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# Facilitation and impairment of conditioning in the preweanling rat after prior exposure to the conditioned stimulus

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**Olfactory aversion conditioning of preweanling rats, 10 or 18 days postnatal, was tested after some had been given nonreinforced experience with the to-be-conditioned odor stimulus. In three experiments, it was established that the amount of prior exposure to the CS determined the effectiveness of conditioning. For both ages, odor-shock conditioning was more likely impaired with longer durations of preexposure. This effect was more apparent in the older animals. Low to moderate degrees of prior exposure to the CS under some conditions facilitated, rather than impaired, olfactory conditioning in the 10-day-old rat. This result is in agreement with one previous study in which facilitation in learning was reported for this age after short-term preexposure to the CS. The present study adds to previous data on differential effects of CS preexposure on conditioning. Although the conditions under which facilitation rather than impairment occurs are not yet clear, age-related differences in the effects of CS preexposure were apparent in the present experiments.**

Nonreinforced exposure to a stimulus has been found to affect subsequent associability of that cue. It has usually been found that short-term nonreinforced experience with a to-be-conditioned stimulus impairs learning, relative to subsequent conditioning to that stimulus (Lubow, 1973).

In developmental research, it has been observed that facilitation of conditioning sometimes follows stimulus preexposure. Such positive transfer from prior exposure usually has been shown by means of Gibson and Walk's (1956) paradigm, in which rat pups are given relatively prolonged exposure to two different visual stimuli in their home cages. On a subsequent discrimination task, the pups that have received prior experience with the cues typically show enhanced learning, relative to nonpreexposed controls.

Many procedural differences are evident when one compares investigations that report facilitation of learning due to preexposure with those that report latent inhibition. Decrements in learning due to prior experience of the CS are typically found in adult rats that have been discretely exposed to the to-be-conditioned cue for brief periods in a novel environment that is used later for conditioning. Facilitation effects, on the other hand, have been more frequent after relatively prolonged stimulus exposure begun at early ages in the familiar home cage environment.

Although several of these procedural differences have been proposed in order to account directly or indirectly for the differential influence of preexposure on later associability of cues, no clear picture has yet emerged. For instance, the age of the animals tested seemed to be a potentially critical factor, with facilitation in young animals and latent inhibition in adults. Cross-study comparisons have indicated otherwise, however. For example, Hall (1980), who used a paradigm similar to Gibson and Walk's (1956), reported that facilitation effects were observable in adult rats; and Rudy and Cheatle (1979) found latent inhibition effects in 2-day-old pups.

Another variation of procedure proposed in order to account for the difference in results has been preexposure duration, with facilitation occurring after more prolonged preexposure, and attenuation after briefer experience. This factor appears also to have been ruled out, however. Spear and Smith (1978), testing preweanlings on active avoidance learning and retention, found facilitation with brief prior exposure to a vibrotactile stimulus in 9-day-old rats, but not in slightly older rats. Channell and Hall (1981), testing adult rats, also observed facilitation with a short preexposure period (1 h), and latent inhibition following longer (50-h) stimulus exposure.

Still other explanations have implicated contextual differences between preexposure and testing (Channell & Hall, 1981; Lubow, Rifkin, & Alek, 1976; Rudy, Rosenburg, & Sandell, 1977). The context in which preexposure is conducted appears to determine which stimulus preexposure effect will be found; prior experience with stimuli in the familiar context of the home cage has resulted in facilitation, whereas preexposure in the novel context that is later used for conditioning has resulted in latent inhibition (Channell & Hall, 1981). The failure to observe a decrement in learning when preexposure and conditioning contexts are different is predicted by Wagner

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(1976, 1978), but it is still unclear why facilitation should occur. Lubow et al. (1976) proposed that the novel context used for testing may increase arousal and thus enhance learning. However, Channell and Hall (1981) found that even when all subjects were made equally familar with the test context, facilitation was observed among rats preexposed in their home cage. Bateson and Chantrey (1972) offered a theory of perceptual learning in which they proposed that "classification" of stimuli during preexposure determines how well a later discrimination between the exposed cues will be learned. Perceived cues were said to be either "classified apart" or "classified together," depending on spatial and temporal proximity. If the perceived stimulus classification corresponds to the former case, the discrimination will be learned more rapidly (facilitation), whereas in the latter case, discrimination learning will be attenuated (latent inhibition).

