Apomorphine-induced conditioned aversion to a novel food¹

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Rats were permitted to ingest both a novel and a familiar substance prior to injection with apomorphine hydrochloride (a nausea-producing drug) or isotonic saline. Subsequent 2-choice preference tests showed that apomorphine produced a conditioned aversion to the novel substance, but only with the more palatable of the two novel substances employed.

Revusky & Bedarf (1967) found that rats associate the gastro intestinal upset accompanying aversive X-irradiation with the novel food of a pair. Specifically, they permitted Ss to become familiar, through drinking sessions, with either grape juice or milk but not both. Then they administered X-irradiation treatment following an ordered presentation of both substances. Regardless of which food was novel or familiar, and regardless of the order of presentation, there was a consistent decrease in preference by X-irradiated Ss for the novel food, when both foods were presented later in a two-choice preference test.

Rats also will show a conditioned aversion to a single solution that has been paired with apomorphine, a nausea-producing drug, as the noxious US (Garcia, Ervin, & Koelling, 1966). However, since Ss in this study were never presented with pairs of stimuli during either the treatment or test phases of the experiment, it is unclear whether or not this conditioned aversion varies as a function of the degree of novelty of the food.

In the present study an attempt was made to determine (a) whether the nature of the illness-producing agent is a critical factor in the Revusky-Bedarf phenomenon, and (b) whether the conditioned aversion described by Garcia et al is influenced by the degree to which the associated food substances are novel or familiar to the S.

Method

One week prior to the beginning of the study, all 40 of the 2-3 months old female Sprague-Dawley rats were placed on a 23-h water deprivation schedule. Ss remained on this drinking schedule, with free access to Rockland Lab Chow, throughout the entire experiment.

On Days 1-5, one-half of the Ss were familiarized with grape juice (undiluted and unsweetened) and one-half with milk (equal parts condensed milk and water by volume). Familiarization was defined as 1 h access to the substance, in the home cage, during the S's normal watering period.

On Days 6-8 all Ss were given 15 min access to each substance (novel food (N) followed by familiar food (F), or F followed by N, in a counter-balanced design). Fifteen min after drinking the second of the two solutions, all Ss were given intraperitoneal injections of either isotonic saline (placebo) or apomorphine hydrochloride (5 mg/cc) with isotonic saline as the vehicle. Experimental Ss received 15 mg/kg body wt of apomorphine solution; control Ss received an equal volume of placebo.

These procedures established eight groups of five Ss each. The basic experimental setup can be abstracted from Table 1, which shows a 2 by 2 by 2 factorial design with novel substance (milk or grape juice), order of presentation (F followed by N, or N followed by F), and injection treatment (apomorphine or saline) as the three independent variables.

On Days 9-11 (Test Days 1-3) all Ss were, for the first time, given 1 h access to both grape juice and milk simultaneously. The amount ingested of each substance was measured and converted to a Novel Food Preference Score by computing the following ratio: no. ml novel food ingested/total ml of both substances ingested.

Results

Three separate 2 by 2 by 2 analyses of variance (one for each Test Day) showed both novel substance and injection to be significant variables (for novel substance: $F = 111.48, 614.54, \text{ and } 305.51$ for the three Test Days, $df = 1/39, p < .01$; for injection:

$F = 59.39, 61.12, \text{ and } 9.00$ for the three Test Days, $df = 1/39, p < .01$). The interaction of these two variables also was significant ($F = 51.54, 46.57, \text{ and } 6.41$ for the three Test Days, $df = 1/39, p < .01$ for the first two Test Days and $< .05$ for the third). A Scheffé test isolated the source of the significant interaction as the following: apomorphine-injected Ss drank significantly less novel food than their saline controls but only when milk was the novel substance. Table 1 depicts this interaction effect for Test Day 1 (Day 9).

On Test Day 3, for the first time, the order of presentation of the food substances during treatment had an effect on preference for the novel substance. This emerged in the form of a statistically significant triple interaction ($F = 4.41, df = 1/39, p < .05$). A Scheffé test indicated a "weakening" of the conditioned aversion to novel milk: only Ss in the F-N Group, for which the novel food was presented closer in time to the apomorphine injection, showed a significantly lower preference for novel milk.

Figure 1 shows the apomorphine and placebo preference functions over the three Test Days for groups for which either milk or grape juice was the novel substance. It is clear that (a) apomorphine-injected Ss exhibited a decreased preference for novel milk, (b) there was no injection effect when the novel substance was grape juice, and (c) milk was preferred to grape juice, regardless of degree of familiarity, by control Ss.

Ingestion on the conditioning (injection) days was also recorded. Here it was discovered that when grape juice was novel, very little grape juice (16.0% of the total) was consumed; when milk was novel, a relatively larger volume (35.5% of the total) was consumed. Thus, it is clear that at least two variables affected drinking during the conditioning stage: the novelty of the substance and its palatability.

