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BURYING BY RATS IN RESPONSE TO AVERSIVE AND NONAVERSIVE STIMULI

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Previous investigations have shown that rats bury a variety of conditioned and unconditioned aversive stimuli. Such burying has been considered as a species-typical defensive reaction. In the present studies, rats buried spouts filled with Tabasco sauce, or condensed milk to which a taste aversion was conditioned, but did not bury water-filled spouts or spouts filled with a palatable novel food (apple juice) to which a taste aversion was not conditioned. However, in other experiments rats consistently and repeatedly buried Purina Rat Chow, Purina Rat Chow coated with quinine, and glass marbles. This indicates that a variety of stimuli, not all aversive or novel, evoke burying by rats. Whereas the behavior may reasonably be considered as a species-typical defensive behavior in some situations, the wide range of conditions that occasion burying suggests that the behavior has no single biological function.

Key words: species-typical defensive reaction, burying, noxious foods, novelty, taste aversion conditioning, rats

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Recently, Wilkie, MacLennan, and Pinel (1979) demonstrated through an elegantly simple series of experiments that rats would bury a drinking spout filled with a bad-tasting liquid (Tabasco sauce), or a palatable food (sweetened condensed milk) to which a taste aversion was conditioned. An earlier study by Pinel and Treit (1978) also found that rats would bury a localized source of electric shocks. In these investigations, hooded rats were tested in chambers with floors covered by particulate bedding (ground corn cobs), and burying involved using the snout and forepaws to shove this material toward and over the drinking spout or shock source.

Even though rats regularly rearrange bedding materials, Pinel and coworkers reported that the source of liquid food was buried only if the food's taste was intrinsically noxious, or was first experienced prior to a bout of lithium-induced malaise. Bedding usually was removed from beneath spouts containing other kinds of food or water. Since foods were buried only if their taste was aversive, either intrinsically or by virtue of taste aversion conditioning, Wilkie et al. (1979) proposed that burying noxious food was a species-typical defensive reaction.

Bolles (1970) popularized the concept of species-typical defensive reactions in an attempt to account for gross differences in the ease with which different response topographies are learned under avoidance or escape contingencies. According to Bolles, the phylogenetic endowment of each species is such that a limited number of responses, the species-typical defensive reactions, are evoked by exposure to noxious stimuli. When experimental contingencies negatively reinforce actions compatible with these responses, learning is rapid. For example, crouching and fleeing are predominate defensive reactions in the rat, and these activities are easily acquired as avoidance or escape responses (Bolles, 1970). However, species-typical actions may be incompatible with the required operant in a given study. If this occurs—as when pigeons are required to peck keys to escape shock—learning proceeds slowly, if at all.

Burying food seemingly appears under conditions different from those that produce fleeing and crouching in rats; these latter responses have not been associated with exposure

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to noxious foods. To this extent, it does not seem particularly useful to group burying with crouching and fleeing as species-typical defensive reactions.

Nonetheless, burying bad food is an interesting behavior both with respect to its possible adaptive value and the range of environmental conditions that evoke it. The present studies sought to explore further the phenomenon of food-burying by rats.

EXPERIMENT 1

This study systematically replicated Wilkie et al.'s (1979) demonstration that rats bury a drinking spout filled with a bad-tasting liquid (Tabasco sauce), but do not bury a concurrently available tube filled with water. This study differed from Experiment 3 of Wilkie and coworkers primarily in the kind of bedding material used: those researchers presented rats with ground corn cobs whereas wood shavings were employed as bedding here. The present study also determined whether rats would bury a novel palatable food (apple juice).

Subjects

Four adult male hooded rats served. They were individually housed under a 12-hr light/dark cycle.

Apparatus

Each rat was housed and tested in one of four chambers constructed of sheet aluminum and clear Plexiglas. The chambers were 35-cm long, 25-cm wide, and 19-cm high. The back wall, side walls, and bottom of each chamber were aluminum. The ceiling and front wall were clear Plexiglas, which allowed for unobstructed observation. Each chamber was equipped with a wire-mesh feeder mounted on the rear wall 7 cm above the floor. Unless otherwise specified, the feeder was always filled with Purina Rat Chow. A hole drilled in the left side wall 6 cm from the front wall and 7 cm above the floor allowed the spout of a drinking tube to enter the chamber, while another hole symmetrically located on the right side wall allowed a second spout entry. During all studies, bedding material (wood chips or wood shavings) covered the chamber floor to a depth of 4 cm. Thus the drinking spouts were 3 cm above the undisturbed bedding. Lines etched into the side walls at 1-cm intervals above and below the drinking spout openings allowed the height of bedding material at each spout to be determined easily by direct observation.

Procedure

In the first seven days, subjects were allowed to adapt to the experimental situation. Throughout this period, water was available in both tubes and the feeder contained Purina Rat Chow. At the end of the adaptation period, subjects were exposed to a procedure where access to water was restricted to 1 hr per day (c. 3:00-4:00 p.m.). During the time that water was available, both tubes were present and filled with tap water. During the remaining 23 hr of each day, the tubes were removed. Bedding was levelled prior to insertion of the tubes, and the height of bedding at each spout was measured at 30-min intervals. Hardwood shavings (P. J. Murphy Co., Moonachie, N.J.) covered chamber floors during Experiment 1; bedding was changed every 5 days in all studies.

Following 5 days of restricted access to water, subjects were exposed to undiluted Tabasco pepper sauce (McIlhenny Co., New Iberia, La.). Exposure consisted of filling one spout with the sauce (the left spout for two rats, the right spout for the remaining two), and inserting that spout alone into the chamber at the onset of the usual drinking period (3:00 p.m.). Thitry minutes later, the second tube, filled with water, was inserted and the bedding levelled. After both tubes were introduced, height of bedding material at the spouts was recorded at 30-min intervals for 3 hr, and at irregular intervals (Figure 1) over the next two days. Following the test with Tabasco sauce, a series of manipulations like that described above was conducted with apple juice (Burnette Farms, Hartford, Mich.) adulterated with a 10% (weight/weight) concentration of table sugar (Domino Granulated, Amstar Corp., N.Y.) presented as the novel food. Presenting apple juice determined whether rats would bury any novel liquid food, or only food with aversive taste properties.

