

sentational process also exists in S kittens. Despite the variable rate with which M and S kittens acquired the response, if and when the response appeared, it was accompanied and defined by specific and identical behavior in all kittens: (i) Both M and S kittens made their initial lever presses at criterion with a directness, sureness, and minimum latency indicative of informationally motivated behavior. For example, the average latency of the first lever press made on the first day of response acquisition was 3.5 seconds for both M and S kittens. (ii) Both M and S kittens were similarly attentive—in terms of body orientation and eye movements—to those demonstrator performances that directly preceded their own response acquisition. (iii) With one exception, both M and S kittens had a characteristically sharp response-acquisition curve (Fig. 1). All observing kittens acquiring the response moved from lever pressing at or below 50 percent to lever pressing at 90 percent or criterion as a step function. Thus, whereas the speed, efficiency, and success of response acquisition and discrimination were influenced by whether the kitten observed his mother or a strange female, when the response appeared it was invariably accompanied by the above behavior.

The mother may function as a more effective demonstrator for several reasons. These include her having nursed the kittens, having provided contact proximity, having some kind of maternal "teaching instinct" (5), providing a still lactating and therefore stimulating or arousing presence during the observation period (6), and providing a familiar and therefore rewarding or relaxing presence during the observation period. All or any combination of the above might constitute a social or affective bond that enhances learning by observation.

Perhaps response acquisition depends on the existence of or, in the case of S kittens, on the eventual formation of an affective or social bond with the demonstrator. In fact, both M and S kittens displayed what are considered friendly relations (7) with the demonstrator cat. Both mothers and strangers were generally nonaggressive toward the kittens, licked them, and exhibited "altruistic" behavior by pressing the lever and either sharing or allowing the kitten to eat the entire reward. Also, whereas M kittens observed a mean of 16 demonstrator performances on the first day,

as compared with a mean of 7 for the S kittens, this initial difference in attentiveness disappeared by the second day, when M kittens observed a mean of 18 demonstrator performances and S kittens a mean of 16. This suggests that any distraction caused by the strange demonstrator's presence was quickly reduced or eliminated.

In conclusion, these data show that a mother cat may function as an important vehicle for information transmission, via observation. Perhaps the suggested primacy of learning by observation in the adult cat (8) and in other mammals (9), as opposed to trial and error learning or operant conditioning, stems from the particular social and biological responses developed in the infant by a period of mother-dependence (10).

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## Object-Carrying by Rats: An Approach to the Behavior Produced by Brain Stimulation

**Abstract.** *Rats were provided with opportunity to turn reinforcing hypothalamic stimulation on and off by traversing back and forth across a chamber. When provided with edible and inedible objects, all animals that self-stimulated carried them from the stimulation to the nonstimulation side. Neither food deprivation nor a history of stimulus-bound eating produced a preference for the edible objects. Equivalent stimulation provided without regard to the animals' location in the chamber did not elicit object-carrying. Results are interpreted in terms of the natural conditions which normally elicit this species-specific unit of behavior. Implications for understanding other behavior patterns elicited by hypothalamic stimulation are suggested.*

Rodents carry objects in situations related to hoarding, nest building, and retrieving of young. Rodents may also carry items such as stones that do not seem to be related to storing food and maternal behavior and have no obvious utility for the animal at all (1). The "pack" or "trade" rat (*Neotoma cinerea occidentalis*), for example, may even leave behind an object it had been carrying in favor of a more desirable

shiny object. In a sense, object-carrying by some species may be viewed as a basic, adaptive response that under specific circumstances is incorporated into more complicated behavior patterns which may serve the purposes of specific motivational states.

In the course of studying the behavior that may be elicited by electrical stimulation of hypothalamic structures, we have found circumstances in which

stimulation elicited a very high rate of carrying behavior in rats. An analysis of the experimental conditions during which stimulation would and would not be accompanied by object-carrying revealed some striking parallels with the stimulus conditions eliciting this behavior in the natural environment and consequently offered guidelines for analyzing the elicitation of different behavior patterns by hypothalamic stimulation.

The animals used were 21 Holtzman albino rats (275 to 400 g) of both sexes. Twisted bipolar electrodes (2), bare only at the adjacent tips, were implanted in diverse hypothalamic sites (Fig. 1). As some of the animals had two electrodes implanted, a total of 25 electrode sites were studied. All of the animals were tested in advance under standardized conditions to determine whether the stimulation would elicit eating, drinking, or gnawing on wooden

blocks. Briefly, the tests consisted of 30-second trains of stimulation separated by 60-second interstimulus intervals (3). Stimulation at 13 sites had consistently exhibited one or several of these "stimulus-bound" behaviors, whereas at the remaining 12 sites stimulation elicited only arousal and a forward moving "searching" response, but otherwise no specific behavior.

