Behavioral Neuroscience
1987 Vol 101 No 2 158-163

0735-7044/87/$00 75

Role of Temporal Order and Odor Intensity in Taste-Potentiated Odor Aversions

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The role of the temporal order of odor and taste was studied in two experiments, and a third experiment studied the role of odor intensity in flavor-toxicosis conditioning with thirsty rats licking water spouts in a "wind tunnel" In all experiments, odors and tastes were presented for 2 min to rats, and 30 min later, a toxin (lithium chloride) was intubated In Experiment 1, an odor was presented 90 s before, during, or 90 s after a taste to independent groups Experiment 2 was a within-subjects partial replication of the first Each rat was presented with one odor, then a taste, then a second odor with each stimulus separated by 45 s The results of Experiments 1 and 2 indicated that (a) odor alone is not associated with illness under our conditions, (b) presenting an odor and a taste at the same time potentiates the odor component so that it is associated with illness, (c) 45-s and 90-s intervals between odor and taste eliminate potentiation, and (d) taste and odor interact asymetrically, that is, odor has little affect on the development of taste-illness associations In Experiment 3, an odor and a taste were presented simultaneously, and odor intensity varied As odor intensity increased, the strength of the taste-potentiated odor aversion increased, whereas the aversion to the taste remained constant However, even at the highest intensity, odor presented in the absence of taste did not result in odor aversions

After a specific taste is followed by delayed illness, animals learn to avoid the taste Using a similar design, after a specific odor is followed by delayed illness, typically animals do not learn to avoid the odor Interestingly, when the odor and taste are presented together and followed by delayed illness, the strong taste enhances the weak odor so that the odor when tested alone is strongly avoided (e g., Palmerino, Rusiniak, & Garcia, 1980, Rusiniak, Hankins, Garcia, & Brett, 1979) This effect, called *potentiation*, is opposite to the traditional overshadowing results in which a strong component reduces learning involving a weak component (Kamin, 1969)

The three experiments reported here examine the role of two factors, the temporal order of odor and taste and odor intensity, in the potentiation of an odor aversion by taste. The examination of the relevant factors that control potentiation is particularly important because of differences reported in the literature at both theoretical and empirical levels Although several laboratories have reported potentiation (e g., Durlach & Rescorla, 1980, Lett, 1980), some others have reported failures (e g , Bouton & Whiting, 1982, Mikulka, Pitts, & Philput, 1982)

The first two experiments focus on the role of the temporal order of odor and taste presentation in potentiation In natural situations when a rat is foraging for food, odor precedes and overlaps taste Odor and taste serve different purposes in foraging for food Odor is primarily utilized during initial foraging and tends to quickly habituate An individual odor, therefore, is interfered with by other ambient odors during conditioning because of the rat's constant sniffing Accordingly, when the temporal interval between odor and illness is increased, the capacity of an animal to associate the odor with the illness rapidly declines For example, if poison is delayed until 30 min after the odor, then the odor does not usually become aversive Taste is used during the latter consummatory phase of foraging Taste is not quickly habituated to and little interference from other tastes occurs because rats eat several small meals each day, and each meal is widely spaced in time. Accordingly, when a single taste is followed by illness, a strong taste aversion develops even if the illness is delayed several hours (see Garcia & Holder, 1985) However, if the odor and taste are presented together, odor aversions can be established even when the illness is delayed for relatively long periods (Palmerino et al , 1980)

Taste-potentiated odor aversions have interesting implications for the classic principle of association by contiguity In defense of this principle, some people have argued that taste-illness associations can occur even when the taste and illness are separated by 30 min or longer because the taste is still present at the time of illness (Bitterman, 1975) The presence of odor-illness associations, when long intervals separated the odor and illness, cannot be explained by the lingering presence of the odor or the lack of interfering cues occurring during the odor-illness delay. The animal experiences many odors throughout the delay.