In summary, nonreinforced presentations of a novel stimulus often affect the animal's subsequent learning of contingencies involving that stimulus. Associability can either be enhanced or attenuated by prior stimulus experience, depending apparently on the subjects, the conditions of preexposure, or the type of training involved.

The aim of the present study was to examine how short-term exposure of preweanling rats to an olfactory cue would alter associability of that odor. Relatively few studies have examined the influence of short-term preexposure on learning in immature animals. Misanin, Guanowsky, and Riccio (1983) and Misanin, Blatt, and Hinderliter (1985) completed ontogenetic investigations of latent inhibition involving gustatory stimuli, but the youngest animals they tested were previously weaned 19-day-olds. Rudy and Cheatle (1979) and Spear and Smith (1978) are the only investigators who have reported effects of brief preexposure on learning in preweanling rats. Rudy and Cheatle (1979) found an impairment in odor-illness conditioning due to CS preexposure in 2- and 8-day-old pups, whereas Spear and Smith (1978) reported both facilitation (in 9-day-old rats) and attenuation (in 12-day-old rats) of avoidance behavior as a function of brief preexposure to the to-be-conditioned vibrotactile stimulus that they employed as the CS.

In the present study, 10- and 18-day-old rats were preexposed to a lemon, peppermint, or methyl salicylate odor for one of several durations sampled within the interval of 0–45 min. Changes in associability of the preexposed olfactory cue were assessed.

## GENERAL METHOD: EXPERIMENTS 1 AND 2

### Subjects

The subjects were 10- and 18-day-old male and female Sprague-Dawley-derived rats that were born and reared in the rat breeding colony at the State University of New York at Binghamton. The date of birth was designated as Day 0, and litters were culled to 8–10 pups within 24 h after parturition. The animals were housed with both parents and littermates in standard maternity cages, which were partially filled with pine shavings. All rats were maintained on a 16:8-h light:dark illumination cycle, with the lights coming on at 0600 hours.

### Apparatus

The preexposure of the individual rat pups to the specified odor was conducted in separate 9 × 9 × 15 cm clear Plexiglas chambers with standard wire mesh or stainless steel grid floors. The compartments were maintained at 32–34°C by heating pads placed beneath them. Discrete odor presentations were delivered by an "olfactometer" designed and constructed in our laboratory by Norman G. Richter. When this device was turned on, air was filtered from the building's ventilation system into an air pressure regulator (PSI = .05). The air was then moved into a manifold (Airmite devices, Inc., F-25) with four individual outlets, each having a section of 1 cm diam tubing connected to it. The air flowed through these tubes into four corresponding Skinner valves (Honeywell, B20A9052). The airstreams were then forced into one of two 500-ml flasks, which contained either 30 ml of undiluted lemon oil or 30 ml of undiluted peppermint oil (both odorants were obtained from Humco Laboratories, Texarkana, Texas). From the flasks, the scented airstream was moved through another manifold, where the four lines were combined into a single output. For the purpose of the present experiments, the output was again divided into four lines. The scented streams from these lines were then directed into each conditioning chamber. When the air from the olfactometer was turned off, the odor was cleared by a fan connected to the university's ventilation system. The odorants in the flasks were replenished every month.

Spatial odor-preference testing was performed in a room different from the one used for preexposure and conditioning. The odor test was administered in a 27 × 10 × 12 cm Plexiglas apparatus. The odorants were spread on small pieces of cotton, which were placed beneath the standard wire mesh floor on opposite sides of the chamber. One cc of either lemon or peppermint oil was placed at one end of the apparatus, and 2 cc of Virginia Dare Artificial Ripe Banana No. 112 was located at the other end. All odor-preference testing was conducted in a dimly illuminated room. The only source of light was a General Electric 25W red bulb.

### Procedure

The preexposure occurred over 2 consecutive days, at either 10 and 11 or 18 and 19 days of age, with one preexposure session performed per day. Sessions were spaced by 24 h. The conditioning occurred 1 h after the preexposure on the 2nd day. For simplicity, the subjects are referred to only as 10- and 18-day-olds throughout the present experiments, even though manipulations were conducted when pups were 10 and 11 or 18 and 19 days old.

