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Single-element assessment of conditioned inhibition

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Conditioned inhibition was observed in a flavor conditioning setting. All groups received excitatory trials in which a coffee taste and environmental cues were paired with toxicosis. Experimental groups also received inhibitory trials in which the conditioned excitatory cues were followed 0, 5, or 15 min later by exposure to a vinegar solution. Controls experienced this sequence with a 24 h interval. While conventional tests of inhibition usually assess the inhibitor's effects on some excitatory stimulus, this experiment tested vinegar preference in the absence of an excitatory context. All three experimental groups preferred vinegar more than controls did. Moreover, there was a nonsignificant trend toward increased vinegar preferences as the interval separating the excitatory cue and the vinegar cue was increased from 0 to 15 min. These results are important because they (1) demonstrate that a flavor conditioned inhibitor may be tested directly, as excitors are usually tested, and (2) suggest that temporal factors may be important in the development of conditioned inhibition.

Presently, two series of experiments constitute the existing documentation of conditioned inhibition in flavor aversion learning (Best, 1975; Taukulis & Revusky, 1975; see also Speers, Gillan, & Rescorla, 1980). Numerous demonstrations exist in other paradigms, beginning, in fact, with Pavlov (e.g., Hammond, 1967; Marchant, Mis, & Moore, 1972; Pavlov, 1927; Rescorla, 1969). The experiment reported here extends the evidence on conditioned inhibition in flavor conditioning by exploring two aspects of this phenomenon. First, the test for inhibition involved a single-element assessment technique in which the presumed flavor inhibitor was presented outside an explicit excitatory context. This technique differs from conventional tests of conditioned inhibition that revolve around "retardation" and "summation" procedures (cf. Rescorla, 1969). Second, the experiment assessed the relative magnitude of conditioned inhibition as a function of the interval separating the excitor and the potential inhibitor during inhibitory trials.

METHOD

Subjects

The subjects were 40 male albino rats (Holtzman Company, Madison, Wisconsin). These subjects were used in a previous experiment but were arranged in four groups (n = 10 in each) for this experiment to balance prior treatments across groups. Subjects had continuous access to Purina Formulab, but water was restricted to 20 min/day 3 weeks prior to and then throughout the experiment. Watering occurred between 1500 and 1700 h daily without exception and was always presented in centrifuge tubes fitted with rubber stoppers and metal spouts, attached to the fronts of the home cages. Lights were dimmed between 1800 and 0600 h daily.

Procedure

Subjects were weighed daily between 0600 and 0800 h and all experimental treatments occurred between 1000 and 1300 h. Water was presented for 20 min 4 h later.

On Day 1, all groups were treated identically. Subjects were removed from their home cages, carried individually into an adjacent room (a distance of about 4 m), and placed in one of five standard operant conditioning chambers. Each chamber was distinctly different from the home cages in grid floor patterns, height, width, depth, and construction materials, and each was enclosed in a sound-attenuating shell. The subjects remained in the chambers for 5 min, during which a small glass dish (2 cm high and 6 cm in diameter) filled with 5 ml of a coffee solution (1.0% Nestle's Decaf w/v in tap water) was also present. After this 5-min period, each subject was removed and injected with lithium chloride (LiCl) (10 cc/kg of .15 M LiCl, ip).

On Day 3, subjects in all groups again experienced the chamber-coffee stimuli for 5 min, as on Day 1. However, the injection administered after the confinement period was with saline (10 cc/kg of .15 M NaCl, ip) instead of LiCl. Subjects in Group Cof-0-Vin received 10-min access to a vinegar solution (3% apple cider vinegar w/v in tap water) immediately after the saline injection. Similarly, subjects in Group Cof-5-Vin and Group Cof-15-Vin received a 10-min exposure to the vinegar solution 5 and 15 min, respectively, following the saline injection. Subjects in the control group received a 10-min exposure to vinegar on Day 4, 24 h following the saline injection on Day 3. The vinegar was presented in centrifuge tubes in exactly the same way the animals received their daily water, and amounts were recorded to the closest .5 ml. In order to equalize fluid exposures, the control group was allowed 10-min access to water 10 min following its saline injection on Day 3. The remaining three groups were allowed 10-min access to water on Day 4 when the control group received its vinegar exposure.

The Day 1 treatments (chamber-coffee stimuli followed by LiCl) were repeated on each of Days 2, 5, 8, and 13. The Days 3-4 treatments (chamber-coffee stimuli followed by a NaCl injection, followed by delayed access to vinegar) were repeated on Days 6-7, 9-10, 11-12, and 14-15. These treatments thus resulted in five excitatory conditioning trials (chamber-coffee stimuli paired with LiCl) and five inhibitory conditioning trials, in which the procedural excitor (chamber-coffee stimuli) was followed shortly by vinegar in the experimental groups and after a 24-h delay in the control group. The procedures also insured that each group received the same number of LiCl-reinforced chamber-coffee stimuli, the same number of nonreinforced chamber-coffee stimuli, and identical exposure to vinegar.

On Day 16, the day before the test day, no treatments were

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administered except for the usual watering session. On Day 17, the test day, all subjects were allowed 20-min access to two centrifuge tubes, one containing water and the other vinegar. The amounts of each fluid consumed were computed by weighing the bottles before and after the test on an electronic balance accurate to .1 g.

