Specificity of cue to consequence in aversion learning in the rat: Control for US-induced differential orientations

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In four experiments, each using a single conditioning trial, rats avoided a light more than a saccharin solution after these stimuli had been paired with footshock, whereas saccharin was avoided more than the light after these stimuli had been paired with lithium injection. The use of a single conditioning trial precludes possible US-induced differential orientations from influencing which stimuli will be associated on the conditioning trial. This cue-consequence specificity effect was obtained even when subjects conditioned with lithium received a noncontingent footshock prior to the test session, and when subjects conditioned with footshock received a noncontingent lithium injection before testing (Experiments 2-4). Weak aversions to the light in rats given a light-lithium pairing and noncontingent footshock and to the saccharin in subjects that received a saccharin-footshock pairing and noncontingent lithium administration were obtained in Experiment 2. However, these weak aversions were not obtained when subjects were given three nonreinforced exposures to the test chamber before the test session (Experiments 3 and 4). These results indicate that US-induced differential orientations do not mediate the cue-consequence effect in aversion learning.

One of the most important findings in the area of conditioning and learning is that the pairing of taste and audiovisual cues with internal malaise leads to a selective aversion to the taste stimulus, whereas similar pairings with footshock lead to a selective aversion to the auditory and visual stimuli. This cue-consequence specificity in aversion performance was first demonstrated by Garcia and Koelling (1966) in rats. Garcia and Koelling offered an associative interpretation of the effect. However, because of the theoretical significance of this phenomenon, demonstrations of it have been closely scrutinized to see if the effect can be explained in terms of non-associative processes.

The most systematic nonassociative interpretation of the cue-consequence specificity effect was offered by Rescorla and Holland (1976). They proposed that this phenomenon results from differential orientations caused by the two types of unconditioned stimuli. This interpretation assumes that shock causes animals to orient or attend selectively to visual and auditory stimuli, whereas internal malaise causes them to attend selectively to taste stimuli. Such selective orientations caused by the unconditioned stimuli can lead to selective associations of taste with toxicosis and of audiovisual cues with footshock if mul-

tipple conditioning trials are administered. If footshock serves as the unconditioned stimulus, for example, the footshock delivered in the first conditioning trial would cause a selective orientation to audiovisual stimuli in the second conditioning trial, and this would facilitate the association of audiovisual cues with footshock in the second trial. The shock delivered in the second trial would enhance orientations to and conditioning of the audiovisual cues in the third trial, and so on. The end result would be a strong selective association of audiovisual cues with footshock. A corresponding sequence of events can favor the conditioning of taste as opposed to audiovisual cues when repeated conditioning trials with toxicosis are administered.

The differential orientation hypothesis is more applicable to multiple-trial experiments than to experiments in which only one conditioning trial is administered. The taste and audiovisual cues presented on the first trial are not preceded by exposure to footshock or toxicosis. Therefore, one cannot assume that experimenter-induced differential orientations to taste and audiovisual stimuli exist on the first conditioning trial. Interestingly, however, all demonstrations of the cue-consequence specificity effect in adult rats have involved multiple conditioning trials (Domjan & Wilson, 1972; Garcia & Koelling, 1966; Garcia, McGowan, Ervin, & Koelling, 1968). Therefore, the present investigation was conducted to see if the cue-consequence specificity effect can occur after only one conditioning trial. In addition,

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in Experiments 2-4, subjects were exposed to both the toxicosis and footshock unconditioned stimuli before the test session in a further effort to minimize the possible contribution of nonassociative processes to the results.

EXPERIMENT 1

The procedure of Experiment 1 was similar to that of the original cue-consequence demonstration (Garcia & Koelling, 1966), with the exception that only one conditioning trial was administered. Three groups of rats were exposed to a compound conditioned stimulus consisting of the taste of a saccharin solution and a flash of light activated by licks at a drinking tube. Immediately after this CS exposure, one group of subjects was given footshock, a second group was given an injection of lithium chloride to induce internal malaise, and a third group was given a saline injection. Following conditioning, the two elements of the compound CS were tested separately. Each subject was given two test sessions. One test consisted of a choice between a drinking tube containing saccharin and a tube containing tap water, and the second test consisted of a choice test between two drinking tubes filled with water. In the latter tests, each lick at one of the tubes produced a flash of light; licks at the other tube had no exteroceptive consequences.

Method

Subjects. Twenty-one male Sprague-Dawley rats, 60-90 days of age, were used. The animals were bred in the laboratory and were housed individually in hanging wire-mesh cages. Six days before the start of the experiment, access to water was limited to 30 min each day, but food was continuously available. Experimental treatments were always administered before the daily 30-min access to water.