RESULTS AND DISCUSSION

All rats were observed to lick the spout containing Tabasco sauce, but little (less than 3 ml total) of the substance was consumed across a two-day period. As indicated by Figure 1, over

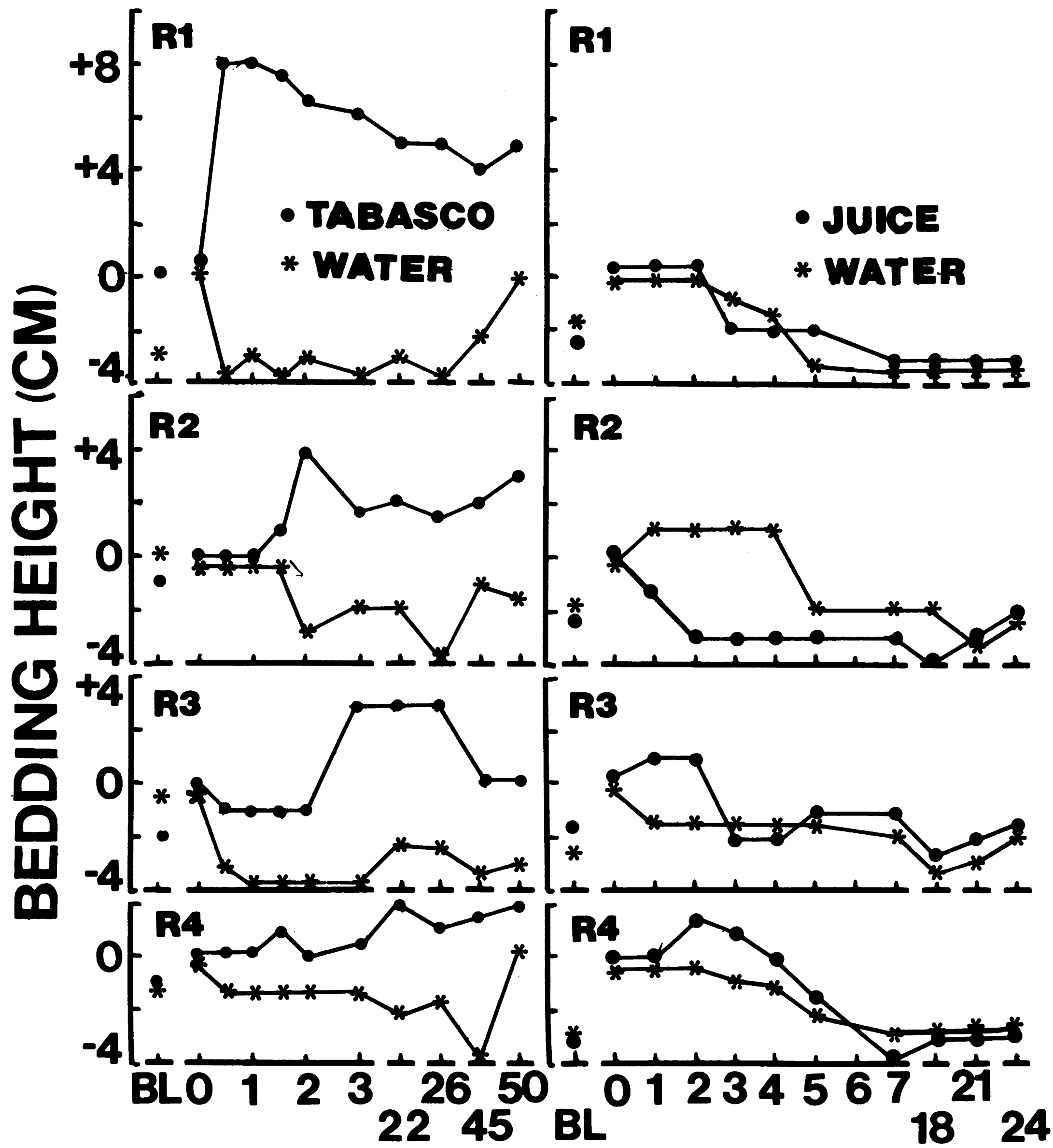

Fig. 1. Height of bedding material at the two spouts at various times after their introduction. Points above BL represent the average height at the two spouts during the two preceding baseline sessions. Bedding was levelled at the time the spouts were introduced (0 hr); the spouts entered the chambers 3 cm above the levelled bedding (7 cm above the chamber floor). The left frame shows performance when water and Tabasco sauce filled the tubes, whereas the right frame indicates performance when sweetened apple juice and water were available.

the period of observation all subjects shoved bedding material toward the tube containing Tabasco sauce, whereas bedding was removed from beneath the water-filled tube. All of the rats consumed the full amount of sweetened apple juice presented, 50 ml, within 24 hr. They did not shove bedding toward the tube containing apple juice; rather, this tube was treated like the water-filled tube and bedding was removed from beneath it.

These results generally parallel those reported by Wilkie et al. (1979), and support the notion that rats will bury the source of noxious liquid foods, i.e., foods that they do not eat because of gustatory factors. They do not, however, bury novel but palatable liquid foods. That food-burying was observed in different laboratories, with different bedding materials and measurement systems (Wilkie and associates used video recordings and levelled the bedding following each observation) suggests that the phenomenon of burying badtasing liquids is a robust one (Sidman, 1960).

EXPERIMENT 2

Wilkie et al. (1979) considered the burying of bad-tasting liquid foods to be unconditioned. They reported that conditioned burying also could be induced by pairing a novel palatable food with an injection of lithium chloride in a taste aversion paradigm. Experiment 2 attempted to evoke burying by pairing the taste of a novel food, sweetened condensed milk, with a subsequent injection of *d*-amphetamine, a compound previously demonstrated to be effective in producing taste aversions (e.g., Berger, 1972; Cappell & Le Blanc, 1971).

Subjects and Apparatus

Subjects and apparatus were the same as used in Experiment 1. However, wood chips instead of wood shavings were used as bedding in this and all subsequent experiments. This change was based on the superior ability of the chips to absorb urine and fecal matter, and the greater ease of measuring the height of this bedding material.

Procedure

Initially, access to water was restricted to one hour per day for seven consecutive days, as in Experiment 1. At the end of that time, a single taste aversion conditioning session was conducted. In taste aversion conditioning, one spout (the left for two rats, the right for two), filled with sweetened condensed milk (Borden Eagle Brand, Borden, Inc., Columbus, Ohio) mixed with an equal volume of tap water, was inserted into the chamber for 30 min at the beginning of the usual drinking period (3:00 p.m.). No water was available during this time. After receiving 30 min of access to the milk, each rat was removed from the chamber and injected intraperitoneally with 8 mg/kg *d*-amphetamine sulfate (obtained from Sigma Chemical Co., St. Louis, Mo.) dissolved in isotonic saline solution prepared to a 1 ml/kg injection volume. After injection, rats were placed in a holding cage for approximately 5 min. During this time, the second tube, filled with tap water, was inserted into each cage and the bedding levelled. Rats were then returned to the chambers and the height of the wood chips (P. J. Murphy Co., Moonachie, N.J.) beneath the two spouts measured at irregular intervals (Figure 2) across a three-day period.