The delay between odor and taste and the order of the odor and taste appear to be important factors in controlling the establishment of taste-potentiated odor-illness associations

This research was supported by U S Public Health Services Grant NS11618 and National Institute of Health Grant HD05958

The authors thank Alma Lopez and Leah Ridge for their assistance in running the animals

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Coburn, Garcia, Kiefer, and Rusiniak (1984) found that as the time between odor and taste increased, odor-illness associations decreased, and this decrease was much faster when the odor followed the taste. However, the equipment used in that study did not have the capacity to strictly control the onset and offset of the odor used. Therefore, in the first two studies reported here, the temporal order of the odor and taste components were varied in a classical compound conditioning paradigm in which we used a much improved apparatus.

In addition, Experiment 3 varied the odor intensity to see the effect on potentiation and direct odor and taste-aversion learning. Taste intensity is a powerful factor in determining the strength of aversions to tastes and odors in potentiation procedures (Rusiniak et al., 1979; Spear & Kucharski, 1984a, 1984b), but odor intensity has not been studied.

In all three experiments, odor was presented in an olfactometer, a "wind tunnel" apparatus designed to present discrete odor stimuli. A constant airstream, into which odor was introduced for 2 min, moved through a chamber housing a rat. At the "up wind" end of the chamber, a water spout was made available so that the rat could lick plain or tasty water during each trial.

Experiment 1: Between-Groups Comparison

In Experiment 1, five groups of rats were presented with a 2-min odor and, about 30 min later, were intragastrically intubated with a toxin. For three of the groups, the odor was presented 90 s before, during, or 90 s after a 2-min taste. For the remaining two groups, taste was never presented.

Method

Subjects and apparatus. Subjects were 30 experimentally naive male Sprague-Dawley rats 60–90 days of age at the start of the experiment. The rats were housed under standard laboratory conditions with food ad lib and a 10:14 hr light/dark cycle. Sessions were run on consecutive days during the first third of the light cycle.

The rats were habituated, trained, and tested in an olfactometer. This apparatus consisted of two 18.5 × 6.5 × 12.5 cm Plexiglas chambers at one end of which the rat could poke its muzzle through an opening into a smaller 3 × 5 × 4 cm chamber to lick fluid from a stainless steel spout. Access to water, always distilled, could be prevented by turning the spout away from the rat. For each box, compressed air was first forced through a 32 cm column of activated charcoal and then through an 20 cm column of Drierite (anhydrous $CaSO_4$) before being bubbled through either pure Schilling almond extract (the odor) or distilled water (unscented air). Solenoid-operated valves determined whether the odor or unscented air was presented. A constant airstream flowed from the smaller to the larger chamber so that a virtual "square wave" of odor could be administered to the drinking rat. The odor was cleared within 15 s by an exhaust fan attached to the back of each chamber, which continually evacuated air out of the room; odor leakage into the room housing the apparatus was not evident to our noses. Except for the 2 rats being run, all other rats were kept in an adjoining room further isolated from the experimental odors. Electromechanical instrumentation in the room with the olfactometer recorded the number of licks during drinking trials.

Procedure. The rats started each daily session thirsty (they were given access to tap water for 45 min each day in their home cages after being run in the olfactometer). For the first 17 days, the rats were habituated to drinking water in the olfactometer for two 2-min trials. Trials were separated by 90 s when the rats remained in the experimental chambers and water was not available. On Day 7, only the 4 rats with the lowest response rates were run. On Days 9 and 10, each rat was sham intubated (i.e., intubated but not infused) 30 minutes after all rats were habituated for that day.

After the last habituation day, rats were assigned to one of five groups (6 per group) so that water consumption on the last day of habituation was similar for each group. The groups differed on whether or not a taste was presented and whether the taste (if presented) preceded, followed, or occurred at the same time as an odor presented on a single acquisition day. On the acquisition day, odor and taste (0.1% saccharin in distilled water) were presented for two 2-min trials separated by 90 s. Group O-T received odor and water during the first trial, and taste and unscented air during the second. Group O-W, a control group (W = unflavored distilled water), received odor and water during the first trial and unscented air and water during the second. Group T-O received taste and unscented air during the first trial and odor and water during the second. Group W-O, a control group, received unscented air and water during the first trial and odor and water during the second. Group OT received simultaneous odor and taste during the first trial and unscented air and water during the second. Immediately after the second trial, each rat was returned to its holding cage. Thirty minutes after odor presentation, each rat was intragastrically intubated and infused with 0.15 M lithium chloride (190 mg LiCl/kg). On the acquisition day, food was not available 1 hr before or 1.5 hr after intubation. Three of the 30 rats did not lick when the saccharin water was presented for 2 min. For these rats the trial was extended 30 s, and these remaining 3 rats licked.