For the preexposure phase, pups within each litter were randomly assigned to groups corresponding to three exposure levels (0, 15, or 45 min of odor presentation) and two odorants (lemon or peppermint). On the 1st day of preexposure, the rat pups were removed from their home cages and placed in individual Plexiglas chambers. Four animals were exposed at a time. They were given 0, 10, or 30 discrete nonreinforced presentations of either a lemon or a peppermint odor on the first day of preexposure, and half this number on the next day. The stimulus duration was 60 sec, with a 3-min interstimulus interval (ISI). The initial preexposure session lasted 2 h for all subjects. Therefore, the animals given 0 preexposure were simply familiarized with the apparatus for 2 h; the pups in the 15-min exposure groups received 10 stimulus presentations during the first 40 min of the session and then remained in the apparatus for the following 80 min; and the rats in the 45-min preexposure groups were given 30 odor presentations, which took up the entire 2-h period. After preexposure, the subjects were returned to their home cages. Twenty-four hours later, the pups were again exposed, receiving one-half the number of odor presentations given on the first day (0, 5, or 15). This second preexposure session lasted only 1 h. The subjects were returned to their home cages at the end of each exposure session.

The conditioning procedures were administered 1 h after odor exposure on the 2nd preexposure day. The experimental animals were given four pairings of the preexposed odor (either lemon or peppermint) with a scrambled footshock of 1 mA for 1 sec. The odors were delivered by the olfactometer; the CS duration was 15 sec, with the US occurring immediately after odor presentation. The intertrial interval (ITI) was 4 min. The control animals received either four 15-sec CS exposures (4-min ISI) with no reinforcement or four footshocks followed 20 min later by four 15-sec CS presentations.

Immediately after conditioning, the subjects were given a spatial odor-preference test. One subject at a time was placed at the center of the rectangular Plexiglas chamber and allowed to move about freely over the two odorants for 3 min: the preexposed/conditioned odorant (either lemon or peppermint) under one side of the test chamber, and a novel odorant (banana) under the other. Odor position was balanced across subjects within each condition. The chamber was divided in half, providing a section for each odor. An animal was considered to be "over" a particular odor if its snout and both front paws were in the designated area for that odor. Time (in seconds) spent over the preexposed/conditioned odor was recorded. The preference testing was conducted in a dimly illuminated room, and the odorants were changed every 4 subjects.

## EXPERIMENT 1

The present experiment was designed to investigate the effects of short-term odor preexposure on classical conditioning involving the preexposed odorant as the CS. The rats were preexposed to the odor for one of three durations, followed by conditioning with an aversive reinforcer. It has been shown for preweanling rats that pairing an odor with a mild footshock results in an avoidance of that odor in a subsequent spatial odor-preference test (see Bryan, 1979; Kessler & Spear, 1980; Kucharski & Spear, 1984; Markiewicz, Kucharski, & Spear, 1986; Serwatka, Molina, & Spear, 1986; Serwatka & Spear, 1988).

### Method

**Subjects**. The subjects were 98 10-day-old rats from 13 litters and 91 18-day-old rats from 12 litters.

**Apparatus**. For preexposure and conditioning, the subjects were placed in individual 9 × 9 × 15 cm Plexiglas chambers that rested on a stainless steel grid floor. The odors were delivered by the olfactometer. A 1-mA scrambled electric shock was delivered for 1 sec by a Grason-Stadler shock generator (Model E6078B). The odor testing was performed in the apparatus previously described in the General Method section.

**Procedure**. The subjects were randomly divided, within each age group, into 18 treatment conditions defined by preexposure (0, 15, or 45 min of stimulus preexposure), conditioning treatment (paired, P; unpaired, UP; or CS-only, CSO) and odor (lemon or peppermint).

The subjects were preexposed at 10 and 11 days of age or at 18 and 19 days of age. Conditioning started 1 h after the second preexposure session. For conditioning, the pups were placed into the same Plexiglas chambers in which the preexposure had occurred, and the training proceeded as described in the General Method.