Results and Discussion

Each rat was observed to drink sweetened condensed milk when initially exposed to the food. During the three hours immediately following drug injections, bedding was not shoved toward the tube containing milk nor removed from beneath the tube containing water (Figure 2). Observation of subjects indicated that chewing the bedding material (pica) and licking the forepaws (grooming), types of behavior commonly associated with high doses of amphetamines (Seiden & Dykstra, 1977), occurred frequently during this period. Within seven hours of receiving *d*-amphetamine, each subject had accumulated bedding under the milk-filled spout and removed bedding from beneath the water-filled spout. This pattern persisted across the balance of the study, and systematically replicates earlier reports that pairing a novel food with drug injection in a taste aversion paradigm produces conditioned burying of the food source. Thus, Experiments 1 and 2 seem to support Wilkie et al.'s (1979) contention that burying by rats occurs in response to liquid foods with intrinsically aversive properties, or aversive properties acquired through conditioning. Other research by Pinel and associates has further demonstrated that conditioned defensive burying is evoked by traps that strike rats, prods that shock them, flashcubes that discharge near them, and hoses which direct airbursts into their faces (Terlicki, Pinel, & Treit, 1979). These data suggest that burying is evoked by a wide range of aversive stimuli, and is not strongly restricted by the properties of the object associated with the aversive stimulation. This suggests that burying may indeed be a general defensive response in rats. However, if this designation is to be useful, burying should not only be

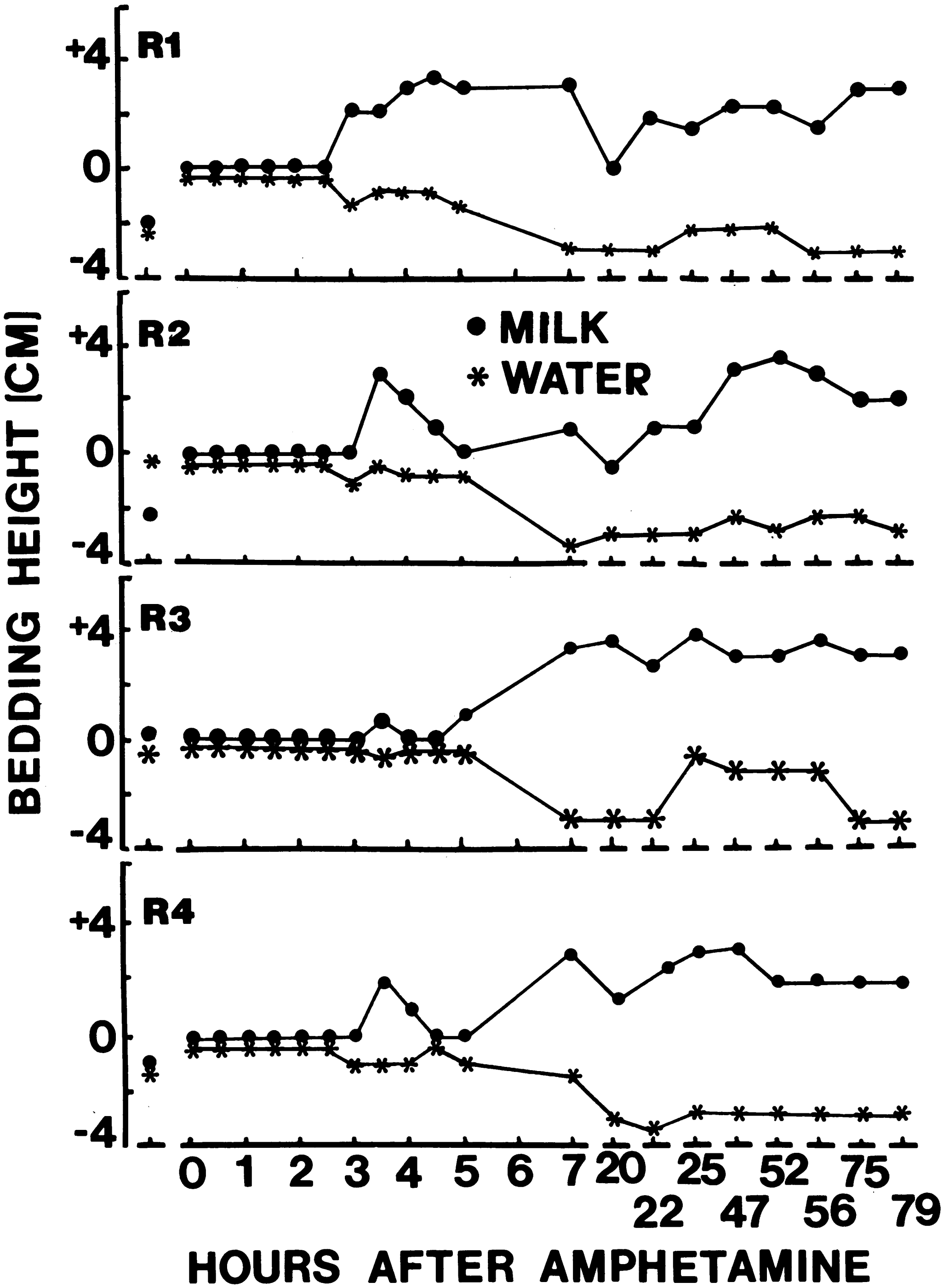

Fig. 2. Height of bedding material at the water and milk spouts at various times after injection of *d*-amphetamine (0 hr). Details are as in Figure 1.

evoked by exposure to noxious stimuli, but also should not be evoked by innocuous or appetitive stimuli.

EXPERIMENT 3

Experiment 3 demonstrates that rats consistently bury food pellets with aversive tastes, palatable food pellets, and marbles.

Subjects and Apparatus

Subjects and apparatus were the same as for Experiments 1 and 2.

Procedure

Subjects were given unlimited access to Purina Rat Chow and water during a five-day period. At the end of that time, the first burying test was arranged. At the onset of this test, the rats were placed in holding cages for 5 min, the bedding was levelled, and 25 pieces of Purina Rat Chow were placed atop the bedding in the center of the cage. Each piece of food was between 2.5 and 3.5 cm in length and the total weight of the 25 pieces, which was recorded, was between 125 and 135 g. After the food was placed in the chamber, the rats were not observed for 24 hours. The food hopper was full and water was freely available during this period. Twenty-four hours after the food was placed in the chambers, subjects were placed in holding cages and each of two observers independently recorded the number of food pellets that were not buried (i.e., were fully exposed), the number partially buried (i.e., some part of the pellet was covered by bedding), and the number fully buried (i.e., not visible). The experimenters sifted through the wood chips to determine the number of fully buried pieces; only pieces of food longer than 2.0 cm were counted. The total weight of the recovered food was recorded, and interobserver agreement was assessed by comparing the ratings of the two observers. They disagreed in their scoring of two of 86 pieces of food recovered. Interobserver agreement, calculated in the same manner, was similarly high in Experiments 4 and 6. Due to the unambiguous nature of the data collected, interobserver agreement was not calculated in Experiments 1 and 2, although another method was used to calculate interobserver agreement in Experiment 5.