Following acquisition, the rats were returned to the habituation schedule for 2 days. Odor testing was begun on the third postacquisition day, odor and water were presented during the first trial and water and unscented air during the second. After 2 more days of habituation, taste testing was begun, taste and unscented air were presented on the first trial, and water and unscented air during the second. The odor and taste tests were each repeated a second time, again separated by 2 days, and this time the order of the trials was reversed (i.e., odor or taste was presented on the second trial and unscented air and water were presented on the first).

Data analysis. During each trial, the number of licks was recorded for each rat. Analyses of variance (ANOVAs) treated rats as a random factor and group as a fixed factor. Unless otherwise noted, tests of significance are based on the square root of the rat's response rate. Response rates were transformed to square roots in order to help normalize the data in an attempt to meet the statistical assumptions of ANOVAs. All p values are two-tailed.

Results and Discussion

Figure 1 shows the number of licks during both the taste and odor tests for all five groups. When odor was tested, Group OT was the only group to show an aversion to the odor. An ANOVA showed a reliable group effect, $F(4, 20) = 3.7$, $p < .05$, which can be attributed to the OT group's avoidance of the odor. Group O-T and T-O licked during the odor test at the same rate as their respective controls, O-W and W-O, $ts(10) \leq 1.27$, $p > .2$. However, the group that received odor and taste at the same time, Group OT, licked much less during the odor test than the two groups that received odor and taste separated by 90 s, $ts(10) \geq 4.1$, $ps < .01$.

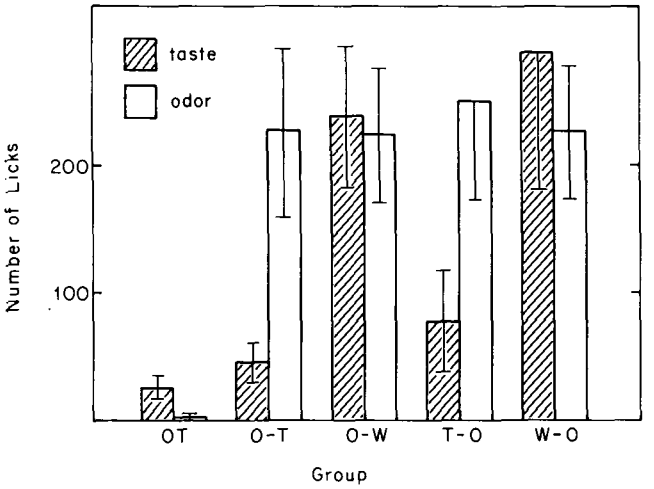

Figure 1 Experiment 1 Mean number of licks during both the taste and odor tests for all five groups (During acquisition, rats were given two trials separated by 90 s, and 30 min later, they were intubated with lithium chloride Average drinking scores during odor [empty bars] and taste [striped bars] test trials are indicated Note that for the groups that were presented with taste during acquisition [Groups OT, O-T, and T-O], there was a strong taste aversion, but that an odor aversion was apparent only for the group given odor and taste simultaneously [Group OT] [Values plotted are biweights and error bars represent standard errors based on the biweights])

As expected, only when taste was presented 30 min before illness during acquisition (Groups OT, O-T, and T-O) was there an aversion to the taste when it was presented during the test This result was verified with an ANOVA of the lick rates of all groups that showed a reliable group effect, $F(4, 20) = 7\ 6$, $p < 001$ Individual t tests showed that all groups that received taste during acquisition had similar lick rates, $ts(10) \leq 1\ 5$, as did the two control groups (O-W and W-O), $t(10) < 1$ However, all groups that received taste during acquisition made fewer licks during the taste test than the two control groups that were not given taste during acquisition, $ts(10) \geq 2\ 7$, $p < 05$

If taste was followed by illness during acquisition, whether or not odor was presented before, during, or after the taste, then there was a strong aversion to the taste measured on a subsequent taste-test trial Although the timing of odor and taste did not affect the development of a taste-illness association, this timing appears critical for establishing odor-illness associations When taste and odor occur at the same time, but not when separated by 90 s, taste potentiates an odor-illness association