The dependent measure assessed in the present study was conditioned odor preference. Immediately after training, the pups received a spatial odor-preference test. For this, a pup was placed at the center of a clear rectangular Plexiglas chamber and allowed to move freely over two odorants, 1 cc of the preexposed/conditioned odorant and 2 cc of a novel banana odorant. The test lasted 3 min, and the time over the conditioned odor was recorded.

### Results and Discussion

**Ten-day-olds**. A significant conditioned aversion to the CS was evident for only the pups given 15 CS preexposures (see Figure 1). A 3 × 3 × 2 ANOVA performed on these data revealed a significant main effect of preexposure [$F(2,80) = 44.84$, $p < .001$] and a significant preexposure × treatment interaction [$F(4,80) = 5.893$, $p < .001$]. Post hoc comparisons (with the Fisher test: $p = .05$; see Keppel, 1982) found the locus of the interaction to be that the difference between the paired and control conditions was significant only with 15 CS preexposures.

These results suggest that the conditioning was facilitated by a moderate amount of CS preexposure (15 min), but impaired if a larger amount (45 min) was given. A difficulty in accepting this conclusion arises because conditioning was not clearly established in the nonpreexposed condition. Perhaps a floor effect on measurement at the 0 preexposure level prevented the observation of an aversion; with 15 min of preexposure to the to-be-conditioned odor, the baseline preference for that odor may have been increased sufficiently to measure the aversion. Experiment 2 addresses this problem.

**Eighteen-day-olds**. The four odor–footshock trials employed for training were sufficient to establish a conditioned aversion in 18-day-old pups. This learning was attenuated by CS preexposure (see Figure 2). A 3 × 3 × 2 ANOVA performed on these data revealed a significant main effect of preexposure [$F(2,73) = 16.18$, $p < .001$] and a significant treatment × preexposure interaction [$F(4,73) = 2.46$, $p < .05$]. Post hoc comparisons showed that whereas the pups in the nonpreexposed–paired condition had less of a preference for the conditioned odor than the nonpreexposed controls, there were no differ-

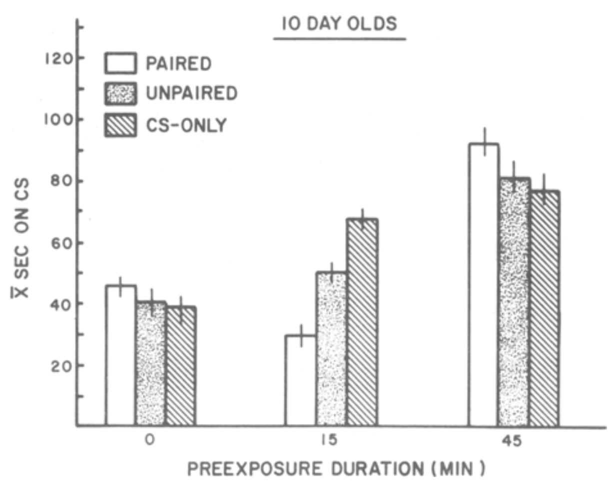


**Figure 1. Experiment 1: Mean (±*SE*) time spent on odor CS for 10-day-old pups from each preexposure × treatment group after four discrete odor-aversion conditioning trials.**

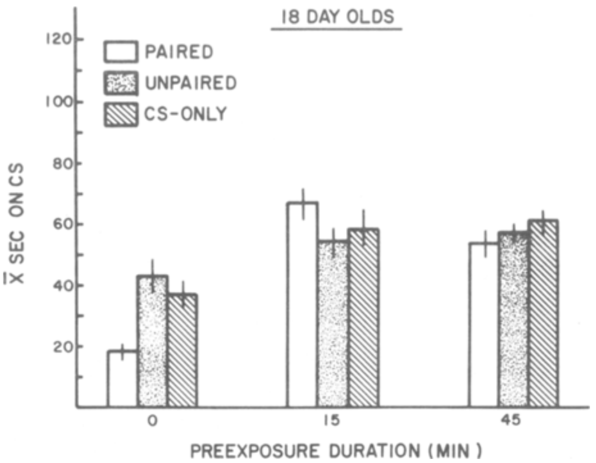


**Figure 2. Experiment 1: Mean (±*SE*) time spent on odor CS for 18-day-old pups from each preexposure × treatment group after four discrete odor-aversion conditioning trials.**

ences between the paired and control conditions after 15 or 45 min of preexposure.