Apparatus. Adaptation, conditioning, and testing took place in a 20 × 20 × 30 cm experimental chamber (Lafayette Co., unit 85000). The sides and back wall were composed of stainless steel, and the front wall was made of clear plastic. The floor consisted of 3-mm-diam steel rods, spaced 7 mm apart. Stainless steel drinking spouts could be inserted through the front wall of the chamber through two holes 10 cm apart, 2.5 cm above the floor. A 7-W light bulb, located 10 cm above and midway between the two drinking spouts, provided the visual stimulus. The only other source of illumination in the room was a 15-W red light bulb located outside the experimental chamber.

Procedure. The subjects received three daily adaptation sessions of drinking tap water from the two drinking spouts in the experimental chamber. Each adaptation session began with a forced-sampling procedure: The subjects were first allowed access to only the left drinking tube, then to only the right drinking tube, then again to only the left drinking tube, followed finally by simultaneous access to both tubes for 10 min. Each time only one drinking tube was available, it remained in the experimental chamber for 30 sec, starting with the first lick at the spout. The purpose of this forced-sampling procedure was to accustom the subjects to drinking from both of the drinking spouts.

One or 2 days following adaptation, the subjects were placed in the experimental chamber and given access to a drinking tube

containing a .15% solution of sodium saccharin. Each lick at this spout also produced a brief (approximately 1/3-sec) flash of the light above the spout. Sixty seconds after the first lick, Group Sh received a 1-sec, 2-mA scrambled footshock, Group Li received a 1.5% body weight intraperitoneal (ip) injection of .15 M lithium chloride, and Group Na received an ip injection of a 1.5% body weight solution of .15 M saline ($ns=7$). If the subject was not drinking at the end of the 60-sec CS period, the unconditioned stimulus was delayed until the subject completed a 3-sec bout of drinking.

On the day after the conditioning trial, each subject received two 10-min choice tests, spaced 2 days apart. Three animals in each group received the light test first, while the remaining four subjects in each group were given the saccharin test first. During the saccharin test, the subjects were given a choice between a drinking tube containing saccharin and a drinking tube containing water. During the light test, the subjects had access to two drinking tubes containing water, with one tube activating the light flash when licked and the other tube producing no light when licked. A forced-sampling procedure, identical to that used during adaptation, was used at the start of each test session. The drinking tube that produced the CS (saccharin or flash of light) was always presented first. The amount consumed from each drinking tube was recorded to the nearest .25 ml every 2 min.

Results and Discussion

For both choice tests, preference scores for the CS (light flash or saccharin) were determined at 2-min intervals by dividing the intake from the spout producing the CS by the total intake from both drinking tubes during each 2-min interval. The order of the two tests was not treated as a factor in the data analysis. The mean preference scores for the test with the light stimulus are presented in the left panel of Figure 1. Animals that received a footshock following the light-saccharin compound CS (Group Sh) showed almost complete avoidance of the light during the postconditioning test. In contrast, animals injected with lithium (Group Li) showed no more tendency to avoid the light than did animals injected with saline (Group Na). A repeated-measures analysis of variance performed on these preference scores revealed a significant group effect

Figure 1. Mean preference ratios for the light (left panel) and saccharin solution (right panel) following a single pairing of light-saccharin compound with footshock (Group Sh), lithium (Group Li), or saline (Group Na).

[$F(2,18)=17.58$, $p < .05$]. Comparisons with the Student/Newman-Keuls test indicated that Group Sh had a significantly lower preference for the light stimulus than did Group Li or Na at each test interval ($ps < .05$). Group Li, however, evidenced no aversion to the light, as the preference scores of Group Li did not differ significantly from those of Group Na at any 2-min interval of the test session ($ps > .05$).

The right panel of Figure 1 displays the mean preference scores for the saccharin solution from the saccharin/water choice test. Group Li showed a much lower preference for the saccharin solution than did Group Sh or Group Na, whereas Groups Sh and Na had almost identical preference scores. An analysis of variance on these preference scores revealed a significant group effect [$F(2,18)=4.62$, $p < .05$]. Student/Newman-Keuls tests on these data indicated that Group Li had a significantly lower preference for the saccharin solution than did Group Sh or Group Na at every test interval ($ps < .05$). In contrast, Group Sh failed to differ significantly from Group Na at all five intervals ($ps > .05$).