Experiment 2: Within-Subjects Replication

The results of Experiment 1 showed that odor is potentiated by taste in flavor-illness learning only if the odor is presented close in time to the taste If the odor and taste are separated by as little as 90 s, then odor is not associated with illness However, in a similar study, Coburn et al. (1984) found odor aversions when the odor preceded tastes by 1 or 2 min The apparent inconsistency between the results of Experiment 1 and those of Coburn et al warranted a second attempt to find a taste-potentiated odor-illness association when the taste and odor are separated in time Experiment 2 is this second attempt and uses a within-subjects design This design might be better at detecting an effect of taste-odor temporal order than the one used in Experiment 1 because the comparison in Experiment 2 is within animals, and, therefore, variance should be reduced. Variance during the odor test was large in Experiment 1

In Experiment 2, each rat was presented with two different odors on a single acquisition day There were three 2-min trials, each separated by 45 s During the first trial, one odor was presented, on the second trial, a taste was presented, and on the third trial, an odor different than that presented on the first trial was presented Thirty min after the taste was presented, the rats were intubated with poison The odors should differ in the amount of conditioning they acquire if the temporal order of the presentation of an odor relative to taste is important. In a more natural environment, a rat would be exposed to a variety of odors before and after it experiences a taste Presenting one salient odor before and another after the taste should not confront the rat with an especially complex problem that it would not normally encounter

Method

Subjects and apparatus The subjects were 14 rats randomly selected from Experiment 1 with the restriction that at least 2 rats and no more than 3 came from each of Experiment 1's five groups The animal colony room, feeding, and olfactometer (only one box was used for all rats) were the same as in Experiment 1 The rats were given 1 hr access to tap water in their home cages after each daily session The odors and taste differed from Experiment 1 The two odors used were vanilla (air was bubbled through 100% Schillings Pure Vanilla Extract) and maple (air was bubbled through 100% Schillings Pure Maple Vanilla Extract), and the taste was salty (0 4% NaCl) These two odors were chosen because rats show similar neophobic responses to them and similar aversions when they are presented with a saccharin solution followed by LiCl (Nachman, Rauschenberger, & Ashe, 1977)

Procedure The rats were given 5 days of habituation training as described in Experiment 1 except that there were now three 2-min trials each separated by 45 s On the sixth day, the single acquisition day, each rat was presented with one odor on the first trial, the taste on the second trial, and a second odor on the third trial For half of the rats, vanilla was given on the first trial and maple on the third, for the other half, the trial to odor assignments were reversed After the third acquisition trial, the rats were immediately removed from the olfactometer box and placed in their home cages Thirty min after the taste was presented, the rats were intragastrically intubated as described in Experiment 1 After acquisition, there were 2 more habituation days followed by 3 testing days each separated by 1 habituation day On the first testing day, an odor was presented on the first and third trials and water was presented on the second trial The order of the odors was the same as during acquisition The second day of testing was the same as the first except that the order of the odors was reversed On the third testing day, taste was presented on the second trial and water and unscented air were presented on the first and third trials

Data analysis The number of licks on each trial was recorded as described in Experiment 1 Tests of significance were based on the mean of the two odor test trials of each type (e g , Trial 1 test day 1, and Trial 3 test day 2) and the single taste test Group averages and *t* tests were based on biweights of the square roots of the value for each rat with a weighting constant of nine iterated six times (for a description and justification, see Mosteller & Tukey, 1977)

Results and Discussion

Figure 2 shows the number of licks during testing for each of the four stimuli presented on test trials (a) test of the odor presented on the first acquisition trial, (b) test of the taste, (c) test of the odor presented on the third acquisition trial, and (d) water alone During testing, the rats showed a mild aversion to the taste but no aversion to either the odor presented before or the odor presented after the taste during acquisition The taste aversion was indicated by the finding that the rats licked less during the taste test than during either the water-alone baseline $t(9) = 2\ 6$, $p < 05$, or the odor test, $ts(9) \geq 2\ 33$. $p < 05$ There was no difference during the test between the lick rates during the odor that was originally presented first during acquisition and the odor presented second, $t(9) = 1\ 2$, $p > 05$ The lack of an aversion to either odor was indicated by the result that lick rates during either odor were similar to rates during the water-alone baselines, $ts(9) < 1$

