

The Effect of Flavor Preexposure upon the Acquisition and Retention of Poison-Based Taste Aversions in Deer Mice: Latent Inhibition or Partial Reinforcement?

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An investigation was made of the effects of prior familiarization with sucrose on the acquisition and extinction of LiCl-induced aversions to sucrose by mice of the genus *Peromyscus*. As in previous studies on other species, it was found that flavor familiarization inhibits the formation of learned taste aversions. However, in contrast to some reports on other species, it was demonstrated that for *Peromyscus* familiarization does not accelerate, but instead retards, the extinction of taste aversions. It was noted that (a) the contrasting extinction results reported for other species may be confounded with masked acquisition effects, (b) the latent inhibition effect is often not obtained with fewer than 20 preexposures, yet the flavor-preexposure effect has been demonstrated with as few as one preexposure, (c) the flavor-preexposure schedule is logically and operationally equivalent to a short partial-reinforcement schedule, and (d) both the acquisition and extinction effects shown by *Peromyscus* are consistent with a partial-reinforcement interpretation. Therefore, it was suggested that future analysis of the phenomenon might profitably consider the possibility that the flavor-preexposure effect upon taste-aversion learning may be a case of partial reinforcement.

It is well established that animals can learn to avoid ingesting distinctive flavors following a single flavor/toxicosis pairing and that the formation of these poison-based aversions is strongly influenced by the novelty of the flavor paired with illness (Ahlers & Best, 1971; Bolles, Riley, & Las-kowski, 1973; Domjan, 1972; Farley, McLaurin, Scarborough, & Rawlings, 1964; Kalat, 1974; McLaurin, Farley, & Scarborough, 1963; Re-

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vusky & Bedarf, 1967; Wing & Birch 1974; Wittlin & Brookshire, 1968). Several studies on white rats have indicated that significant reductions in the initial intensity of poison-induced taste aversions can be produced by as few as three safe preexposures to the experimental flavor (Elkins, 1973a; Fenwick, Mikulka, & Klein, 1975; Kiefer & Braun, 1977; Klein, Mikulka, & Hamel, 1976; Mikulka & Klein, 1977; Vogel & Clody, 1972), and some authors have observed significant reductions following a single safe preexposure (Kalat & Rozin, 1973; McFarland, Kostas, & Drew, 1978; Siegel, 1974). In addition, there are some claims that safe flavor preexposure will facilitate the extinction of learned taste aversions (Elkins, 1973a; Fenwick et al., 1975; Mackay, 1974; McLaurin et al., 1963), but this is disputed by Mikulka and Klein (1977) who assert that "familiarization training only affects the acquisition of a taste aversion and not the rate of extinction" (p. 518). However, it is possible that Mikulka and Klein failed to detect preexposure effects upon aversion extinction because their procedures may have been less sensitive than those previously used. For example, with a two-bottle test, Mikulka and Klein failed to detect any extinction differences after twelve, 30-min trials, while Elkins (1973a) detected a difference between his 1-day-preexposed group and his controls only after twenty, 24-hr trials. Similarly, when Mikulka and Klein failed to detect any differences with a one-bottle test they acknowledged that their measure of milliliters consumed in 30 min might have been less sensitive than the measure with which Fenwick et al. succeeded in finding a difference.

To date, most of the work investigating the role of relative flavor novelty in the formation of poison-based taste aversions has been done upon the laboratory rat, although one report has specifically studied the phenomenon in codfish (Mackay, 1974) and several reports have touched upon the role of novelty in the formation of poison-based taste aversions by other species (Brett, Hankins, & Garcia, 1976; Czaplicki, Porter, & Wilcoxon, 1975; Emmerick & Snowdon, 1976; Gustavson, Kelly, Sweeney, & Garcia, 1976; Kanarek, Adams, & Mayer, 1975; Kimeldorf, Garcia, & Rubadeau, 1960; Rusiniak, Gustavson, Hankins, & Garcia, 1976). The restriction of the investigation primarily to one domesticated species is unfortunate, since several general models of feeding and of taste-aversion learning are based to some extent upon the important role of novelty in the process of dietary selection (Domjan, 1977; Kalat & Rozin, 1973; Rozin, 1975; Rozin & Kalat, 1971, 1972; Westoby, 1974). Therefore, the present study will extend the study of the phenomenon to another taxon: mice of the native North American genus *Peromyscus*. Aversions toward a 20% (w/v) sucrose solution induced by ip injections of LiCl will be employed as the test behavior since some data bearing upon the occurrence of such aversions are already available (Robbins, 1977b, 1978).

