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Formation and retention of conditioned taste aversions and UCS habituation

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In Experiment I rats received 10 consecutive daily injections of either apomorphine hydrochloride or NaCl followed by 4 days of saccharin solution exposure paired with apomorphine or NaCl injections. Relative consumption of saccharin solution and water during conditioning indicated that preconditioning apomorphine UCS habituation retarded acquisition of a conditioned saccharin aversion. In Experiment II rats received 6 days of saccharin solution exposure paired with injections of either apomorphine hydrochloride or NaCl, then 10 daily injections of either apomorphine hydrochloride or NaCl, followed by 4 days of saccharin preference testing (no drug injections). Postconditioning apomorphine UCS habituation did not interfere with retention of saccharin aversion acquired in initial conditioning phase. These results showed that novelty of UCS is crucial in acquisition of but not retention of conditioned taste aversions.

For classical conditioning in general and conditioned taste aversion learning in particular, habituation to an unconditioned stimulus (UCS) prior to conditioning attenuates degree of conditioning expressed as either retarded acquisition or reduced resistance to extinction. For example, retarded acquisition of a conditioned response following preconditioning UCS habituation was found in human eyelid conditioning (MacDonald, 1946; Taylor, 1956), in rabbit nictitating membrane conditioning (Mis & Moore, 1973; Siegel & Domjan, 1971), and in conditioned suppression (Kremer, 1971; Siegel & Domjan, 1971). Rescorla (1973) reported reduced resistance to extinction and not retarded acquisition of conditioned suppression as a result of preconditioning noise UCS habituation. Regarding conditioned taste aversion learning, both retarded acquisition (Cannon, Berman, Baker, & Atkinson, 1975; LeBlanc & Cappell, 1974) and reduced resistance to extinction (Elkins, 1974) have resulted from preconditioning UCS habituation using ethanol, lithium chloride, cyclophosamide, morphine, or amphetamine as drug UCSs. Experiment I investigated acquisition of conditioned taste aversion as a function of preconditioning UCS habituation when an apomorphine hydrochloride UCS was used.

Attenuation of conditioning by UCS habituation is not limited to UCS habituation done prior to conditioning, for UCS habituation administered following conditioning has been found to reduce resistance to extinction of conditioned suppression in rats (Rescorla, 1973). Experiment II is an investigation of retention of a conditioned aversion following the same number of apomorphine UCS habituation trials administered in Experiment I.

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EXPERIMENT I

Method

Subjects. The subjects were 32 male Sprague-Dawley rats 49 days old at the beginning of the experiment, with a mean body weight of 205 g.

Apparatus. Animals were housed in test boxes which had three adjacent holes, 65 mm apart, and clips for insertion of graduated Richter tubes. The saccharin solution contained 1 g of sodium saccharin in 1 liter of distilled water (.1% sodium saccharin solution). The apomorphine hydrochloride injections consisted of 15 mg of apomorphine hydrochloride per kilogram of body weight in a solution of 5 mg apomorphine hydrochloride per milliliter of .9% NaCl solution; control injections were an equal volume of .9% NaCl solution (saline solution) following the same dose per weight schedule for apomorphine hydrochloride injections.

Procedure. During the first 5 days of the experiment, all subjects were placed on a 23-h water deprivation schedule and received distilled water in a Richter tube placed through the center hole of the test box. For the next 10 days (habituation phase), 16 subjects received daily injections of apomorphine hydrochloride. The remaining 16 subjects received saline control injections. Injections were given ½ h after termination of a drinking period.

For the next 5 days (conditioning phase), each group of 16 subjects was subdivided into two groups of equal size. One of the groups which had received habituation to apomorphine-induced illness (Group pre A-A) and one of the groups which had served as a saline solution control for habituation (Group pre S-A) were given 1-h periods with exposures to .1% sodium saccharin and distilled water for 5 successive days. Richter tubes were placed in each lateral position of the test box; solution positions were rotated daily. One-half hour after termination of each drinking period, subjects were injected with apomorphine hydrochloride using the same procedure as that employed in the habituation phase. The other two subgroups (pre A-S and pre S-S) also received the 1-h two-choice drinking procedure but were given a saline control injection ½ h after drinking tubes were removed.

Results

Amount of distilled water ingested on the last day of the habituation phase was not reliably different between subjects receiving apomorphine injections and those receiving control NaCl injections [$t(30) = .049, p > .5$]. Thus, illness did not affect water consumption during UCS habituation.

Observations of animals during the habituation phase indicated that the illness produced by an apomorphine injection manifested itself within 5 min after injection of the drug. Animals showed extreme agitation, climbed the walls of the cage, bit or licked the bars of the cage, and sometimes showed uncoordinated movements. Behavioral symptoms lasted approximately 90 min and were just as prevalent after the 10th daily injection as after the first.