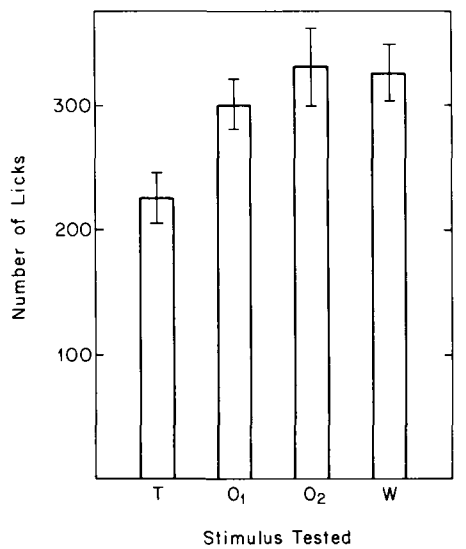

Figure 2 Experiment 2 Mean number of licks during testing for each of the four stimuli presented on test trials (All rats were presented with an odor, then 45 s later a taste, and then 45 s later a second odor Thirty min after the taste, the animals were intubated with LiCl There was evidence of a taste aversion [T] but not of an aversion to the odor presented before [O1] or after [O2] the taste during acquisition Values plotted are biweights of the means across the two odor tests and the biweights of the single taste test and water [W] test Error bars represent standard errors based on the biweights)

Any possible difference in the strength of the odor aversion between the odor presented before and the odor presented after the taste was not obscured by peculiarities during acquisition All rats drank at high levels during the middle trial when the taste was presented There was no difference between the amount of licks during the maple and the vanilla odors, $t(9) < 1$, or between the first and last trial of acquisition

The aversion to the taste was less than that observed during Experiment 1 At least two factors may have contributed to the lesser aversion First, the rats in Experiment 2 had previously experienced illness in Experiment 1, which has been shown to attenuate taste aversions (Cappell & LeBlanc, 1977) Second, unlike the saccharin used in Experiment 1, the salt used in Experiment 2 is an important component of the rats' diet Rats can develop taste preferences for tastes paired with salt (Fudim, 1978), and these preferences, if present, would lessen the strength of the aversion measured in Experiment 2. The role of these types of preferences in potentiated odor aversions is not known However, even with weak or absent taste aversions, taste-potentiated odor aversions are still found For example, a taste that is too weak to support a taste-illness association can potentiate an odor aversion (Rusiniak et al , 1979) Furthermore, when the gustatory neocortex is lesioned, taste-illness associations are completely disrupted, yet taste-potentiated odor aversions are left intact (Kiefer, Rusiniak, & Garcia, 1982) Therefore, the weak taste aversion found here should not have obscured possible potentiated odor aversions.

Experiment 3: Odor Intensity and Taste-Potentiated Odor Aversions

We have reviewed some work that indicates that the strength of the taste-potentiated odor aversion is not perfectly correlated with the strength of the taste aversion There is, however, at least one documented relation between the taste parameters used and the subsequent strength of the odor aversion The strength of a taste-potentiated odor aversion is a direct function of the concentration of the taste present on the conditioning trial (Rusiniak et al , 1979) In the present experiment the intensity of an odor was varied and the taste concentration was held constant Different groups of rats were given a high, medium, or low intensity odor, either alone or in compound with a taste followed by delayed illness The rats were then tested for aversive conditioning to the odor and taste cues separately

Method

Subjects and apparatus The subjects were 42 male Sprague-Dawley rats obtained from Simonsen Labs, Gilroy, California, weighing 280–380 g at the beginning of the experiment The apparatus and animal maintenance were the same as described in Experiment 1 except for the details involving the odor Odors were achieved by passing the air through a bottle containing either 1% or 10% Schilling's almond extract mixed in distilled water or 100% almond extract The drinking bottle contained either distilled water or a taste (0 1% saccharin in water)