For the older pups, then, there was no hint of preexposure-mediated facilitation of conditioning. Instead, both levels of CS preexposure led to clear impairment in conditioning—that is, there was a latent inhibition.

## EXPERIMENT 2

In Experiment 1, CS preexposure was demonstrated to influence odor-aversion learning in 10-day-old rats, but the data were difficult to interpret, because conditioning was not clearly established in the nonpreexposed-paired subjects. In Experiment 2, more extensive conditioning procedures were used in order to avoid this problem. Six, rather than four, training trials were employed after the various degrees of CS preexposure in 10-day-old rats.

### Method

**Subjects**. The subjects were 39 10-day-old rats representing 7 litters.

**Procedure**. The pups were randomly divided into six groups corresponding to level of preexposure (0, 15, or 45 min of odor presentations) and conditioning treatment (paired, P, or CS-only, CSO). Preexposure, conditioning, and testing were performed as in Experiment 1, but with two exceptions. First, a banana (Virginia Dare Artificial Ripe Banana No. 112) rather than a lemon or peppermint odor was the CS used for preexposure and conditioning. Second, training consisted of six, rather than four, odor-footshock pairings, in order to improve the likelihood of acquisition in the nonpreexposed-paired animals.

### Results and Discussion

Conditioning was facilitated by 15 min of CS preexposure but impaired by longer (45-min) preexposure. This replicated the results of Experiment 1 in circumstances in which conditioning was clearly established in nonpreexposed-paired subjects (see Figure 3).

A 3 × 2 ANOVA on these data revealed significant main effects of preexposure [$F(1,33) = 4.375, p < .05$] and treatment [$F(1,33) = 9.027, p < .005$], and a significant preexposure × treatment interaction [$F(2,33) = 4.422, p < .02$]. Fisher tests established that the differences between paired and control groups were significant after 0 or 15 min of preexposure, but not after 45 min, and that significantly less CS preference occurred in the 15-min preexposed-paired subjects than in the nonpreexposed-paired animals. A separate 2 × 2 ANOVA involving only the 0- and 15-min preexposure conditions confirmed the facilitation exhibited after moderate CS preexposure in terms of a significant preexposure × treatment interaction [$F(1,22) = 4.635, p < .04$]. The nature of the interaction indicates that the degree of conditioning, indexed by the difference between the scores of the conditioned animals and those of the controls, was greater with 15 min of preexposure to the CS than with no preexposure.

The results of this experiment replicated those of Experiment 1 in terms of the effects of CS preexposure on conditioning in 10-day-old rats. The results agree that a moderate amount of CS exposure (15 min) prior to conditioning may facilitate rather than retard conditioning. The circumstances of this facilitation in both experiments included procedures yielding weak conditioning among animals not given CS preexposure. With more CS preexposure (45 min), conditioning was impaired. The older, 18-day-old rat pups showed a somewhat different pattern of effects of CS preexposure duration on conditioning. With these animals, an impairment of conditioning was evident with 15 min of preexposure to the CS. A similar impairment occurred with the 45-minute preexposure.

With an intermediate period of preexposure, then, it was clear that the impairment in conditioning was a good deal greater for the older preweanlings. It was also the case, however, that the older preweanlings had stronger conditioning with no CS preexposure. The next step was to compare the effects of CS preexposure in circumstances

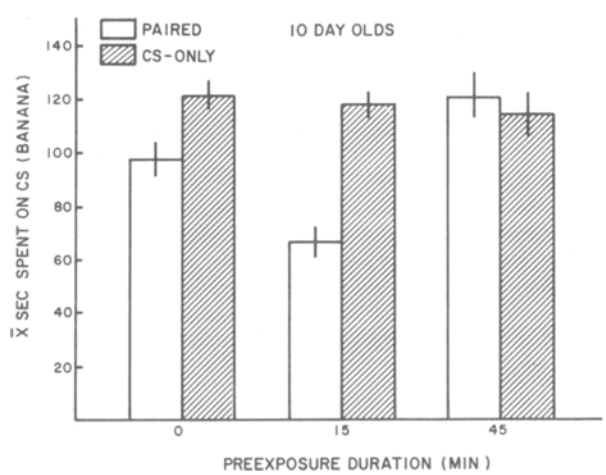


**Figure 3. Experiment 2: Mean (±*SE*) time spent on odor CS for 10-day-old pups from each preexposure × treatment group after six discrete odor-aversion conditioning trials.**

in which the degree of conditioning without CS preexposure was equivalent for the 10- and 18-day-old rats. In Experiment 3, procedures established in previous experiments were employed to meet these conditions.