EXPERIMENT 1

Methods

The animals in this study were experimentally naive, adult (100–160 days of age), male and female *Peromyscus maniculatus bairdi*—a common grassland species of deer mouse. The animals were the first generation of laboratory-born offspring from original stocks captured on or near the Michigan State University campus. During these studies the animals were housed individually in plastic laboratory cages measuring 15 × 15 × 30 cm, equipped with wire lids, and supplied with wood shavings, cotton nesting material, and lab chow.

Since *Peromyscus* cannot tolerate the restriction of fluid availability to short intervals every day, regular and reliable drinking patterns were produced by placing the 65 subjects on the following fluid-availability schedule: On Day 0 the animals were removed from their colony cages, where water had been available *ad lib.*, and were placed into their experimental cages. At 1300 hr, their water was removed, beginning a 24-hr deprivation. At 1300 hr of Day 1, drinking tubes filled with water were placed on each cage, left for 20 min, then removed and the amount consumed recorded. Consumption was measured to ± 0.1 ml by offering the fluid in 10-cc plastic syringes which had been modified into calibrated drinking tubes (after Robbins, 1977a). Immediately following the recording of data the tubes were refilled, replaced upon the cages, and left in position for approximately 24 hr. At 1300 hr on Day 2, the tubes were removed, beginning another 24-hr deprivation, and the data recorded. This alternation of fluid-availability/fluid-deprivation was continued throughout the experiment. This schedule provides a regular, postdeprivation, 20-min drinking period, suitable for taste-aversion-inducing manipulations, on every odd-numbered day, while providing 24 hr of *ad lib.* water consumption on every even-numbered day.

Water was presented to all of the animals according to this schedule for 8 days. Then the animals were weighed and assigned randomly to one of five treatment groups ($n = 13$ for each). Group 1 (no-pre/Li) was assigned as the no-preexposure control and received no sucrose preexposures prior to its sucrose/LiCl-injection pairing; Group 2 ([1-pre(22)]/Li) received a single safe preexposure to sucrose (20% w/v) 22 days prior to its sucrose/LiCl pairing; Group 3 [1-pre(4)]/Li received a single safe preexposure to sucrose 4 days prior to its sucrose/LiCl pairing; Group 4 (10-pre/Li) received 10 safe preexposures to sucrose beginning 22 days prior and ending 4 days prior to its sucrose/LiCl pairing; and Group 5 (no-pre/Na) received no safe preexposures to sucrose prior to its sucrose/NaCl pairing. After the completion of the preexposure schedule on Day 27, all groups received water for 3 days. Then, on Day 31, all groups received a 20% sucrose solution during their 20-min drinking period, following which

they were injected ip with a 0.6 M solution of their assigned substance. The volume of the injectant was held constant at 0.015 ml/g of body w so that each animal received 9.0 mEq of solute/kg of body w. Following this single flavor/illness pairing, 12 extinction trials were administered by presenting 20% sucrose solution to all animals during their 20-min drinking periods on the odd-numbered days from Day 33 through Day 55.

Noncontingently poisoned sensitization controls were omitted because (a) some data already exists upon poison-induced flavor sensitization in deer mice (Robbins, 1978), and (b) the present experiment is intended to test the effect of relative flavor novelty upon subsequent taste aversion acquisition and extinction—it is not intended to assess the relative contributions of learning and sensitization in the formation of taste aversions in these animals.

