Sand-digging in mice: Functional autonomy?[1]

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Mice which learned to dig nine lbs. of sand for food reward displayed little performance decrement when extinguished, replicating previous findings. In addition, it was found that: (a) mice will dig whether or not food is present in the goal box; (b) although all mice dig, food reward and deprivation significantly increase rate of digging. The results provide no evidence for "functional autonomy."

"Functional autonomy" refers to the suggestion that "activities and objects that earlier in the game were *means* to an end, now become ends in themselves" (Allport, 1937). Since the concept of functional autonomy can be applied to any behavior which is not reinforced with known primary or conditioned reinforcers, evidence for the concept is of theoretical importance (e.g., Seward, 1963). Probably the two most widely cited examples of functional autonomy in the animal literature are those of Datel & Seward (1952), and Earl (1957). Datel and Seward placed the irritant collodion on rats' ears. Rats scratched their ears for several weeks after the collodion applications. Recently, however, Fantino, Braun, Vollero, & Bradley (1967) showed that double-blind judgments of macroscopic irritation always accompanied persistent ear-scratching. Earl trained mice to dig through nine pounds of sand to reach a goalbox containing food. When the mice were satiated or when food reward was delayed, they continued to dig. Earl suggested that the sand had "developed invitational character." His study has been cited as an example of functional autonomy by several authorities (e.g., Bindra, 1959; Hall, 1961). The present study is a further analysis of the variables which determine rate of digging in the mouse.

Method

The Ss were 18 male ruby-eyed mice which were 80-110 days old at the start of the experiment. The identical sand-digging units differed from Earl's in three ways: (1) The digging compartment or "start box" was 12 in.^{3} whereas Earl's was 6 in.^{3}. (2) The reward box was also 12 in.^{3} whereas Earl's was a 1 gallon jar similar to the S's home cage where it was fed daily. In addition, for some mice in the present experiment a smaller "reward box" was placed within the reward box. On food reward trials, food was placed in the smaller box. This smaller reward box had the same dimensions as the home cage but one side was open, permitting entry. (3) A photocell was mounted by the entrance to the reward compartment. When the photocell beam was crossed, a running-time meter stopped operating, providing a measure of the time taken by S to dig through the sand. Since the amount of sand dug was weighed after each session, measures of digging rate were provided in grams per minute. For a complete description of the apparatus, the reader is referred to Earl.

Following Earl's general procedure, 16 Ss were given preliminary training by depriving them of food for 20 h and allowing them to explore the empty sand tube. For eight of these Ss (Group F) food was present in the goalbox, as in Earl's experiment. The other eight Ss (Group N) did not receive food in the goalbox. The amount of sand in the tube and sand bin was gradually increased over a 25 day period from 0 to 4300 g (about 9 lb). Each daily session consisted of one trial in which the S dug through all the sand and gained 15 min access to the goalbox; if the S did not dig all the sand it was removed after 2 h. Subjects Nos. 7, 13, and 16 from Group N rarely succeeded in digging the entire 4300 g. For these Ss, a lesser amount of sand was placed in the bin (for S No. 7, this was 1000 g; for Ss Nos. 13 and 16, 3000 g). Groups F and N were further divided into Ss which had the smaller reward box (Group S) resembling the home cage placed within the larger reward compartment and those which did not (Group L). Hence, the four main subgroups were FS, FL, NS, and NL. Owing to deaths early in training, only Group FL had an N=4; the other groups each had three Ss. The food reward was Purina Mouse Chow which was also made available for a daily period of 3 h in the home cage. This 3 h period commenced 15 min after removal of S from the apparatus.

The following training stages followed pretraining: Stage 1-14 sessions under 20 h food deprivation; Stage 2-11 "satiation" sessions during which S had food continually available in their home cages; Stage 3—seven sessions under the 20 h deprivation condition during which Ss could reestablish the Stage 1 baseline rate; Stage 4—27 sessions under 20 h food deprivation during which the reinforcement contingencies of Stage 1 were reversed (Group F no longer obtained food in the goalbox, Group N did). During Stage 4, all Ss succeeded in digging 4300 g of sand per session.

Two additional Ss (Nos. 17 and 18) were studied with a different procedure. They had food continually available in the home cage and, in addition, had food and water available in the start box of the apparatus. No reward was ever present in the reward compartment. They were also given the opportunity to dig sand and obtain access to the empty reward com-

Table 1. Rate of Sand Digging in g/min Averaged Over Last Seven Days of Initial Deprivation, Satiation and Reversal Treatments

S No.	Group	(i) Deprivation	(ii) Satiation	(iii) Deprivation-Reversal
1	FL	79.3	69.1	65.0
2	FL	69.5	72.4	51.7
3	FL	70.9	40.2	71.6
8	FL	61.3	35.5	93.2
6	FS	83.7	41.1	70.3
14	FS	97.6	68.8	Dead
15	FS	83.0	74.6	Dead
4	NL	54.0	24.8	109.3
16	NL	50.8	42.8	57.8
7	NL	12.9	15.1	65.5
11	NS	89.3	99.8	94.0
12	NS	70.6	54.4	90.6
13	NS	30.8	32.7	Dead

partment. The amount of sand was gradually increased from 0 to 4300 g. They were each studied for 30 sessions with 4300 g.

Results and Discussion

Data for the main Ss are presented in Table 1. A t test for correlated groups (in Table 1, column i vs column ii) revealed that Ss dug at a higher rate when deprived than when satiated ($t = 3.13$, $df = 12$, $p < .01$). Another t test for correlated groups (column i vs column iii) showed that Ss tended to dig at a higher rate when food was available in the goalbox ($t = 1.94$, $df = 9$, $.05 < p < .10$).

A two-way analysis of variance was performed separately for the deprivation and satiation phases to determine the influence of the F vs N and S vs L manipulations. In deprivation, food reward increased digging rate ($F = 6.35$, $df = 1/9$, $p < .05$) but the effect of the small goalbox was only marginally significant ($F = 3.68$, $df = 1/9$, $p < .10$). There was no significant interaction ($F < 1$). In satiation, neither the reward condition ($F = 1$) nor the size of the goalbox ($F = 2.75$, $df = 1/9$, $p < .20$) influenced digging rate. There was no significant interaction ($F = 1.15$).

The two satiated control Ss were studied with food and water always available in the start box, but with an empty goalbox; both learned to dig nine pounds of sand. Their digging rates over the last seven sessions averaged 70.4 g/min and 38.1 g/min, respectively. These rates are well within the range of the experimental Ss.

The data from these two Ss are sufficient to indicate that Ss learn to dig sand whether or not digging produces food. In this connection, it should be noted that King & Weisman (1964) have shown that the opportunity to dig in sand may be used as a reinforcer, and Deutsch (1960) observed that rats would dig tunnels when placed in an earth-filled tank. In addition, our data indicate that the ordinary deprivation and reward conditions did affect sand digging. Although all Ss dug, digging was enhanced by depriving the Ss and by providing food reward. The small goalbox resembling the home cage may have enhanced digging rate, but this result was not conclusive. The trend in these data suggests, however, that digging by Earl's mice in extinction may have been enhanced by the similarity between the goalbox and the S's home cage.

The present results offer no support for the concept of functional autonomy, since sand-digging was established in satiated, nonreward Ss. A weak form of functional autonomy would require only that Ss which had previously been given food reward would dig at a permanently higher rate than Ss which never attained food reward. Such persisting patterns of behavior have been demonstrated, for example, in hoarding behavior (Licklider & Licklider, 1950). The present study offers no support for even this weak form since Groups F and N did not differ when they were subsequently satiated.

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Note

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