Reinforcing properties of odors for the albino rat

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Food deprived and satiated rats were tested in a free operant situation to evaluate the behavior directing properties of odors that were either familiar and significant (food) or novel (amyl acetate). Both odors directed behavior but the rate and durability of the reinforcing properties of the stimulus were a function of the animal's motivational state and previous experience with the stimulus.

Over the past decade a number of experiments have demonstrated that if a response is followed by a discriminable change in the level of sensory stimulation (below the limits defined by the pain threshold for intense stimuli) the probability of the re-occurrence of that response is increased. This relationship has been demonstrated for a number of different stimuli in a number of different species (Kish, 1966). These stimuli are said to have reinforcing properties since they can increase frequency of a response, maintain responding over a period of time and direct the animal's choice behavior (Tapp & Simpson, 1966).

While all animals are sensitive to a wide range of environmental stimuli, different species are biologically endowed with different receptor sensitivity and thus tend to seek and rely on information about their environment gained by their more efficient sense modality. It is a common observation that the laboratory rat spends a considerable amount of time exploring the environment by sniffing and examining the variety of odors that are available within a stimulus situation. It is assumed that the reinforcing properties of a stimulus are related to their informational characteristics; odors should have strong reinforcing properties for the rat since they appear to be such an important source of information about the environment. Two experiments were conducted to evaluate the reinforcing characteristics of odors for the albino rat.

Method

The apparatus employed in these experiments has been described in detail by Long & Tapp (in preparation). In brief, it consisted of a 9 x 12 x 15 in. Plexiglas box with two levers on opposite walls of the box 1 in. above the grid floor. The levers were mounted on a relay contact assembly and were virtually silent in operation. A force of 22 gm moved the levers a distance of 4 mm and closed the relay contacts.

The Plexiglas box was housed in a light-tight gutted refrigerator cabinet and a continuous flow of air from the building ventilation system passed through the refrigerator cabinet and rapidly eliminated the odors used in the experiments. Odors were introduced into the Plexiglas box through 1/4-in. Teflon tubing mounted 1 in. above the center of each lever. The air which

carried the odor came from a compressed air line regulated to 2 lb. per sq. in. The flow of air into the box was controlled by an electric valve located outside the refrigerator cabinet and sound insulated to minimize its operation noise. The air was odorized by passing it through a screw-top wash bottle which contained the odor-producing material. The apparatus was programmed such that when the lever was depressed the air valve opened, allowing air to flow into the box for the duration of the response.

The Ss in the two experiments were 32 naive male albino rats 120-150 days of age purchased from the Holtzman Company. They were housed individually and maintained on a diet of 15 gm of powdered food per day for 10 days before they were tested in the apparatus. Water was always available in the home cage. In both experiments half of the Ss were tested 2 hr. following their daily feeding time (satiated); the other half were tested 2 hr. prior to their feeding time (deprived). The testing procedure consisted of placing the animals in the apparatus for a predetermined time period and recording the number of lever presses on each lever at the end of the testing session. For all Ss, one bar delivered odorized air and the other delivered air which passed through an empty wash bottle.

Experiment 1 was conducted to evaluate the reinforcing properties of the odor of powdered food. Powdered food (50 gm) was placed at the bottom of one wash bottle well below the input and output holes in the bottle top. The 16 rats in this experiment were tested for 2-hr. sessions on alternate days for three days.

Experiment 2 was conducted to determine the reinforcing properties of an odor that had not been previously associated with eating. In this experiment, the odor of amyl acetate (banana oil) was used because human observers find the odor rather pleasant (Engen & McBurney, 1964) and it was extremely doubtful that the animals had ever experienced this odor. The conditions of this experiment were identical to those used in Experiment 1 with two exceptions: (a) the rats were tested for 1-hr. sessions, and (b) the odor was supplied by soaking cotton balls in 5 ml of amyl acetate.

Results

The results of the experiments are depicted in Fig. 1, which is a plot of the mean number of responses on each lever for the three sessions for the deprived and satiated animals. As can be seen from the top half of Fig. 1, in Experiment 1 the deprived animals responded at very high rates on the lever which produced the odor of powdered food for all three days of the experiment. Seven of the eight deprived rats preferred the lever which produced the odor on day 1 and all animals in

Fig. 1. The results of Experiment 1 (upper figure) are based on the number of responses for a two-hour session conducted on each of the three days of the experiment. The odor employed was the odor of powdered food. The results of Experiment 2 (lower figure) are based on one-hour sessions and amyl acetate was used for the odor. Note the different scales on the ordinates.

this group preferred this lever on days 2 and 3. Seven of the eight satiated Ss preferred the lever which delivered the odor on the first day of the experiment but response rates on the two bars for this group did not differ on the second and third days. The analysis of variance performed on the results of Experiment 1 indicated that the differential response rates on the two levers exhibited by the deprived and satiated animals is highly reliable ($F=10.28$, $df=1/14$, $p<.01$). Further analysis of the data revealed that the rate of responding on the air bar for deprived animals was not different from the rate of responding exhibited by the satiated animals on either lever (Newman-Keuls test for $p<.05$).

The results of Experiment 2 are shown in the bottom half of Fig. 1. As can be seen, both the deprived and satiated Ss showed a preference for the lever which delivered the odor ($F=5.02$, $df=1/14$, $p<.05$) but these groups did not differ from one another in this respect. Furthermore, it is apparent from the figure that the magnitude of responding decreased over the three days of the experiment and at a somewhat different rate on the two levers ($F=2.99$, $df=2/28$, $p<.07$). Thus while the initial preference for the lever which delivered the odor was high, this preference was negligible by the third day of the experiment.

A comparison of the values on the ordinates in Fig. 1 indicates that the response rates within the daily sessions for the two experiments were quite different. An analysis of variance performed on the mean daily response levels for the first hour of the daily session in Experiment 1 and the daily response levels in Ex-

periment 2, indicated that the deprived animals responded higher for the odor than the satiated animals ($F=4.77$, $df=1/28$, $p<.05$). This effect was due to the high response rates exhibited by the deprived animals in Experiment 1 on the lever reinforced with the odor of food. Response rates on this lever for this group were higher than for any other condition (Newman-Keuls test for $p<.01$). There was a significant preference for the reinforced lever in each of the other groups based on comparisons made within each group ($p<.05$), but the rates of responding between the remaining groups did not differ from one another nor did they differ from the rate of responding on the control lever exhibited by the food deprived animals of Experiment 1 (Newman-Keuls test for $p<.05$).

Discussion

The results of these experiments indicate that odors, like other stimuli, have reinforcing characteristics for the rat in that they can direct the animal's behavior. However, as is also the case with other stimuli, the strength of the reinforcing properties of the stimulus, defined in terms of either the durability or the rate of responding elicited by the stimulus, is a function of the organism's motivational state and his previous experience with the stimulus. An odor that has not been previously experienced will direct the animal's behavior (Experiment 2) but as the novelty of the odor decreases its behavior directing properties decrease. This is also true for other sensory reinforcers such as light onset (Tapp & Simpson, 1966). However, when the stimulus represents a source of satisfaction compatible with the organism's existing need state, the durability and strength (rate) of the behavior directed by that stimulus are considerably increased (Experiment 1).

The response rates elicited by the deprived animals for the odor of powdered food were quite high in comparison with most other rewards. To the authors' knowledge, no other rewarding events except electrical stimulation of the brain and escape from foot shock, have been shown to be such effective reinforcers when delivered on a similar schedule.

References

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