Results

The results are given in Figure 1. The effect of relative novelty upon aversion acquisition was analyzed by comparing the performance of the various groups on the first extinction trial of this figure. Group 1 (no-pre/Li), Group 2 [1-pre(22)/Li], and Group 3 [1-pre(4)/Li] all showed mean consumptions below 0.15 ml, while Group 4 (10-pre/Li) showed a mean of 0.77 ml, and Group 5 (no-pre/Na) showed a mean of 1.61 ml. One-way analysis of variance indicated differences among the groups [$F(4, 60) = 39.4106, p \leq 0.001$], and subsequent comparisons using Duncan's multiple range test (Duncan, 1955) indicated that Groups 1, 2, and 3 were not

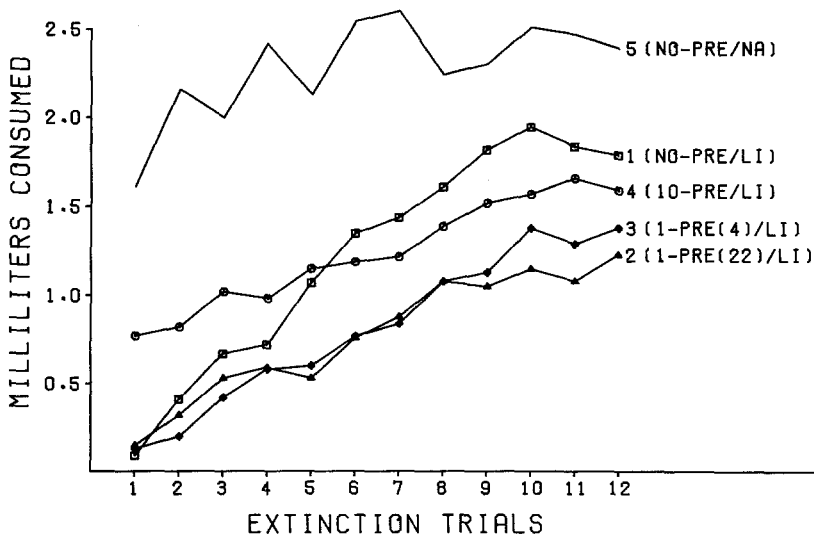


FIG. 1. Mean sucrose consumption following the sucrose/injection contingency in Experiment 1. The notations to the right of the curves indicate the treatment groups as defined in the text.

different from each other but were all different from Groups 4 and 5. In addition, Group 4 was found different from Group 5 (Duncan's test, $p \leq 0.05$).

The effect of relative novelty upon aversion extinction was analyzed by making daily comparisons among the groups using analysis of variance followed by Duncan's test on each of the remaining trials. A LiCl-injected group was considered to have extinguished its aversion on the day when Duncan's test found no difference between its mean and that of the NaCl-injected Group 5. Only Group 1 (no-pre/Li) ever attained this criterion, doing so on extinction trial 9. On the same day, it acquired significant differences with Groups 2 and 3 which had had one safe preexposure to the sucrose. That is, the group with no safe preexposure extinguished its aversion so rapidly when compared with the groups that had experienced one safe preexposure, that by extinction trial 9 the non-preexposed animals were drinking significantly more than either of the 1-day-preexposed groups.

Discussion

The significant difference on the first trial between Group 1 (no-pre/Li) and Group 4 (10-pre/Li) indicates that, for deer mice, familiarization with a flavor can interfere with the subsequent formation of a taste aversion toward that flavor. However, the equally significant difference between Group 4 (10-pre/Li) and Group 5 (no-pre/Na) shows that ten 20-min preexposures are insufficient to block completely the formation of aversions. The lack of difference among the no-pre/Li and the two 1-pre/Li groups indicates that in the present experimental context the slight decrease in novelty produced by a single safe 20-min exposure has no detectable effect upon aversion acquisition by *Peromyscus*. Thus, it seems that for deer mice, as for other species, sufficient safe preexposure to a flavor will attenuate the subsequent formation of poison-based aversions toward the flavor.

Despite this interspecific similarity in the effect upon aversion acquisition, the comparison of the extinction curves suggests that for *Peromyscus* safe preexposure retards extinction aversion—a finding in disagreement with the previously cited work on other species. Since this difference is striking and unexpected, a replication is warranted. This is provided in the next experiment.

EXPERIMENT 2

This experiment used experimentally naive subjects to replicate the previous experiment exactly, save for three modifications: (a) For economy, only three of the treatment groups were run: no-pre/Li, 1-pre(4)/Li, and no-pre/Na; (b) the number of extinction trials was increased from 12 to 16 to provide increased resolution of extinction differ-

ences; and (c) the data were collected blind by an assistant to protect from experimenter bias. As before, $n = 13$ for each group. Since the treatment groups of this replicate correspond to Groups 1, 3, and 5 of Experiment 1, they will be referred to as Groups 1, 3, and 5 in this experiment as well.