The percentage preference score for saccharin solution during each of 5 days of conditioning phase was computed by dividing volume of saccharin by total saccharin and water consumed. Figure 1 shows the mean percentage preference scores of each group for each of 5 conditioning days. For Day 1 it should be noted that there is no difference in preference scores for saccharin solution between apomorphine injected and NaCl injected animals [$t(30) = .96, p > .25$]. This preference score for Day 1 of the conditioning phase is an index of relative preference between water and saccharin 24 h following the last habituation trial and before the first conditioning trial presentation of UCS. For the last 4 days of the conditioning phase, it was readily apparent that subjects receiving NaCl injections during the habituation phase but apomorphine injections during the conditioning phase (Group pre S-A) formed a conditioned aversion to saccharin. However, subjects which had received 10 habituation trials prior to conditioning (Group pre A-A) showed a preference for saccharin which was quite similar to the groups for which saccharin was never paired with illness (Groups pre A-S and pre S-S). Analysis of variance (habituation treatment by conditioning treatment by trials) supported this: Conditioning treatment had a significant effect [$F(1,28) = 18.2, p < .01$] and the interaction of Habituation Treatment by Conditioning Treatment was significant [$F(1,28) = 18.8, p < .01$]. Scheffé tests yielded a significant difference between Group pre S-A and other groups but no reliable differences among the other groups.

EXPERIMENT II

Method

Subjects. The subjects in this experiment were 32 male Sprague-Dawley rats, 51 days old at the beginning of the study, with a mean body weight of 209 g.

Apparatus. Same as in Experiment I.

Procedure. As in Experiment I, the subjects were placed on a 23-h water deprivation schedule for 5 days. Then for 6 successive days all subjects received a 1-h exposure to Richter tubes containing either saccharin solution or water.

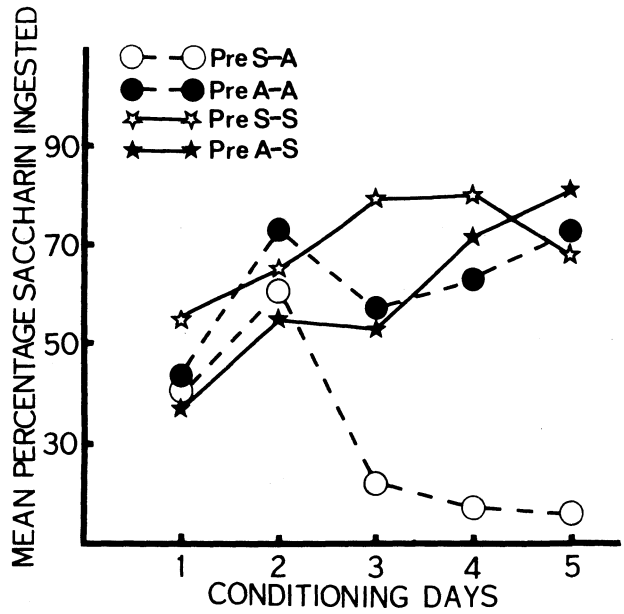

Figure 1. Mean percentage preference for saccharin over Conditioning Days 1-5 for the groups of Experiment I. Groups pre A-A and pre A-S received UCS habituation trials prior to conditioning; Groups pre S-A and pre S-S were injected with saline prior to conditioning.

One-half hour after termination of the drinking period, 16 subjects received an injection of apomorphine hydrochloride and 16 subjects received a saline control injection (conditioning phase).

Following the conditioning phase, all subjects were returned to 1 h daily exposure to water only. Eight subjects from each previous group of 16 (Groups A-post A and S-post A) received 10 daily injections of apomorphine ½ h after termination of the drinking period. The remaining animals (Groups A-post S and S-post S) received saline control injections.

Finally, all subjects received a 3-day 1-h two-tube choice test between saccharin solution and water to determine whether habituation trials with the illness-producing UCS after taste aversion conditioning would affect the acceptability of the saccharin conditioned stimulus for experimental subjects (test phase).

Results

The saccharin preference scores over the 6 conditioning days of the conditioning phase of the experiment for the subjects receiving pairings of saccharin and apomorphine injections, that is, Groups A-post A and A-post S combined, and the subjects receiving pairings of saccharin and control injections, that is, Groups S-post A and S-post S combined, are in the first part of Figure 2. Analysis of variance (conditioning treatment by trials) indicated that subjects receiving saccharin-apomorphine pairings showed a reliable diminution of preference for saccharin [$F(1,30) = 9.22, p < .01$], although the subjects in Experiment II did not avoid saccharin to the extent that subjects in Experiment I did.