Procedure Each day the rats were given water for 10–15 min in their home cages, starting 3–5 days before the beginning of the experiment The experiment was conducted in two replications, with 18 rats in the first replication and 24 rats in the second The rats in the first replication were habituated to the apparatus for 9 days by being placed in the box for 2 min with water in the drinking bottle The rats in the second replication were given 12 days of habituation in the same way Two days before acquisition, all rats were sham-intubated as described in Experiment 1 about 1 hr after the habituation trial

After the last habituation day, the rats were randomly assigned to six groups (7 rats per group, 3 from the first replication and 4 from the second) The groups differed in the odor intensity and whether or not taste was presented during a single acquisition trial During acquisition, Groups L-O, M-O, and H-O received the low (1%), medium (10%), and high (100%) odors, respectively, and water in the drinking bottle for 2 min Groups L-OT, M-OT, and H-OT received the same intensities of odor (low, medium, or high, respectively) but were given tasty water to drink All rats were intubated with 0 15 ml LiCl (190 mg/kg) 30 min after the end of the trial Food was removed from the home cages immediately before the trial and was not returned until 2 hr after LiCl delivery

Testing occurred on the third and fifth days after acquisition The 2 days before and the 1 day in between testing were habituation days Three or 4 rats in each group received an odor on the first test day and the taste on the second, and the remaining rats received the taste and odor in the opposite order The odor test consisted of the same intensity odor used to train the rat, with water in the drinking bottle The taste test consisted of the taste and unscented air

Data analysis Data were collected and analyzed in the same way as described in Experiment 1 When the effect of odor intensity on taste and odor aversions was statistically analyzed, only Groups H-OT, M-OT, and L-OT were considered

Results and Discussion

Figure 3 shows licking during the odor and the taste tests separately for each group There were no overall difference between the two replications in the odor test and no significant interactions involving the replication factor, $Fs(1, 28) = 1\ 28$, $ps < 25$ The data for each replication were, therefore, pooled for all additional analyses.

The taste test showed a strong effect of the presence versus absence of the taste during acquisition As expected, the rats that had received both odor and taste on the conditioning trial licked less during the taste test than the rats that had received odor alone, $F(1, 26) = 11\ 5$, $p < 01$ The intensity of the odor during acquisition did not affect the strength of the taste aversion because the taste aversion was the same for the three groups given odor and taste during acquisition, $F(2, 12) = 1\ 06$

The odor-potentiation effect was clear The groups trained with both odor and taste showed a much greater aversion to the odor than the groups trained with the odor alone, $F(1, 26) = 104$, $p < 001$ As the intensity of the odor increased, the taste-potentiated odor aversion increased as well The main effect of odor intensity did not quite reach traditional levels of significance, $F(2, 12) = 2.9$, $p < .1$, but the difference between the groups given only odor and those given odor and taste together increased as a direct function of odor intensity Individual comparisons showed a significant difference between H-OT and L-OT, $t(12) = 2\ 3$, $p < 05$. However, the differences between M-OT and H-OT and between M-OT and L-OT were not reliable, $ts(12) \leq 1\ 1$

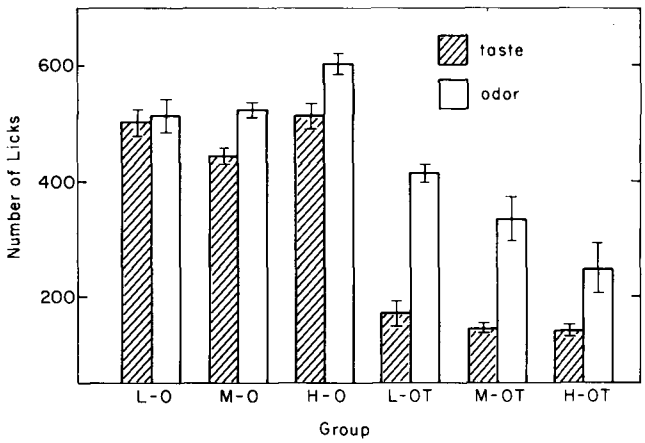

Figure 3 Experiment 3 Mean number of licks during the odor and the taste tests separately for each group (All rats were presented with a high, medium, or low (H, M, and L, respectively) intensity odor For three of the groups (H-OT, M-OT, and L-OT), saccharin-flavored water was presented simultaneously with the odor For the remaining three groups (H-O, M-O, and L-O), unflavored distilled water was presented simultaneously with the odor Thirty min after the trial, the animals were intubated with LiCl Note that for the groups that received both odor and taste during acquisition both taste aversions and odor aversions were apparent, and the strength of the odor aversion increased as the intensity of the odor increased For groups that received only the odor and no taste, neither odor nor taste aversions were apparent Values plotted were calculated as described in Figure 1)