## EXPERIMENT 3

Although Experiment 3 included the basic components of the conditioning episodes of Experiments 1 and 2—the CS was a novel odor, methyl salicylate in this case, and the US was a footshock—the method of presenting these events was different. Rather than being presented in discrete bursts, in Experiment 3 the odor was an ambient characteristic of the location in which the CS preexposures were presented or in which the CS was paired with the footshock. Other experiments in our laboratory had indicated that this technique would yield equivalent and substantial conditioning in 10- and 18-day-old rat pups.

Prior to pairings of the odor and footshock in Experiment 3, 10- and 18-day-old pups were exposed to the CS odor for 0, 3, 9, or 27 min. Our previous experiments, Experiment 1 and other studies (see Hoffmann & Spear, 1984; Kraemer, Hoffmann, & Spear, 1988), had indicated that prior exposure to the CS might yield a different pattern of effects in 10- and 18-day-old pups. Although all levels of preexposure to the CS seemed detrimental to the conditioning of 18-day-olds, intermediate levels had either no effect or a facilitating effect on the conditioning of the 10-day-olds. A similar pattern had been reported by Spear and Smith (1978) in testing instrumental conditioning with a quite different CS and with different ages: prior exposure to the CS tended to facilitate conditioning in younger preweanlings but tended to impair it or have no effect in older preweanlings.

Experiment 3 was in part intended to compare the effects of prior CS exposure on two different ages of preweanlings in still another conditioning paradigm, with the hope of establishing further robustness in the general validity of these CS preexposure effects.

### Method

**Subjects**. Eighty-two 10-day-old rats from 10 litters and 70 18-day-old pups from 9 litters served as the subjects for the present study.

**Apparatus**. The subjects were preexposed in clear Plexiglas chambers, 15 × 15 × 15 cm, which were fitted with Plexiglas lids. Cotton scented with 2.5 cc of methyl salicylate (Fisher Scientific) was placed in a small compartment that extended from the lid. The chambers rested on a flat surface covered with paper toweling. Four small holes (5 mm diam) were drilled 3 cm from the bottom of the chamber for ventilation.

The subjects were conditioned in 18 × 9 × 18 cm clear Plexiglas chambers, which rested on a grid floor. Footshock (0.3 mA for 2.5 sec) was delivered by a Coulbourn Instruments solid-state shocker (Model E13-16). Cotton scented with 2 cc of the methyl salicylate was placed beneath the grids under each chamber, and the tops of the conditioning compartments remained open.

Testing occurred in a 28 × 12 × 14 cm clear Plexiglas chamber fitted with a wire mesh floor.

**Procedure**. The subjects of each age were randomly divided into five groups, including four that were given 0 (P0), 3 (P3), 9 (P9), or 27 (P27) min of methyl salicylate exposure prior to pairings of that odor with footshock, plus an explicitly unpaired control group (UP).

The pups were removed from the home cage and placed with littermates in maternity cages partially filled with clean pine shavings. These cages were maintained at 32-34°C by heating pads placed beneath them.

For preexposure, 3-4 pups of the same age were placed into one preexposure chamber. The duration of separation from their home nest was held constant in the following manner: initially, the subjects from Group P27 were placed in their chamber; exposure for the subjects in Groups P9 and P3 began 18 and 24 min later, respectively. All animals were removed from the preexposure chambers at the same time and returned to the holding cage for 30 min before conditioning. The subjects in Groups P0 and UP remained in the holding cage for this entire 57-min period prior to conditioning.