After the amount of food buried was determined, the bedding was levelled and the rats returned to the chambers, where they were maintained for four days with free access to food and water. On the fifth day, a second burying test was conducted. This test was identical to the first, except for the food presented. In this test, Purina Rat Chow coated with quinine sulfate, a substance not readily consumed by rats (e.g., Benjamin, 1955; Deutsch & Deutsch, 1973, p. 634), was used. The pellets were coated by being soaked for 3 min in a solution composed of quinine sulfate (Sigma Chemical Co., St. Louis, Mo.) dissolved in tap water to a 10% concentration, after which they were rolled in powdered quinine sulfate. Observational procedures, like test procedures, were identical to those described above. After burying of the quinine-adultered food was assessed, rats were returned to the chambers and given free access to food and water for four days. Then, a third burying test was conducted. In this test, 25 glass marbles (Imperial Toy Co., Los Angeles, Calif.) approximately 1.5 cm in diameter were placed in each chamber. Conditions and observational procedures were as reported above.

Following the burying test where marbles were presented, animals were tested a second time with Purina Rat Chow, Rat Chow coated with quinine, and marbles. This second series of tests was identical to the first with one exception: animals were food-deprived for 72 hr prior to each test. Food deprivation involved removing all food from the chambers. This second series of tests was conducted under deprivation conditions because animals were water deprived to some degree in the burying studies described by Wilkie et al. (1979), and in our earlier studies.

Results and Discussion

The essential results of this experiment are unambiguous: whether or not they were food-deprived, rats buried Purina Rat Chow, Rat Chow coated with quinine, and marbles (Figure 3). When not food-deprived, only Rat R2 consumed a measurable amount of the quinine-coated food; that rat consumed 11 g. Deprivation increased the amount of quinine-coated food eaten by all rats; individual rats consumed 25 to 37 g under this condition. However, less quinine-coated food than uncoated food was consumed both when the rats were food-deprived and when no deprivation

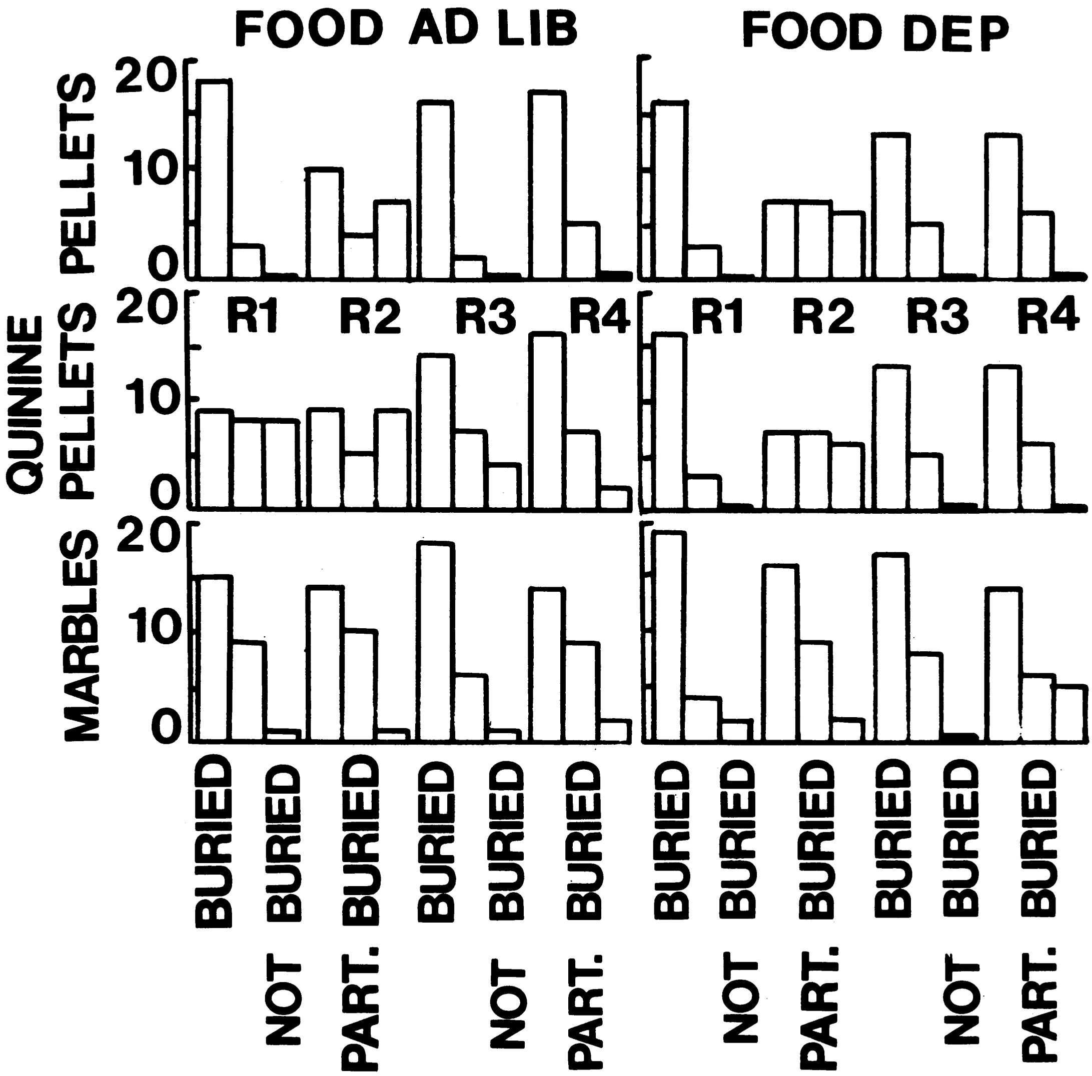

Fig. 3. Number of items buried when rats were (right frame) and were not (left frame) food deprived. In separate tests, rats were presented with 25 pieces of Purina Rat Chow, 25 pieces of Purina Rat Chow coated with quinine, and 25 glass marbles. Data represent the number of items fully buried, partially buried, and not buried 24 hrs after exposure.

was arranged. Individual subjects ate 30 to 36 g of uncoated chow when not deprived, and 37 to 49 g under the deprivation condition. This suggests that quinine possessed aversive taste properties in the present study, which is consonant with earlier findings (Benjamin, 1955).