The present results indicate clearly that lithium was more effective in conditioning an aversion to the saccharin solution than to the light, whereas footshock more readily conditioned an aversion to the light than to the taste of saccharin. This finding replicates previous demonstrations of this selective association effect in the rat (Garcia & Koelling, 1966; Garcia, McGowan, Ervin, & Koelling, 1968; Garcia & Wilson, 1972). In addition, the present results show that this cue-consequence specificity effect is obtained even if only one conditioning trial is administered. Since no unconditioned stimuli preceded the conditioning trial, the present findings cannot be attributed to possible US-induced differential orientations to the gustatory and visual CSs during the conditioning trial (cf. Rescorla & Holland, 1976).

EXPERIMENT 2

Although the results of Experiment 1 cannot be explained in terms of differential orientations to the taste and light CSs during the conditioning trial, they do not preclude the possibility that such orientations may have determined test performance. Subjects may have learned equal aversions to the light and saccharin CSs, but lithium administered during the conditioning trial may have created a differential orientation favoring taste stimuli, and this, for Group Li, may have resulted in stronger taste aversions than light aversions during the test sessions. Similarly, footshock may have created a differential orientation for exteroceptive stimuli, thereby leading to stronger light aversions in Group Sh. One way to rule out this possibility is to present

both unconditioned stimuli before the test session, and to pair only one of the USs with the target CS. This control procedure was first suggested by Rescorla and Holland (1976) and has been used in studies of selective associations in second-order conditioning (e.g., Rescorla & Cunningham, 1979; Rescorla & Furrow, 1977). The present experiment used this design to determine if differential orientations acting on test performance were responsible for the selective association effect demonstrated in Experiment 1.

One group of rats received a single pairing of a conditioned stimulus and footshock, followed the next day by a noncontingent lithium injection. A second group received a pairing of a CS with lithium, followed on the next day by a noncontingent footshock. The third group was given a saline injection following the CS presentation and a second saline injection the next day. For half the subjects in each group, the CS was a saccharin solution, and for the remaining animals, the conditioned stimulus was a light flash activated by each lick at a drinking spout. The subjects were tested with the appropriate CS at the end of the experiment.

Method

Forty-five female Sprague-Dawley rats, approximately 60-90 days old, served as subjects. The procedure was identical to that of Experiment 1, except as noted. All subjects first received three daily 10-min adaptation sessions in which access to two drinking tubes containing tap water was provided. Each adaptation trial started with the forced-sampling procedure described in Experiment 1.

On the day following the third adaptation session, the subjects were assigned to three groups that had comparable weights: Groups Sh ($n=16$), Li ($n=15$), and Na ($n=14$). All groups were placed in the experimental chamber and given access to a drinking tube that produced a conditioned stimulus when licked. The CS was a .15% saccharin solution for 7 subjects in Groups Li and Na and for 8 subjects in Group Sh. A lick-activated light flash was the conditioned stimulus for the remaining animals in each group. Sixty seconds after the first lick to the spout producing the conditioned stimulus, Group Sh was given a 1-sec, 2-mA footshock, Group Li was given an ip injection of 1.5% body weight .15 M lithium chloride, and Group Na was given a 1.5% body weight ip injection of .15 M saline. For those subjects that were not drinking at the end of the 60-sec period, these treatments were delayed until a 3-sec bout of drinking occurred.

On the day after the conditioning trial, Groups Li and Sh received a noncontingent administration of the US which they had not received during conditioning. Group Li was given a 1-sec, 2-mA footshock in the experimental chamber, and Group Sh was given a 1.5% body weight ip injection of .15 M lithium chloride. Group Na was given a second 1.5% body weight injection of .15 M saline. Two days after the noncontingent US treatment, subjects for which the CS was saccharin were given a choice test between water and saccharin. Subjects for which the light was the conditioned stimulus received a choice test between two drinking tubes containing water. In the latter choice test, licks at one of the spouts produced the visual CS. The tests were conducted exactly like the choice tests of Experiment 1. One subject in Group Li for which light was the CS was ill during the test, and the data from this subject were excluded from analysis.

Results and Discussion

The left panel of Figure 2 presents the mean preference scores of subjects for which the visual stimulus served as the CS. Group Sh showed a much lower preference for the light than did Group Li or Group Na. A repeated-measures analysis of variance performed on these data revealed a significant group effect [$F(2,19)=11.28$, $p < .05$]. Individual comparisons using the Student/Newman-Keuls procedure indicated that Group Sh had a significantly lower preference for the light stimulus than did Group Li or Group Na at every test interval ($ps < .05$). A repeated-measures analysis of variance comparing only Groups Li and Na revealed no significant difference in preference for the light stimulus [$F(1,12) < 1.00$].