For training, the animals in Groups P0, P3, P9, and P27 were given four conditioning trials. Each trial consisted of a 20-sec exposure to the methyl salicylate odor, during which a 0.3-mA, 2.5-sec footshock was administered at the 8th and 18th sec of odor exposure. The trials were separated by a 2.5-min ITI. Group UP received footshock administration in unscented compartments, which was followed 20 min later by methyl salicylate exposure.

Testing occurred 2.5 min after training. The animals were individually placed at the center of the test apparatus. Two cc of methyl salicylate odor were placed under the wire mesh floor at one end of the apparatus, and 0.75 cc of orange oil (Humco Laboratories) was located under the floor at the other end. The animals were allowed to move about freely in the apparatus for 1 min, during which the time spent over the methyl salicylate CS was recorded. The subject was then returned to the center of the chamber and the test continued for an additional minute.

### Results and Discussion

Mean total time spent over the CS during the 2-min odor-preference test for the subjects from each treatment × age group is represented in Figure 4. The training was effective in producing odor aversions at both ages, and the CS preexposure did have an effect on this conditioning. A 5 × 2 (treatment × age) ANOVA confirmed this conclusion by revealing a significant main effect of treatment [$F(4,142) = 10.898, p < .001$]. A significant main effect of age [$F(1,142) = 6.814, p < .009$] was also found. This merely reflected the slight, uniform elevation in preference for the methyl salicylate odor across the UP and preexposed treatment groups seen in the 18-day-old animals. The interaction between treatment and age was not significant.

Post hoc comparisons (with the Fisher test, $p = .05$) revealed that the 10-day-old pups in groups P0, P3, and P9 had significantly greater aversions (i.e., less preference) for the CS than did the control subjects (Group UP), with no difference in preference among these paired groups. Aversions shown by the 10-day-old animals in Group P27, however, did not differ from those of the UP controls. The pattern of results was slightly different for the 18-day-olds. Like the 10-day-olds, Groups P0 and P3 showed similar CS preferences that were significantly less than those of the UP controls, and the pups in Group P27 did not differ from the UP controls. Nine minutes of CS

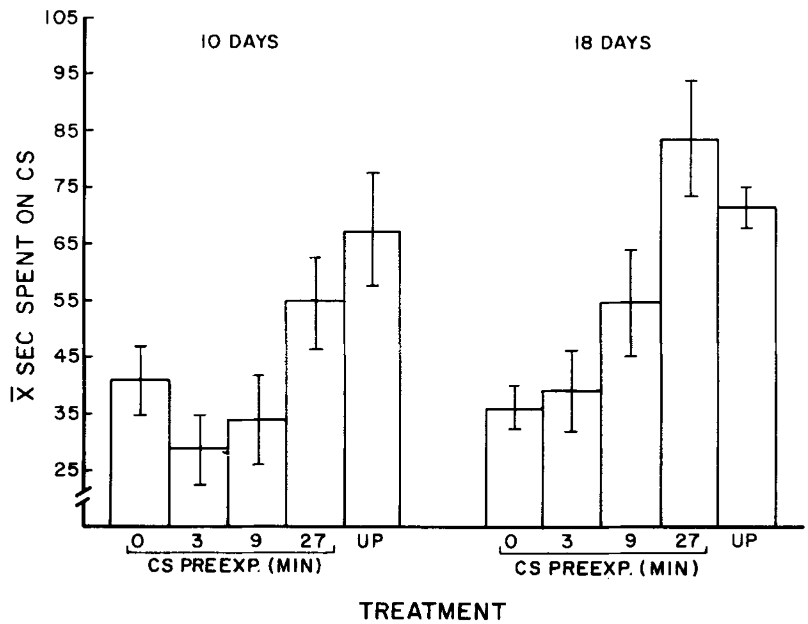


**Figure 4. Experiment 3: Mean (±*SE*) time spent on odor CS for 10- and 18-day-old pups from each treatment group after four ambient odor-aversion conditioning trials.**

preexposure impaired conditioning for the 18-day-olds, but not for the younger pups. The pups in this condition showed significantly less aversion (greater preference) for the CS than did the pups in Group P0, and they did not differ significantly from the UP controls.