Results

Figure 2 gives the results of this experiment. One-way analysis of variance on the data from the first extinction trial showed a significant effect [$F(2, 36) = 34.7023, p \leq 0.001$] and subsequent comparisons (Duncan's test, $p \leq 0.05$) indicated that Group 1 (no-pre/Li) and Group 3 [1-pre(4)/Li] were not different from each other, but both were different from Group 5 (no-pre/Na). An examination of the extinction results (performed as in Experiment 1) confirmed the previous findings as again on extinction trial 9 the nonpreexposed Group 1 extinguished its aversion relative to the NaCl-injected control group, while simultaneously the difference between the no-pre/Li and the 1-pre/Li groups acquired significance. Furthermore, the group with one safe preexposure, Group 3, never extinguished its aversion relative to the NaCl-injected control group, as it was still consuming less on the 16th and final trial [$t(24) = 3.2101, p \leq 0.01$].

In addition to the analysis of the extinction behavior of the different treatment groups, the extinction behavior of the individual animals was examined by assigning to each animal a days-to-extinction value, defined simply as the number of the extinction trial upon which that animal first drank a quantity of sucrose greater than or equal to 50% of that day's mean consumption by the NaCl-injected control group. If an animal never attained this criterion, it was assigned a days-to-extinction value of 17. By

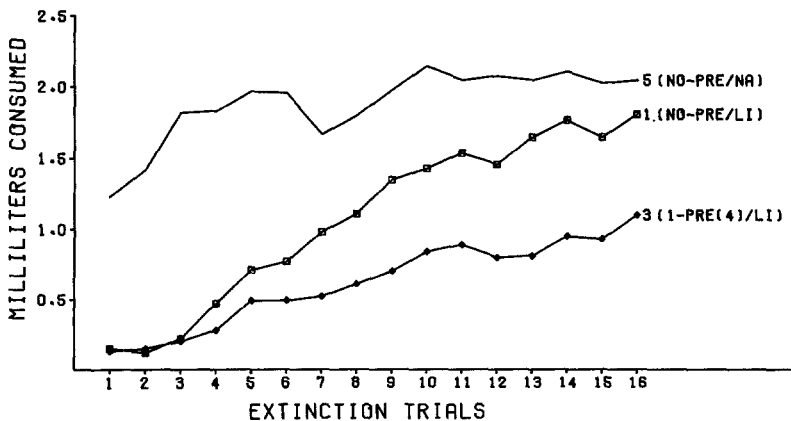


FIG. 2. Mean sucrose consumption following the sucrose/injection contingency in Experiment 2. The notations to the right of the curves indicate the treatment groups as defined in the text.

this method it was found that the nonpreexposed group had a mean of 8.3 days to extinction, while the preexposed group had a mean of 12.1 days. A one-tailed *t*-test indicated that this difference was significant [$t(24) = 1.9865, p \leq 0.05$].

Discussion

Experiment 2 corroborates the findings of Experiment 1 and indicates that in *Peromyscus* safe preexposure to a flavor appears to delay the extinction of a subsequently acquired poison-induced aversion to that flavor. These findings are sufficiently different from those previously obtained with laboratory rats and with codfish to warrant an inquiry into their possible origins and implications.

GENERAL DISCUSSION

A comparison of these results with the extant literature on other species suggests that, for all species tested, safe-flavor preexposure can attenuate the subsequent acquisition of a poison-induced taste aversion. However, the present experiment found that in deer mice flavor preexposure significantly retards the extinction of a subsequently acquired aversion, while studies on rats (Elkins, 1973a; Fenwick et al., 1975; McLaurin et al., 1963) and on codfish (Mackay, 1974) have reported that flavor preexposure appears to accelerate the extinction of such an aversion in these animals. Further analysis, however, suggests that these differences may be procedural, rather than taxon specific, in origin.

