with no free reward available. Training days were extended for animals which did not

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Table 1
Mean Amounts Consumed Per Animal Per Day During All Days of Testing

Group	Three Free Reward Days	Six Barpress Training Days	Two Choice Days		
			Taken Freely	Taken via Bar	Percent via Bar
Food-Food	119 Pellets	204 Pellets	38 Pellets	146 Pellets	79.4
Food-Water	1.7 cc	–	–	–	–
Food-Sucrose	18.8 cc	23.6 cc	10.0 cc	15.1 cc	60.2
Food-Saccharin	2.7 cc	–	–	–	–
Water-Water	6.2 cc	11.7 cc	4.8 cc	5.7 cc	54.3
Water-Sucrose	7.9 cc	12.9 cc	5.1 cc	10.3 cc	66.9
Water-Saccharin	10.2 cc	11.4 cc	10.1 cc	3.2 cc	24.1

reach 800 barpresses, until at least that number was attained. This was not the case, however, in the food-water or food-saccharin groups, as it became apparent early in the study that these deprivation-reward combinations would not produce barpressing. During the 2 days immediately following completion of training, free reward was again present in the chamber. The animals could then choose between barpressing for or freely obtaining the reward. All animals received ½ h of food or water in their home cages immediately after each session in the operant chamber. The amount of liquid or food consumed during all days was recorded according to the manner in which it was obtained.

RESULTS

Mean amounts of the reinforcer consumed for all days of testing are depicted in Table 1. Figures for the first group, food-food, are in terms of 45-mg food pellets; the remaining figures all represent amounts consumed in cubic centimeters. The percentages indicate the mean amount consumed via barpressing during the 2 choice days. No data were available after the third day of testing for the food-water and food-saccharin groups because the reinforcers were not strong enough for the animals to be bartrained. It was therefore concluded that neither water nor saccharin will act as primary reinforcers for food deprived animals, indicating that the reinforcer must have some nutritive value. These two groups were eliminated from all subsequent data analyses.

A three-way analysis of variance in the form of Groups (4) by Choice Days (2) by Amount Free/Amount Earned (2) involving the amount consumed for the four liquid reinforcement groups showed a significant main effect for groups ($F = 6.37$, $df = 3/48$, $p < .01$). This reflected differences between groups in the total amount of liquid consumed during the choice days (see Table 1). There was also a significant interaction between the deprivation-reward groups and the amount consumed freely vs via barpressing ($F = 5.55$, $df = 3/48$, $p < .01$). The water-saccharin group consumed more free saccharin than earned. All other groups showed a preference for the earned reinforcement.

Because the food-food group could not be included in the three-way analysis using amounts consumed, a two-way analysis of variance in the form of Groups (5) by Days (2) involving the four liquid reinforcement groups and the food-food group using percentages of reinforcement obtained via barpressing was calculated; it showed a significant main effect for groups ($F = 6.15$, $df = 4/30$, $p < .01$). The range is 24.1% for the water-saccharin group to 79.4% for the food-food group as shown in Table 1. A Newman-Keuls analysis showed that the percentage of the total consumed obtained by barpressing was significantly lower for the water-saccharin group than all other groups ($p < .05$), and the percentage for the water-saccharin group was significantly different from that of the food-food and water-sucrose groups ($p < .01$). The difference noted by Carder between the food-sucrose and the water-water groups was not found in the present study.

A post hoc analysis of variance using the four liquid reward groups and the three conditions during the experiment, i.e., free days, training days, and choice days, indicated a significant main effect for the amount consumed in the three conditions ($F = 14.52$, $df = 2/36$, $p < .01$). A Newman-Keuls range test for differences showed that the mean amount consumed per animal during the choice days was significantly higher than the amounts consumed during either the training or free days ($p < .01$). A trend analysis of the test situation main effect showed a significant linear trend between the three conditions ($F = 28.57$, $df = 1/36$, $p < .01$). Animals consumed the least amount of liquid during the 3 free days and the greatest amount during the 2 choice days.

DISCUSSION

Saccharin was introduced as a reinforcer in order to isolate the reinforcing qualities of sucrose for food deprived animals. Results suggested that sucrose is reinforcing for its nutritive value rather than for its sweetness, in that an "equally" sweet solution of saccharin proved to be nonreinforcing for a food deprived animal. The finding that saccharin was not reinforcing for hungry animals is in contrast with a number of earlier studies. This discrepancy might be due to differences between studies in terms of the saccharin concentrations which were used. The fact that the present study equated saccharin and sucrose concentration, by the saccharin manufacturer's recommendation for sweetness, may also have contributed to the difference in findings. These data, in any case, substantiate the findings of Carder (1972) and give support to his conclusion that sucrose is more reinforcing in the presence of food-related

consummatory patterns. Jensen (1963) concluded, however, that barpressing may have an intrinsic attractiveness for rats. Results of the post hoc analysis seem to support this notion, as the mean amount consumed per animal was significantly higher during both training and choice days, than for free days. This would indicate that the reward via barpressing was stronger than when it was freely obtainable. Since this trend occurred in all groups (nonnutritive as well as nutritive), it would appear that it is this intrinsic attraction which Jensen described and not the consummatory patterns of Carder which best explained the barpress vs freeloading phenomenon. It would seem then, that while a reinforcer with some food value is needed for food deprived animals, this alone does not explain what the intrinsic attraction is that compelled the animals to "work" for the greater portion of the total amount consumed when the reinforcer was freely available.

The results also indicate that the performance in the choice situation is contingent on the reinforcer, and not on the state of deprivation, as water deprived animals consumed more either by freeloading or via barpressing depending upon which reinforcer was used. In all situations but one, however, the animals preferred to barpress rather than to freeload.

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Microanalysis of fixed-ratio performance in the rat: Behavioral tolerance to morphine*

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Rat performance under a fixed-ratio schedule of food reinforcement was analyzed in terms of distributions of intervals between successive responses (IRTs). A 20-mg/kg IP injection of morphine increased the proportion of longer IRTs without affecting the modal IRT, and increased mean IRT at all positions in the ratio. Fixed-ratio performance returned to baseline during repeated administration of the drug.

Weiss and Gott (1972) analyzed the fixed-ratio performance of pigeons in fine detail by recording and examining in order the intervals between each of the 30 keypecks required for grain presentation (FR 30 schedule of food reinforcement). Amphetamine, imipramine, and pentobarbital were administered, and the authors concluded that these drugs acted mainly on the cohesiveness of the fixed-ratio pattern of keypecking. Subsidiary effects concerned the distributions of interresponse times (IRTs). At the doses used, amphetamine and imipramine, as well as breaking up the coherence of the performance, also increased the frequency of IRTs having twice the duration of the modal IRT. Pentobarbitol promoted coherence of FR performance and increased the frequency of IRTs having one-half the duration of the modal IRT.

The present experiment reports a similar analysis carried out during observations of the development of tolerance of the fixed-ratio performance of rats to repeated administration of a moderately large dose of morphine. Behavioral tolerance to morphine has not been demonstrated in the rat. Such tolerance has been

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