The animals, with a flexible cable attached to their electrodes, were placed in a Plexiglas chamber (60 cm long and 25 cm wide); one half of the floor of the chamber was painted white, and the other half was painted black. Two sets of photocells were located so that they were activated by an animal that had progressed more than half way across either the white or black sections of the floor. When the animal activated one of the two photocells, continuous 60-cycle a-c sine-wave stimulation was delivered through the implanted elec-

trode, while any interruption of the photocell beam on the other side of the chamber turned off the stimulus. The current intensity (range, 10 to 50  $\mu$ a; average, 20  $\mu$ a) was adjusted to the level that seemed to maximize the animal's interest in obtaining the stimulation. Eighteen of the animals (22 electrode sites) learned within minutes to self-stimulate by oscillating between the stimulation (ON) and the nonstimulation (OFF) sides, thereby initiating the hypothalamic stimulation and controlling its duration.

The animals were provided with a minimum of 30 minutes of practice in turning the stimulus on and off, and then a pile of objects was placed on the ON side of the chamber. The objects included Purina Lab Chow pellets, dowel sticks 1.9 cm in diameter which were cut in 6.3-cm lengths, wooden molding strips cut the same length as the food pellets, and rubber erasers. All 18 of the animals which self-stimulated consistently started to pick up objects with their mouths and to carry them to the OFF side of the chamber where they were deposited as soon as they had terminated the stimulation (4). Objects were never picked up when the animals were not stimulated. The three animals which did not self-stimulate exhibited no tendency to pick up and carry the objects, although they were left in the chamber with objects over several nights.

The animals started to carry objects that were placed on the ON side of the chamber after a variable interval (range, 2 to 240 minutes; average, 25 minutes), but, once established, this behavior continued until the experimental conditions were changed. The rate at which the animals traveled back and forth across the 60-cm test chamber and the consistency with which they carried objects can be appreciated by the quantitative data obtained from a 10-minute test period. The animals averaged 73.6 round trips and carried back objects on 84 percent of the trips during the 10-minute tests. Four of the animals were given comparable 10-minute tests with and without objects. When objects were not available, the animals averaged 49 round trips in the 10 minutes and left the stimulation on for an average duration of 6.9 seconds. This may be compared to 84 round trips and an average duration of 2.9 seconds when objects were present. The presence of objects, therefore, clearly increased the rate of self-

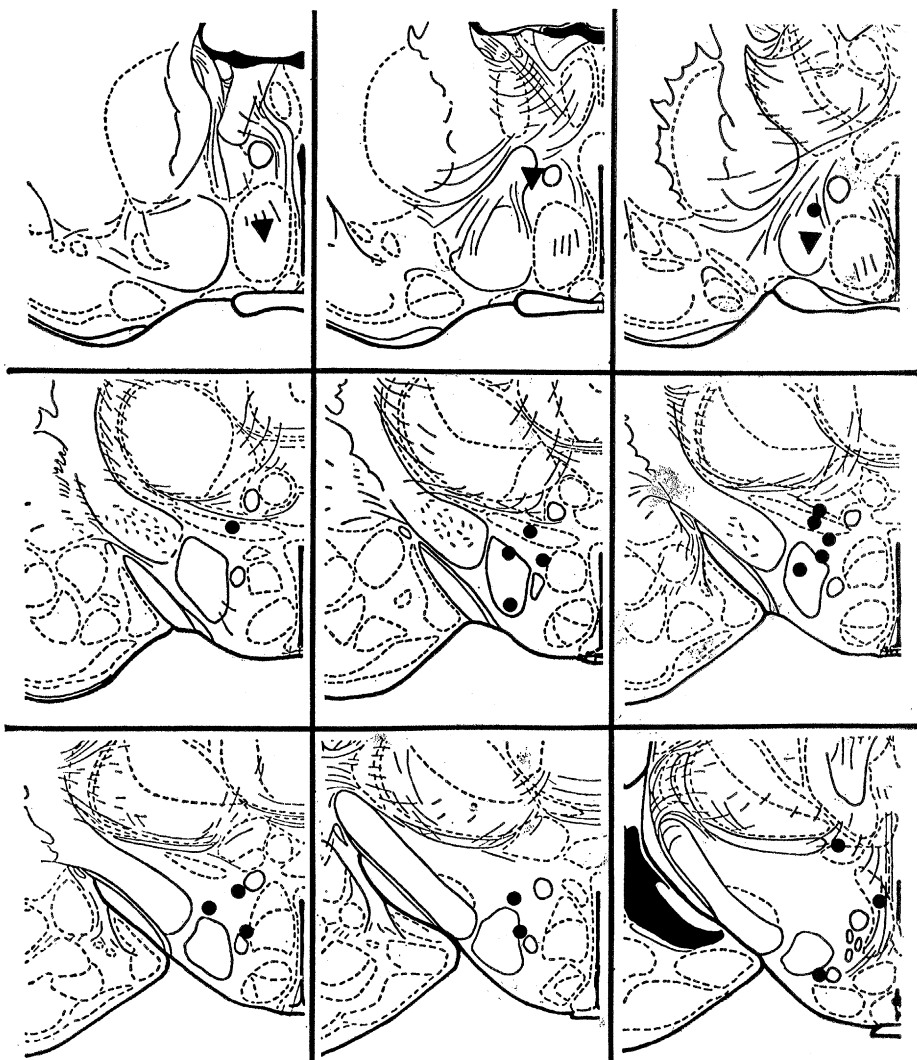


Fig. 1. The location of electrodes which elicited carrying behavior (●) and the three placements which did not support reliable self-stimulation or object-carrying (▼). Not shown in the diagram are three cases for which histology is not available.

stimulation but shortened the duration of stimulation selected.