Mikulka and Klein (1977) observed that comparisons of extinction rates are of limited value unless all groups are beginning extinction from a common level of aversion acquisition, and therefore they designed their experiment so that all groups were starting from a common "floored" level of acquisition (i.e., all groups were drinking virtually none of the flavor paired with illness). However, neither they nor other workers treating the phenomenon (e.g., Elkins, 1973a; Fenwick et al., 1975; McLaurin et al., 1963) have noted that a floored acquisition level can be inappropriate for extinction comparisons. For example, in another paper, Elkins (1973b) demonstrated that two groups of rats, differing only in the amount of toxin administered following a single exposure to saccharin, formed apparently equal floored aversions, but the group that had received less of the illness-inducing agent extinguished its aversion more rapidly. Elkins interpreted these results as indicating that the two groups did not actually acquire a common level of aversion, but that instead their real acquisition differences were masked by the almost total rejection of saccharin shown by both groups, and he observed, "under parameters which produce strong initial aversions, resistance to extinction may be the most appropriate test of differential [initial] aversion strength" (p. 355). Thus, extinction comparisons among groups showing common floored

levels of aversion acquisition must run the risk of confounding real extinction differences with masked acquisition differences. As all of the cited extinction studies on rats and codfish employed comparisons among groups with floored aversions and since all of their results were in the direction expected if masked preexposure-induced acquisition differences existed, it is possible that some or all of their findings regarding the effect of flavor preexposure upon taste aversion extinction may derive from this confounding.

Although the present study also employed groups showing floored aversions, the extinction differences observed with deer mice were exactly counter to those which would have been expected if confounding were occurring, thus allowing the analysis of the present data to disregard the possible confounding or actually to cite it in support of the extinction-retarding effect of safe preexposure in deer mice. That is, if it is assumed that the confounding is occurring in the present study, then it must also be assumed that the initial aversions shown by the 1-pre/Li groups were actually weaker than those shown by the more rapidly extinguishing no-pre/Li groups. Therefore, it appears the extinction-accelerating effects previously reported may have been due to confounding, while the extinction-retarding effects obtained with deer mice are well supported.

Until now, much of the theoretical treatment of the flavor preexposure effect upon taste-aversion learning has considered the phenomenon to be an example of latent inhibition (e.g., Best, 1975; Best & Barker, 1977; Kalat, 1977). However, it must be noted that although the single safe flavor-preexposure treatment is logically and operationally equivalent to the minimal latent-inhibition-inducing schedule, it is also logically and operationally equivalent to the minimal 50% partial-reinforcement schedule. This suggests that the treatment cannot be assigned to either paradigm merely by an operational criterion, but rather additional consideration must be given to determine which interpretation is most appropriate. Both latent inhibition and partial reinforcement are expected to produce attenuated aversion acquisition. However, the latent inhibition theoretic makes no predictions regarding effects upon extinction (save for those indirect effects generated by masked acquisition differences), while partial reinforcement is well known to produce retarded extinction (Jenkins & Stanley, 1950; Lewis, 1960). Furthermore, a latent-inhibition effect is often not obtained with fewer than 20 preexposures (Lubow, 1973), yet the flavor-preexposure effect upon taste aversion learning is regularly obtained with far fewer exposures. Thus, if more weight is given to the unconfounded extinction results obtained with *Peromyscus* than to the potentially confounded results reported for other species, it appears that the data generated in the study of flavor preexposure and taste aversion learning may be more consistent with a partial-reinforcement analysis than with a latent-inhibition interpretation.

Although the effect of flavor preexposure upon taste-aversion extinction has not yet been examined in rats under the partial-reinforcement paradigm, Klein, Mikulka, Rochelle, and Blair (1978) have studied the effects of multiple-trial 50 and 33% partial reinforcement schedules upon taste-aversion acquisition by rats and they obtained the expected attenuation of learning. Unfortunately, they did not allow their animals to run to extinction, so it is not known whether their treatment would also have produced the retardation of extinction normally associated with partial reinforcement.

In summary, the present experiments have found that in deer mice safe-flavor preexposure attenuates the acquisition and retards the extinction of a subsequently acquired taste aversion. As (a) these results are consistent with those expected from a partial-reinforcement schedule, (b) the safe flavor-preexposure treatment is logically and operationally equivalent to a short partial-reinforcement schedule, and (c) the contrasting extinction results previously reported may have been confounded with masked acquisition effects, it is suggested that a consideration of the phenomenon under the theoretic of partial reinforcement might yield valuable insights. In particular, it is suggested that future work on other species might be directed toward determining if under properly controlled situations they too might give results consistent with a partial reinforcement interpretation.

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