In summary, odor-aversion conditioning in 10- and 18-day-old rats was not greatly affected by 3 min of prior experience of the to-be-conditioned CS, although there was a slight, but nonsignificant, trend for 3 min of CS preexposure to enhance conditioning in the younger subjects. Nine minutes of prior CS exposure did not appear to affect conditioning in the 10-day-olds, but it did attenuate conditioning for the 18-day-olds; and 27 min of CS preexposure produced latent inhibition in both ages.

Comparison of the pattern of preexposure effects in these two age groups is somewhat more useful in Experiment 3 than in Experiment 1, because the 10- and 18-day-olds were equated in baseline degree of conditioning and in preference for the CS in the unpaired control groups. The results agreed, however, with the general pattern of effects obtained in Experiments 1 and 2. At intermediate levels of CS preexposure, older preweanlings were more likely to show impairment in their conditioning than were younger preweanlings. There was no hint of impaired conditioning with 9 min of preexposure among 10-day-olds, and with 3 min of preexposure these animals tended to show facilitation of conditioning. The 18-day-olds had clear impairment of conditioning with 9 min of CS preexposure, and no indication of facilitated conditioning with 3 min preexposure.

These results suggest that there are limits to the general applicability of the facilitating effects of prior CS preexposure on conditioning in 10-day-old pups. The three experiments agree that facilitation depends on the amount of preexposure. It is noteworthy also that with continuous ambient odor as the CS (Experiment 3), the facilitating effect of preexposure in 10-day-olds seems at most a relatively weak effect. It was not statistically significant in Experiment 3, despite the large number of subjects. Moreover, additional tests in our laboratory, in which we employed the procedures of Experiment 3 along with a 1-min exposure to the CS, also resulted in the finding that a slight trend toward the facilitation effect in 10-day-old pups did not achieve statistical significance.

## GENERAL DISCUSSION

The present three experiments established that, for the 18-day-old rat, latent inhibition increases according to the degree of CS preexposure. The experiments also established that 10-day-old rats show a similar increase in latent inhibition, given a sufficiently long CS preexposure duration, although it is somewhat less of an increase than that for the 18-day-olds. Finally, this study showed that prior exposure to the CS can, under some conditions, facilitate conditioning in the 10-day-old rat. Yet to be determined are the precise circumstances under which 10-day-old rats do or do not show this facilitation, and why the older animals show impaired conditioning due to CS preexposure under conditions in which the 10-day-olds show no effect or facilitation.

These effects appear not to be specific to a particular CS; in spite of the four different novel odors used as CSs in the present three experiments, the results were in close agreement. The results seem not to be due to a particular method of presenting the CS; the present experiments included both discrete presentations of the odor with an olfactometer and ambient presentations. The present experiments also differed in the characteristics of the US, in terms of both duration and intensity.

Does degree of learning without CS preexposure determine the effect of CS preexposure? We might consider that, roughly speaking, there was an increasingly greater degree of learning from Experiments 1 through 3 among the 10-day-old rats, according to an ad hoc comparison of the conditioned and control animals given no CS preexposure. Yet the results were quite similar across experiments: for the 10-day-olds, a low-to-moderate degree of CS preexposure resulted in facilitation or a tendency toward facilitation of conditioning, whereas increasingly long durations of CS preexposure resulted in latent inhibition at this age. Moreover, in Experiment 3 the 10- and 18-day-old pups were equivalent in terms of basic conditioning in the absence of CS preexposure, yet they differed in terms of the influence of the duration of CS preexposure.

Finally, it did not appear that a change in context between preexposure and conditioning was a critical determinant of the stimulus preexposure effect found. Although the present study did not directly address this issue, a similar pattern of results was obtained, whether animals were preexposed and conditioned in the same (Experiments 1 and 2) or in different (Experiment 3) apparatuses. The issue of whether a change in context between preexposure and test still remains, since in the present experiments preexposure and testing always occurred in different apparatuses.

Although the present study adds to previous results regarding the nature of CS preexposure effects on conditioning in developing animals, the precise conditions under which CS preexposure facilitates conditioning in young animals is unclear. What is established by the present three experiments is that the duration of CS preexposure can be relatively short and still result in facilitation of conditioning, which is somewhat contrary to the indications of previous studies (for reviews, see Hill, 1978; Hall, 1980).

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