Animals selected the food pellets significantly more often than the inedible objects, but an appreciable number of inedible objects were also carried (10-minute average: 40 food pellets, 26 inedible objects). It would be difficult to determine whether the edibility of the food pellets or their familiarity or ease of carrying was a more important influence in their selection. Animals that previously had displayed stimulus-bound eating did not exhibit a higher ratio of food pellets to inedible objects selected. Furthermore, even though a 23-hour period of food deprivation both significantly ( $P < .05$ ) increased the number of round trips and significantly shortened the average stimulation duration selected, the ratio of food pellets to inedible objects selected decreased (10-minute average: 51 food pellets, 52 inedible objects).

In several instances, mice were placed on the stimulation side of the test chamber, and these too were picked up and deposited unharmed on the OFF side. On a few occasions the rats picked up their own tails and attempted to carry them to the other side. Viewed collectively, these results supported our view that object-carrying is a basic unit of behavior which can be studied independently of food-hoarding and maternal behavior. Similarly, the fact that there were no differences either between males and females or between those animals that did and did not display stimulus-bound eating also supports this position.

Although the objects carried by rats when hoarding, nest building, or retrieving pups vary, the transporting is invariably from a more open and vulnerable location to one that is relatively familiar and protected. Ethologists have stressed the necessity of the prior establishment of a home or sleeping site before carrying behavior is displayed in a new environment (5). It has also been hypothesized that hoarding may be a function of the difference in security between the home area and the place where food is found. In the present context, the animal's control over the stimulus may impose a structure on the test chamber that parallels the differentiation between the open field and the home area. We have also determined that when the significance of the sides of the chamber is reversed, the animal adjusts to this modification and carries objects from the new ON side to the

OFF side of the chamber. These latter results suggest that the alternation of internal states induced by the stimulus onsets and offsets may be more important for the initiation of carrying behavior than any specific spatial configuration. These changes in internal state may be a central reflection of the differentiation between open field and home area.

In a subsequent study we calculated the average duration of the stimulation and nonstimulation periods selected by the animals and programmed the equipment to deliver the stimulus in accordance with these parameters. The stimulation was presented, therefore, in a regular sequence without regard to the animal's behavior or location. Initially, if the animals happened to be stimulated on the previous ON side, they picked up an object and started to carry it to the opposite side; if they were stimulated on the previous OFF side, they seldom picked up an object. As there was no consistent relation between the animals' location and the stimulus onsets and offsets, the carrying of objects was terminated within several minutes. Those animals that previously had exhibited either stimulus-bound eating or wood-gnawing reverted to this behavior, but those that had not displayed only general locomotor exploratory behavior.

Several conclusions seem justified by the results: (i) object-carrying by rats is a unit of behavior that may be investigated separately from maternal behavior and food hoarding; (ii) the diversity of sites capable of eliciting carrying behavior suggests that it is unlikely that a specific hypothalamic area mediates this behavior and raises the possibility that the behavior is organized elsewhere in the nervous system; (iii) hypothalamic stimulation by itself does not elicit carrying behavior unless it occurs under conditions which permit a consistent relationship between alternating internal states and the physical space; (iv) the behavior elicited by hypothalamic stimulation should be viewed from the perspective of the environmental conditions which initiate species-specific response patterns prior to the postulation of motivational states related to biological needs.

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## Pheromone Response in Pine Bark Beetles: Influence of Host Volatiles

The effectiveness of population-aggregating pheromones of pine bark beetles *Dendroctonus* spp. is strongly activated by naturally occurring volatiles from the resins of pine trees (1, 2). *trans*-Verbenol detected in the hindgut of female *D. ponderosae* and other species of *Dendroctonus* was essentially inactive when tested in field olfactometers on flying beetles in forests of white pine *Pinus monticola* in Idaho in the late summer of 1967. However, when *trans*-verbenol was sprayed on log sections of *P. monticola* that had low attractive properties, beetles were attracted in appreciable numbers from the forest in spite of competition from natural sources of attractants (3). This effect on *trans*-verbenol was traced to resin of *P. monticola* and particularly to alpha-pinene, a major component (32 to 60 percent) of the oleoresins.

A similar effect with alpha-pinene on the pheromone of *D. frontalis* was observed in Texas the following spring. After the pheromone had been isolated, identified, and given the trivial name of "frontalin" (4), it was demonstrated that it was active alone but that alpha-pinene and *trans*-verbenol would accentuate the pheromone activity of the synthetic compound (5). Because of these effects of the host factor in population aggregation in these two species, we abandoned all efforts to bioassay pheromone activity in association with log sections or standing trees because of the obvious danger that the results would be confused by host volatiles.