The finding that rats bury quinine-covered dry foods is compatible with the suggestion that burying by rats is a species-typical response to aversive stimuli. However, Purina Rat Chow, the rats' normal food, and glass marbles have no apparent aversive properties, yet these stimuli were buried as readily as quinine-coated food. Terlicki et al. (1979) reported that rats sometimes buried a mouse-trap or flashbulb when these devices were first encountered, even if the trap did not spring or the bulb discharge. They considered this to be unconditioned defensive burying which was "part of the neophobic reaction to the appearance of an unfamiliar trap or flashbulb in the familiar test environment (p. 349)." Such burying was not evoked by a wire-wrapped wooden prod or a length of polyethylene tubing, and did not occur in response to the trap or flashbulb if the rats were habituated to these items. Habituation apparently occurred rapidly: Four 30-min sessions in which rats were exposed to the trap or flashbulb in groups of five or six eliminated burying. Burying of marbles and quinine-coated foods in the present study might have involved an unconditioned response to novel stimuli, for the rats had not been previously exposed to marbles or quinine. Such an account, however, does not explain why they buried Purina Rat Chow, a food with which their experience was extensive.

EXPERIMENT 4

Experiment 4 attempted to determine whether burying of marbles reflects an unconditioned, and easily habituated, response to a novel stimulus.

Subjects and Apparatus

The four subjects used in Experiments 1 through 3, and four additional experimentally naive adult hooded rats were used. They were tested in the chambers described in Experiment 1, and two additional chambers of like construction.

Procedure

Two different procedures were used in this study. In one, each of the four rats used in Experiments 1 through 3 was presented with 25 marbles each day for 10 consecutive days. The same marbles were presented each day and testing and maintenance were as described for the no-deprivation condition of Experiment 3, except that marbles were presented and burying measured at 24-hr intervals.

In the second procedure, each of four naive rats was housed in a wire-mesh home cage (18-cm wide, 17-cm high, 24-cm long) containing 25 glass marbles for 21 days prior to the marble burying test. Food and water were constantly available in the home cages. The burying test for these rats involved simultaneously placing the rats and marbles into chambers prepared with food, water, and bedding. Twenty-four hours later, the number of marbles buried, partially buried, and not buried was recorded. In this study, the experimenters wore rubber gloves while handling rats, marbles, and bedding. It is possible that rats buried food and marbles in Experiment 3 because they had acquired aversive gustatory or olfactory properties through contact with the experimenters' hands.

Results and Discussion

Each rat buried most of the marbles every day across the 10-day test period; no downward trends were apparent in the number of marbles buried (Figure 4). In addition, rats that had lived for an extended period in close spatial proximity to marbles also buried them when first given the opportunity (Table 1). These data indicate that burying of marbles, like the burying of Purina Rat Chow in Experiment 3, is not determined by novelty. The use of gloves also ruled out the possibility that marbles were buried because of noxious stimulus properties acquired through contact with human skin. Further, in contrast to the unconditioned burying of traps and flashcubes reported by Terlicki et al. (1979), marble burying did not habituate with repeated exposure. The reason for this difference in findings is not readily apparent, but the present data do indicate that persistent burying may be evoked by stimuli which are not aversive in any usual sense.

However, the burying evoked by aversive and nonaversive stimuli might differ in topography or time course. Such differences would not have been apparent in our previous studies, which did not directly monitor ongoing behavior.

EXPERIMENT 5

In Experiment 5, rats were continuously observed across a 12-hr period to determine the topography and time course of burying when various stimuli were presented.

Subjects and Apparatus

Three adult male hooded rats not previously tested were used. They were tested in three of the chambers described in Experiment 1.

Table 1

Burying of marbles by rats that were housed with them for 21 days.

Rat	*Fully Buried*	*Partially Buried*	*Not Buried*
8	19	3	3
9	20	3	2
10	22	2	1
11	24	1	0