RESULTS AND DISCUSSION

During the 20-min vinegar-water choice test on Day 17, there were no significant differences among groups in total fluid intake (range of mean total intakes among the four groups was from 16.2 g to 16.9 g).

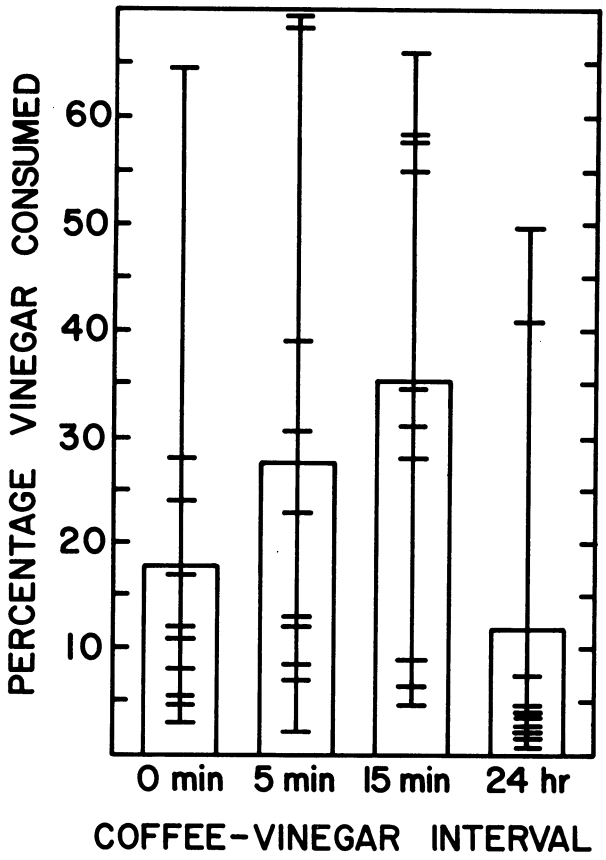

Figure 1. Mean vinegar preference scores of groups. Individual subjects' scores are indicated along the vertical bar within each group.

Vinegar preference scores were computed from this test by dividing the weight (in grams) of vinegar consumed by the combined weight of vinegar and water consumed and multiplying by 100. Mean group preference scores are presented in Figure 1. Each of the three experimental groups (Cof-0-Vin, Cof-5-Vin, and Cof-15-Vin) demonstrated a significantly elevated vinegar preference relative to the control group (largest $U = 24$, $p < .05$). Although there were no significant differences among the three experimental groups, there was a tendency toward greater vinegar preference as the S1-S2 (chamber-coffee stimuli followed by vinegar) interval increased from 0 to 15 min during inhibitory training trials. These results suggest not only that flavor conditioned inhibition is detectable as an increase in test consumption of the target flavor, but also that the development of conditioned inhibition may be a function of the interval between the procedural excitor and the conditioned inhibitor cue during inhibitory training. The function relating S1-S2 interval and the development of conditioned inhibition, however, appears not to be perfectly linear. Indeed, the control group drank less vinegar than the other groups, even though its S1-S2 interval was the longest (24 h).

It should be noted also that the group differences in Day 17 vinegar preference scores are reflected to some extent in the single-bottle vinegar exposures during the five inhibitory training trials. Group mean consumption scores during these exposures are presented in Table 1. All groups demonstrated an initial neophobic response to vinegar before increasing consumption during subsequent exposures. However, there were no significant differences among group intakes until the fifth occasion, when the control group drank significantly less vinegar than all the other groups (largest $U = 17.5$, $p < .05$). Although not all groups received these vinegar exposures at the same time (e.g., the control group's exposures occurred 24 h later than those of all other groups), these results corroborate the results of the two-bottle choice test.

Perhaps the most interesting aspect of this experiment is its method for detecting the presence of conditioned inhibition. The test for conditioned inhibition consisted of exposure to a single vinegar stimulus alone (along with a neutral water solution), and the experimental groups demonstrated significant conditioned inhibitory effects. What makes this single stimulus test

Table 1
Mean Vinegar Consumption Scores (in Milliliters) of Groups Over the Five Inhibitory Trials

	Exposures									
	1		2		3		4		5	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	7.3	2.29	10.3	1.65	11.4	1.97	10.4	2.13	10.0	1.32
Cof-0-Vin	7.8	2.31	10.4	3.29	12.1	2.41	12.9	2.74	13.9	1.80
Cof-5-Vin	7.7	2.15	12.7	2.58	13.5	3.17	12.7	2.68	15.2	2.43
Cof-15-Vin	10.1	3.94	11.3	2.50	12.4	2.82	12.2	2.77	12.5	2.66

theoretically interesting are the conventional conceptualizations of conditioned inhibition. Pavlov (1927), Konorski (1948), and more modern researchers (e.g., Rescorla, 1969; Wagner, Note 1) have generally employed compound stimulus tests, such as summation procedures, because of the apparent assumption that a conditioned inhibitor acts only to inhibit ongoing excitation. This view suggests that an inhibitor elicits no overt behavior by itself. The present experiment would appear to question such a view of conditioned inhibition, since inhibition was reflected in elevated preferences for vinegar when it was presented outside any excitatory context (i.e., on the test day and during the single exposures to vinegar, as represented in Table 1). Additional work should focus on the factors contributing to this single-stimulus test effect and on comparisons between this and more conventional procedures employing summation and retardation techniques.

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