Finally, Table 1 presents the mean per cent novel food ingested on Test Day 1 of the present study compared with the corresponding Revusky & Bedarf (1967) data. The important differences between the two studies are the following: (a) Revusky and Bedarf found an unconditioned neophobia to both novel substances (milk and grape juice), whereas in the present study control Ss preferred milk even when it was the novel stimulus; (b)

Fig. 1. Preference for novel food over the three Test Days as a function of familiarity (i.e., milk novel or grape juice novel) and injection procedure.

Table 1
Comparison of the Mean Percentage Novel Food Ingested on Test Day 1 of
the Present Study with the Data of Revusky and Bedarf

Order of Presentation of the Two Food Stimuli	Milk Novel Treatment		Grape Juice Novel Treatment		Wittlin & Brookshire (Test Day 1)	
	Apomorphine	Saline	Apomorphine	Saline		
	N→F	37.3	71.2	18.7		24.0
	F→N	19.7	63.8	20.6		18.0
	X-ray	Control	X-ray	Control		
	N→F	2.6	26.7	1.0		11.9
F→N	5.2	35.0	5.6	10.9	Revusky & Bedarf (1967)	

the present study failed to confirm the report by Revusky and Bedarf of a conditioned aversion when grape juice was the novel substance.

Discussion

In an attempt to extend the generality of the Revusky-Bedarf (1967) effect (conditioned aversion to the novel substance of a pair), when apomorphine was substituted for X-irradiation as the aversive US, the present study failed to find the predicted aversion to be independent of the two taste stimuli themselves. Only Ss familiarized on grape juice, having milk as the novel substance, demonstrated conditioned aversion to the novel stimulus. However, Revusky and Bedarf's reported decrease in preference for novel grape juice was statistically significant only by a one-tailed test. Therefore, it is not inconceivable that the occurrence of aversive conditioning is dependent upon the taste characteristics of the substances used, i.e., certain foods may serve more readily as conditioned stimuli in the development of aversions. Further support for this conclusion comes from a pilot study from this laboratory, in which it was found that apomorphine-injected Ss familiarized on sucrose octa-acetate (SOA) showed a decreased preference for novel sodium bicarbonate, but apomorphine-injected Ss familiarized on sodium bicarbonate did not show a preference change for novel SOA.

The inconsistency in the results for conditioned aversions between this study and that of Revusky and Bedarf may be explained in a way other than by appealing directly to the stimulus characteristics of the foods. Ss strongly prefer milk to grape juice, all other things being equal. Neophobia (Barnett, 1963), the natural hesitancy to ingest a novel stimulus, decreases as a function of the amount of novel food ingested. Since, on the average, about twice as much milk as grape juice was drunk on the critical conditioning days, it may have been easier for its taste to have been associated with gastro-intestinal upset. Thus, in the establishment of a conditioned aversion to one of a pair of substances, there may be two opposing requirements: (a) one of the substances must be relatively novel, so that it can serve as a highly salient stimulus, but (b) this substance cannot be too novel or too unpalatable such that the animal does not drink enough of it to establish an association with the malaise accompanying apomorphine.

From Table 1 it is clear that preferences of control animals differed in the present experiment as compared to the Revusky-Bedarf experiment. Revusky and Bedarf's control Ss showed an inversion of preference that depended on familiarization treatment. This study's control Ss familiarized on milk preferred milk, while control Ss familiarized on grape juice also preferred milk. These control group differences may be attributable to the different operational definitions of "novelty" employed in the two studies. Revusky and Bedarf's Ss had only 300 licks (roughly 15 min) of exposure to the novel food prior to the test day. The present study's animals had 45 min exposure to the novel food prior to the first Test Day. It is possible, since Ss had greater access to the "novel" food in this study, that any neophobia was overcome through habituation, and natural taste preferences emerged on the first Test Day. Thus control Ss familiarized on grape juice would still demonstrate preference for milk when presented with a choice of both substances.

The animals which failed to demonstrate a neophobia were controls for the Ss which showed conditioned aversion to the novel food. Apparently, neophobia is not a prerequisite for the formation of conditioned aversions to novel foods. This finding is inconsistent with Revusky and Bedarf's hypothesis that neophobia enhances the conditioning of novel food to visceral malaise. The present study found that the group showing neophobia (the milk-familiarized Ss) failed to show conditioned aversion and vice-versa. Once again, attention is called to the fine line between the saliency gained by novelty and the necessity for a certain minimum amount of the novel food to be drunk to insure conditioning.

Another interesting result of this experiment was the finding of a delay of reinforcement gradient in the formation of a conditioned aversion to novel food. The F→N apomorphine group demonstrated a more durable conditioned aversion to novel milk than its N→F counterpart. Thus, the closer temporal contiguity between CS and US seems to have produced better conditioning.

In general, the results confirm the hypothesis that conditioned taste aversions may occur when novel stimuli are associated with gastrointestinal upset. At the same time, it appears that the phenomenon may be more complicated than originally surmised: the association between a novel CS and a noxious US may well depend upon the precise characteristics of the novel stimulus and/or the particular method by which the conditioned taste aversion is established.

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NOTES

1. This research was supported by NSF Grant GB-3434.
2. Now at Albert Einstein College of Medicine.