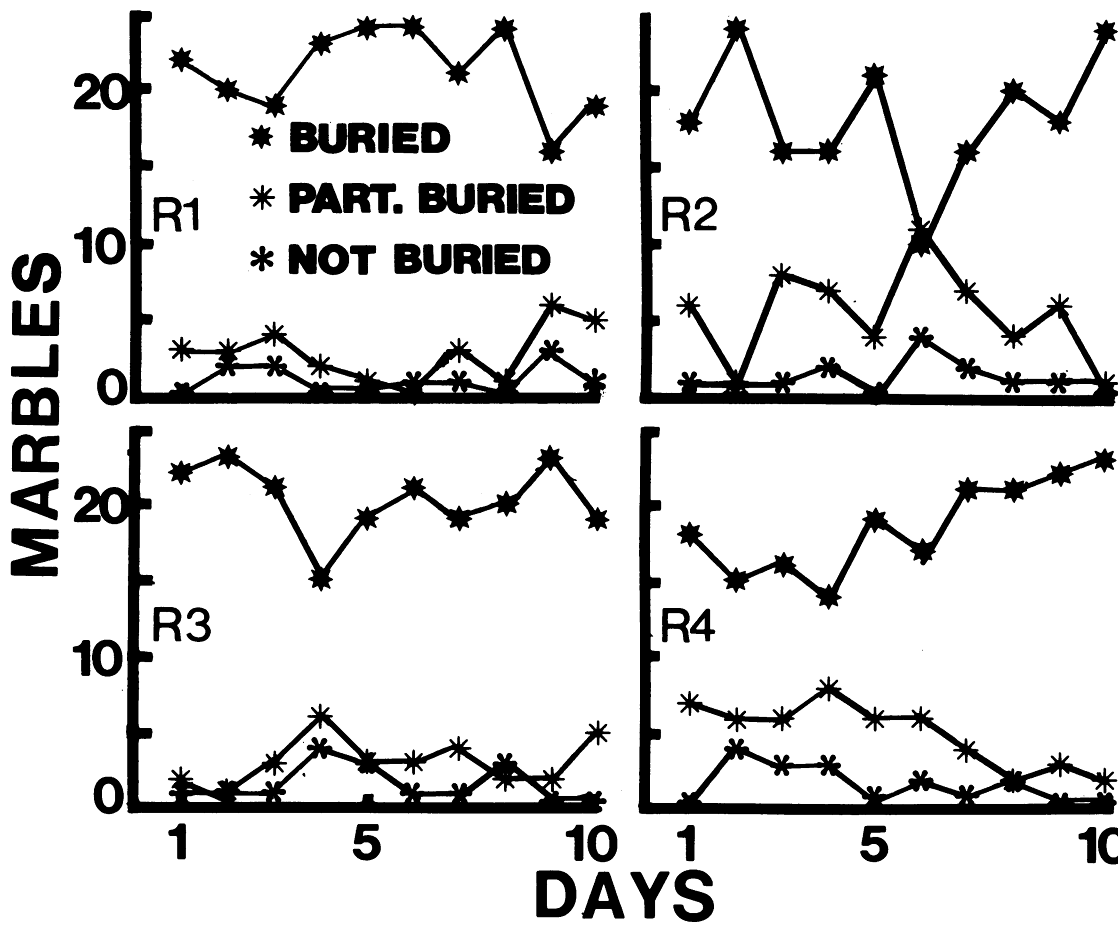

Fig. 4. Number of marbles fully buried, partially buried, and not buried each day across 10 consecutive days. Twenty-five marbles were placed in each chamber at the onset of the experiment. At 24-hr intervals, burying was assessed and all marbles were exposed.

Procedure

This study was a procedural replication of Experiment 3. Thus, burying tests were conducted with Purina Rat Chow, Purina Rat Chow coated with quinine, and marbles. These stimuli were presented in a sequence that differed across subjects. The rats were not food deprived in this study, and an observer continuously watched each animal for 12 hr (the illuminated part of the light/dark cycle) following the onset of each burying test; number of items (totally) buried after 24 hrs also was recorded. During observation, the time of occurrence and typography of any behavior that resulted in burying one or more of the test items was noted, and a cumulative record of items buried across time was kept. Twice during each observational period, at irregular intervals, a second observer independently determined the number of items visible (i.e., not buried) in each chamber. To calculate interobserver agreement, these data were compared to those recorded by the primary observer. In 15 of 18 instances (83%), the two measures agreed perfectly; the magnitude of the disagreement in the remaining instances was one or two items.

Results and Discussion

Figure 5 shows the number of items buried across time when Purina Rat Chow, Purina Rat Chow coated with quinine, and marbles were presented. As in earlier studies, each rat buried food, food coated with quinine, and marbles. The time course of burying was similar regardless of the stimuli presented: Most of the 25 objects were buried within 1 hr,

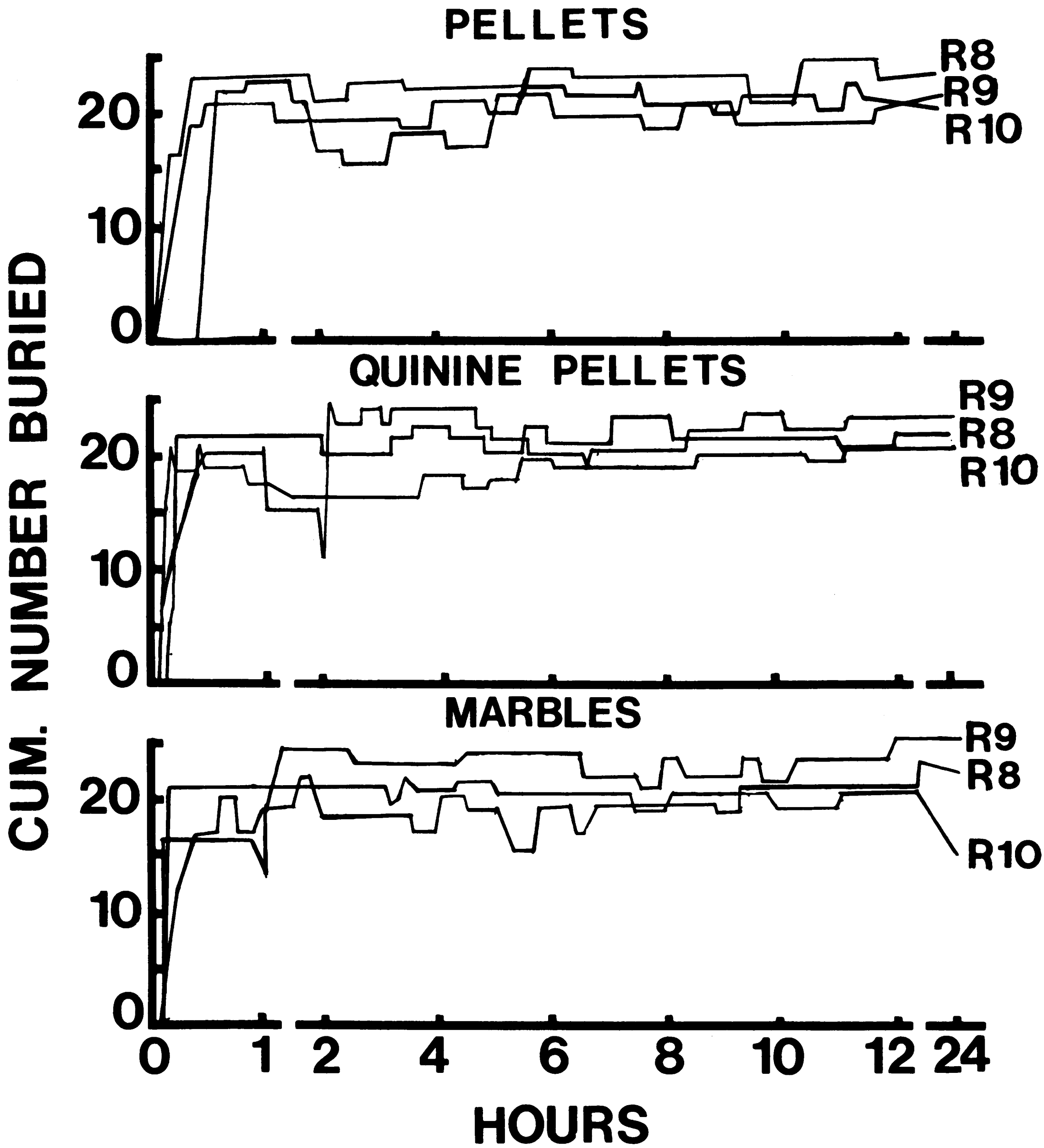

Fig. 5. Cumulative number of items fully buried across time. In separate tests, rats were continuously observed for 12 hrs after being presented with 25 pieces of Purina Rat Chow, 25 pieces of Purina Rat Chow coated with quinine, and 25 glass marbles. The number of items fully buried after 24 hrs is also reported.

although burying was occasionally observed later in the session, as was uncovering of buried objects.