Thus odor potentiation increases as taste intensity increases (Rusiniak et al., 1979), and there is an effect of odor strength as well. During acquisition, as the intensity of an odor presented with a taste increased, so did the aversion to the odor measured on a subsequent odor test trial It should be noted, however, that even the strongest odor cue used here did not produce any conditioning in the groups trained with odor alone However, the effect of odor intensity was restricted to odor aversions potentiated by taste With the procedure used here, changes in odor intensity do not affect the strength of direct odor or taste aversions

The taste-potentiated odor aversions in this experiment appeared weaker than in Experiment 1 despite the fact that the same odor, taste, flavor-illness interval, trial length and number, and LiCl doses were used The rats in Experiment 3 were larger and deprived of water for longer periods, which may have contributed to the increase in drinking This is consistent with the finding that lick rates in Experiment 3 were greater than in Experiment 1 on both odor and taste test trials for each group including cases in which no aversion was established

General Discussion

The three experiments reported here found two factors that affect odor aversions potentiated by taste First, the results of Experiments 1 and 2 showed that the temporal contiguity of the odor and taste during acquisition is important Taste potentiates odor aversions when both components are presented at the same time but not when they are separated by

as little as 45 or 90 s Second, Experiment 3 found that when odor intensity was increased and taste was held constant, the conditioned aversion to the odor increased

The first finding, that the odor and taste must be presented at similar times for the taste to potentiate the odor aversion, is inconsistent with the findings of Coburn et al (1984) The present studies were conducted in the same lab where Coburn et al found odor aversions when the odor was presented 1 or 2 min before, but not 1 min after, the taste during acquisition One explanation for the apparent inconsistency is that different olfactometers were used The olfactometer used in the present studies had an improved exhaust system and, therefore, was able to present and remove odors more briskly than the one used in the earlier work In the earlier work it is likely that the odor presented 1 or 2 min before the taste during acquisition was not entirely removed when the taste was presented Therefore, the taste may have potentiated an odor still partially present This explanation is supported by the second finding that stronger odor aversions are found with greater intensity odors. When the odor was presented before the taste in the Coburn et al study, an odor aversion was found but it was not as strong as when the odor was presented at the same time as the taste. Presumably the intensity of the odor was greater when the odor was presented with the taste than when it was presented before the taste and merely allowed to linger during the taste. The more intense odor resulted in a stronger aversion An additional difference between this work and Coburn et al 's is that in the improved olfactometer, but not the older chamber, the odor was diffused so that the rat could not position its muzzle and drink without smelling the odor

The role of the temporal contiguity of odor and taste adds to the recently reported findings of Kucharski and Spear (1985) They found that a flavor can potentiate an aversion to a second flavor when the two flavors are presented simultaneously but not when the flavors are presented with a 30-s interval between them When separated by 30 s, overshadowing, not potentiation, was observed The flavors used in this study (15% sucrose and 1.25% coffee) had taste and most likely odor properties, so it is not clear whether taste or odor was potentiated Rescorla (1981) reported a similar result in which potentiation of a flavor by another flavor increased when the two flavors were presented simultaneously, in comparison with when they were presented successively Again, the role of odors in this study was not clear because the solutions used may have had both odor and taste components

Combined with earlier work, all three studies reported here show an interesting asymmetry between the effect of odors on taste aversions and the effect of tastes on odor aversions Temporal contiguity of odor and taste strongly affects odor aversions but not taste aversions (Experiments 1 and 2, Coburn et al , 1984) Taste intensity has been shown to affect both taste and odor potentiated by taste aversions (Rusiniak et al., 1979) Odor intensity affected the strength of the odor aversion potentiated by taste but not direct odor and taste aversions

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Received June 19, 1985
Revision received January 6, 1986 ■