The second part of Figure 2 shows the preference scores for each experimental group during the test

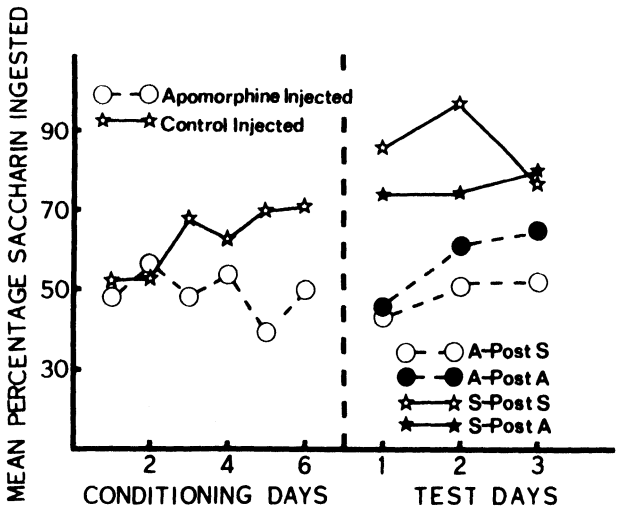

Figure 2. Mean percentage preference for saccharin over Conditioning Days 1-6 and Test Days 1-3 for the groups of Experiment II. Groups A-post A and S-post A received UCS habituation trials following conditioning; Groups A-post S and S-post S were injected with saline following conditioning.

phase. An analysis of variance (conditioning treatment by habituation treatment by trials) done on test phase saccharin preference scores showed that postconditioning UCS habituation did not affect retention of aversion for the A-post A group. The conditioning treatment factor was significant [$F(1,28) = 29.12$, $p < .01$], while the habituation factor was not significant as a main factor [$F(1,28) < 1$] or in its interaction with the conditioning treatment factor [$F(1,28) = 2.27$, $p > .1$].

GENERAL DISCUSSION

The results of Experiment I indicate that, when subjects received 10 daily UCS habituation trials prior to conditioning, a saccharin taste aversion was not learned. This data parallels attenuation of conditioned response (CR) acquisition following conditioned stimulus (CS) pre-exposure for both conditioned taste aversion (Elkins, 1973) and classical conditioning (Lubow, 1973). More specifically, it parallels retarded acquisition of a CR following UCS habituation trials in a number of classical conditioning settings, e.g., Siegel and Domjan (1971), in addition to reduced resistance to extinction of a conditioned taste aversion following illness UCS habituation (Cannon et al., 1975; Elkins, 1974; LeBlanc & Cappel, 1974).

In Experiment II, the postconditioning UCS habituation group (A-post A) clearly retained saccharin aversion acquired in the conditioning phase. Moreover, there is no indication of reduced resistance to extinction for this group relative to Group A-post S. This is counter to the diminution of conditioned suppression over extinction test days following UCS habituation reported by Rescorla (1973).

Several explanations are available to account for the effect of UCS habituation in Experiment I. Because the UCS in this study was presented by injection of a drug, specifically, a narcotic, there is danger that multiple injections could have produced drug resistance. Several arguments reduce the likelihood of drug tolerance playing a primary role in Experiment I. First, Sollman (1943) reported that repeated administration of apomorphine hydrochloride for 42 days did not produce drug tolerance in dogs, a test far more severe than the 10-day drug exposure used in this experiment. Second, observation of rats during the illness period following apomorphine injection in Experiment I indicated that apomorphine-induced illness continued to occur fully, at least reflected by several indexes used to assess degree of illness.

A second possible account would be based on a parallel to a blocking phenomenon (Kamin, 1969), in which a number of CS-UCS pairings with one CS will "block" conditioning to a second CS presented in compound with the previously paired CS. Relevant to Experiment I, the situational cues and the water drinking were inadvertently paired with the UCS during the habituation phase. However, it should be noted that (1) amount of water ingested by habituated animals was not different from that ingested by control NaCl animals during the last day of the habituation phase, and (2) percentage of water drunk in two-tube choice with saccharin on Conditioning Phase Day 1 of Experiment I was no different between UCS habituated groups and control groups; these two observations reduce the likelihood of a blocking aversion to water having been formed during the habituation phase.

Nonlearning of a saccharin aversion by animals habituated to UCS in Experiment I could have resulted from a change in the nature of the UCS per se. Just as novelty of taste CS is important in establishing a conditioned taste aversion (Revusky & Bedarf, 1967), novelty of UCS may in a complementary fashion also be important. Alternatively, a recent theoretical account postulated by Rescorla (in press) maintains that an alteration of memory of UCS, e.g., UCS habituation, will reduce the degree of associative power supported by a CS in relation to a particular UCS. This model has been used to account for reduced behavioral control of a CS following postconditioning habituation to UCS (Rescorla, 1973). The novelty hypothesis is sufficient to account for both Experiments I and II, while, on the other hand, the memory hypothesis is not supported by the results of Experiment II.

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