In general, the topography of burying observed in the present study resembled that described by Pinel and coworkers when rats were exposed to obviously noxious stimuli (Pinel & Treit, 1978; Terlicki et al., 1979; Wilkie et al., 1979). Although some differences were observed across rats and occasions, in most instances burying of all objects involved the following sequence of actions: 1). The rat approached and sniffed the object. In many, but not all, instances, the object was grasped with the forepaws and brought into contact with the mouth. Sniffing the object inevitably occurred prior to the first burying bout of a session, but some subsequent bouts began with-out the rat directly contacting the object. 2). The rat moved away from the object (usually, c. 8 cm), then approached it with the snout lowered into the bedding. As the object was approached, the snout was lifted rapidly, moving the bedding upward and forward. The forepaws, repeatedly moved outward from the body, were employed in conjunction with the snout to shove the bedding toward and over the object. Several movements of the snout and forepaws occurred during each approach sequence, which typically lasted less than 5 sec. The entire sequence of approach and burying movements often was repeated two or three times in a brief period of time (1 min or less), and each bout of burying usually resulted in a number of objects being covered with bedding. Burying movements were consistently directed toward the stimulus objects presented, and these objects were almost always buried only as a result of such a sequence of movements. Across all subjects, three marbles and four pieces of Purina Rat Chow were observed to be buried as a result of the rats displacing bedding while walking about the chamber, or digging bedding from beneath the water spout.

EXPERIMENT 6

It is possible that burying in the present studies was potentiated by the small size of the experimental chambers (865 square cm of floor space minus 80 square cm covered by the food hopper). In the wild, rats live in restricted colony areas, from which they range outward to forage over an area estimated at 20 to 30 m in diameter. Palatable foods found in foraging are carried to nests in the colony, where they are stored until eaten, whereas foods with aversive taste properties are simply avoided (Barnett, 1963).

In our previous studies, we hypothesized that perhaps rats could not escape the stimuli associated with noxious foods by moving away from the food source; they had nowhere to go. Thus burying was the only possible escape response. Experiment 6 determined whether burying of a food paired with drug-induced toxicosis would occur in a relatively large chamber, and also examined whether marbles and Purina rat pellets were buried when rats were not forced into unavoidable contact with them.

Subjects and Apparatus

Three experimentally naive adult male hooded rats were used. They were tested in three chambers constructed of plywood and clear Plexiglas, equipped with a feeder and two drinking spouts as described in Experiment 1. The chambers used for testing Rats 5 and 7 were 85-cm long, 55-cm wide, and 30-cm high. The chamber used for testing Rat 6 was 65-cm long, 45-cm wide, and 30-cm high.

Procedure

Three tests were conducted. Food (Purina Rat Chow) and marble burying tests were conducted as in the no-deprivation condition of Experiment 3. A taste aversion conditioning test, like that described in Experiment 2, also was arranged. As in that study, sweetened con-

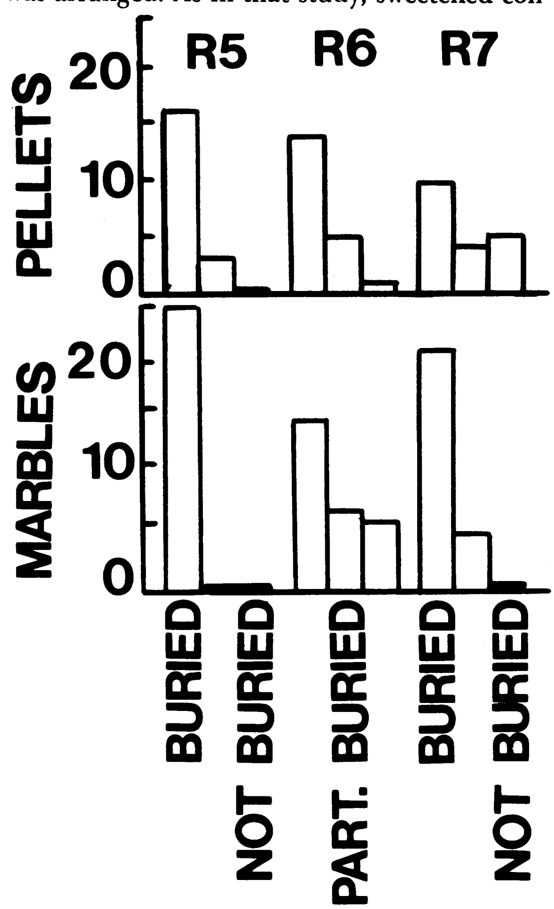

Fig. 6. Number of items buried when rats were tested in large chambers. Rats 5 and 7 were tested in chambers with 4675 square cm of floor space; Rat 6 was tested in a chamber with 2925 square cm of floor space. Floor space of chambers in earlier experiments was 865 square cm. Details are as in Figure 3.

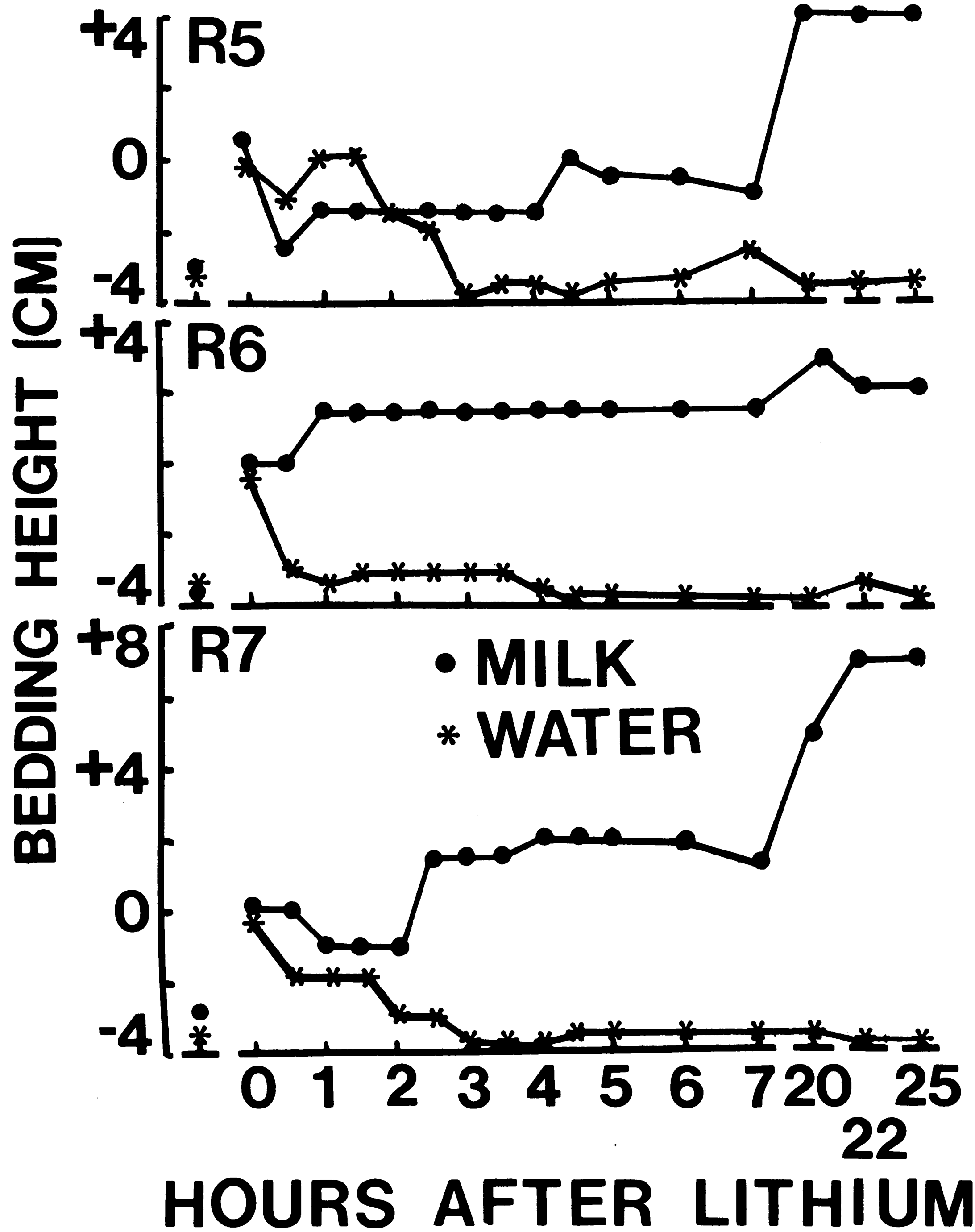

Fig. 7. Height of bedding material at the water and milk spouts in large chambers at various times after lithium chloride injection. Details are as in Figures 1 and 5.

densed milk was presented as the novel food. However, in contrast to that study, the drug injected here was lithium chloride, which was used by Wilkie et al. (1979) in their taste aversion procedure. Each rat received an intraperitoneal injection of 6.4 mg of lithium chloride (Sigma Chemical Co., St. Louis, Mo.), dissolved in 1.0 ml of distilled water.

RESULTS AND DISCUSSIONS

As in earlier studies, all subjects buried Purina Rat Chow, marbles, and a novel food paired with drug-induced toxicosis (Figures 6 and 7). Although the chambers used in this study provided much more floor space than those used in previous experiments, burying was not obviously attenuated. This suggests that burying is not limited to very small chambers, where stimuli are placed in or near rats' nests and cannot be avoided by moving away. While this experiment extends the range of conditions under which burying has been demonstrated, it does not clarify whether burying is a part of wild rats' response to food and other stimuli, or, if so, the biological significance of the response.

GENERAL DISCUSSION

The most interesting aspect of the present studies is the demonstration that burying was evoked by stimuli that seem to have little in common, although not all stimuli engendered burying. Earlier reports emphasized that burying occurred in response to diverse stimuli with known aversive properties, thus burying was considered as a species-typical defensive reaction (Pinel & Treit, 1978; Terlicki et al., 1979; Wilkie et al., 1979). Such a designation certainly does not apply to the burying of rats' normal food or marbles, neither of which were aversive, i.e., evoked escape or avoidance behavior. Rather, these stimuli evoked persistent approach responses. Rats carried Purina Rat Chow in their mouths and ate it, whereas marbles were carried and manipulated. It is, of course, possible that burying of aversive and nonaversive stimuli are topographically separable responses. This was not observed in the present studies; the snout and forepaws were used to shove bedding toward and over all stimuli that were buried. However, extremely subtle differences between the burying evoked by aversive and nonaversive stimuli may have been overlooked, although this seems unlikely.

Even if all burying does involve a homogenous sequence of actions, it is not surprising that the response should appear in more than one circumstance. Most types of behavior are flexible with respect to the environmental stimuli that control them, although concepts such as species-typical defensive reactions imply a rigid stimulus-response linkage where noxious stimuli elicit a characteristic response in all members of a species. This does not, however, indicate that only noxious stimuli control the response. Rats run away from predators, where the behavior may be considered as a defensive reaction (Bolles, 1970), and also run toward food in an alley, where the response is a positively reinforced operant.

It is quite tenable that burying of aversive and nonaversive stimuli are not biologically related. Burying of aversive stimuli may have much in common with other defensive reactions, e.g., fleeing, fighting, and crouching (Blanchard & Blanchard, 1971; Bolles, 1970), although this remains to be shown. Burying of small appetitive or innocuous solids may be in some respects related to hoarding in rats, a type of behavior once studied extensively (review by Munn, 1950).

In hoarding, food and nonfood objects including stones, cakes of soap, and bits of wood are carried to the nest area, where they are stored (Barnett, 1963). Scattering of items around the chamber, a behavior that was sometimes evoked by marbles and Purina Rat Chow prior to burying in the present studies, also has been considered as a form of hoarding (Barnett, 1963; Calhoun, 1949). *Rattus norvegicus,* of which laboratory rats are variants, is a burrowing species that digs well and often (Barnett, 1963), and burying may be a part of hoarding in the natural environment. This apparently has not been reported, perhaps due to the difficulties of observing wild rats in underground burrows. Burying food in caches is, of course, a common behavior of squirrels and certain other rodents.

The failure of rats to bury palatable liquids (apple juice in Experiment 1, milk in Experiments 2 and 6 before drugs had taken effect) indicates that burying is not evoked by all stimuli, and to some extent supports the notion that burying of solids might in fact be related to hoarding. However, the best test of this notion would be to examine whether burying of nonaversive solids is sensitive to variables known to facilitate or inhibit hoarding (see Barnett, 1963; Munn, 1953). Such variables might be expected to similarly affect burying of nonaversive solids, but not liquids. In contrast, burying of aversive stimuli, if a species-typical defensive reaction, should not be sensitive to factors that influence hoarding, but should be affected by variables that influence other defensive reactions (Blanchard & Blanchard, 1971; Bolles, 1970). This latter group of variables would not be expected to influence burying of nonaversive stimuli.

Even if burying of aversive food is a species-specific defensive reaction and burying of other solids is hoarding, the biological significance of burying, if any, is unknown. The adaptive value of any observed behavior can be assumed, but not readily proven. As Barnett (1963, p. 42) emphasized nearly twenty years ago: "Even if we knew for certain that hoarding had survival value, either for the individual or the colony, the immediate stimuli which influence it would still be open to investigation." The same is true of burying.

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