The preference scores of subjects for which the saccharin solution served as the CS are depicted in the right panel of Figure 2. Group Li showed a near-zero preference for the saccharin solution throughout the test session. In contrast, Groups Sh and Na showed similar and substantially higher saccharin preferences than did Group Li, except for the first 2 min of testing. An analysis of variance indicated a significant group effect [$F(2,19)=4.50$, $p < .05$]. Student/Newman-Keuls comparisons indicated that Group Li had a significantly lower preference for the saccharin solution than did Group Na at all five intervals of the test ($ps < .05$). In addition, during Minutes 4-10 of the test, the preference scores of Group Li were significantly lower than those of Group Sh. During the first 2 min of the test session, Group Sh also showed a significantly lower preference for the saccharin CS than did Group Na. However, the preference scores of Groups Sh and Na were not significantly different after the first 2 min of the test. Thus, the aversion shown by Group Sh was quite transient, disappearing by the

fourth minute of the test. The aversion shown by Group Li, however, was maintained throughout the test session, and showed no evidence of attenuation.

The results of the present experiment show that footshock conditioned a much stronger aversion to the light than did lithium, and that lithium was much more effective in conditioning an aversion to the saccharin CS than was footshock. These results indicate that the cue-consequence specificity effect is obtained even if subjects are exposed to both unconditioned stimuli before the test session. However, one noteworthy aspect of the present findings is that there was a slight (although nonsignificant) depression in the preference for the light CS in subjects given a light-lithium pairing. Also, subjects that received a pairing of saccharin and footshock showed some evidence of aversion to the saccharin stimulus early in the test session. In contrast, the results of Experiment 1 showed no evidence that footshock conditioned an aversion to the saccharin or that lithium conditioned an aversion to the light CS. The marginal aversions shown by Group Li to the light and the transient aversion shown by Group Sh to the saccharin solution are consistent with the notion that differential orientations may influence which aversions are expressed at the test trial.

EXPERIMENT 3

Experiment 3 investigated the possibility that the marginal aversion to the light shown by Group Li and the transient aversion to the saccharin shown by Group Sh in Experiment 2 were mediated by the conditioned aversiveness of the test chamber. The design of the present experiment was similar to that of Experiment 2, except that an additional phase was included. Following the noncontingent US presentation, subjects were given three exposures to the test chamber in the absence of any unconditioned stimuli. The purpose of these sessions was to extinguish any possible conditioned aversiveness of the test chamber prior to testing, and thereby permit a more accurate assessment of whether the administration of both footshock and lithium toxicosis to each subject would allow the expression of light-lithium and saccharin-footshock associations.

Method

Twenty male and 17 female Sprague-Dawley rats, from 60 to 90 days of age, were used in procedures identical to those of Experiment 2 except as noted. Subjects were assigned to three groups with similar weights: Groups Li ($n=13$), Sh ($n=13$), and Na ($n=11$). In Groups Li and Sh, light served as the conditioned stimulus for 7 subjects (3 males, 4 females) and saccharin was the CS for the remaining 6 animals (3 males, 3 females). For 6 subjects in Group Na (3 males, 3 females) light was the CS, and for the remaining 5 animals (3 males, 2 females) saccharin was the conditioned stimulus. As in Experiment 2, the subjects in Group Li were exposed to footshock and the subjects in Group Sh were injected with lithium 1 day after the conditioning

Figure 2. Mean preference ratios for the conditioned stimulus of subjects that received a pairing of footshock (Group Sh), lithium (Group Li), or saline (Group Na) with light (left panel) or saccharin (right panel). Subjects in Group Sh were given a noncontingent lithium administration before testing, and subjects in Group Li were given a noncontingent footshock before the test session.

trial. In addition, three daily 10-min background extinction sessions were interposed between the noncontingent US presentation phase and testing. These background extinction sessions were conducted exactly like the adaptation sessions. Each subject was then tested for its preference for the saccharin or light CS, depending on which of these stimuli had been paired with the US for that subject.

Results and Discussion

Since there were no systematic differences in test performance between male and female subjects, the light and saccharin preference scores were pooled across sex in the data analysis. Results of the preference test for the light CS are summarized in the left panel of Figure 3. The preference of Group Sh for the light stimulus was close to zero throughout the test session. In contrast, Groups Li and Na showed substantially higher preferences for the light. A repeated-measures analysis of variance performed on these data revealed a highly significant group effect [$F(2,17) = 11.73$, $p < .05$]. Individual comparisons with the Student/Newman-Keuls test showed that Group Sh had a significantly lower preference for the light than did Group Li or Group Na at every interval ($ps < .05$). Groups Li and Na exhibited almost identical preferences for the light and did not differ significantly ($ps > .05$).

Results of the saccharin preference test are displayed in the right panel of Figure 3. Group Li exhibited a very low preference for the saccharin solution, whereas the saccharin preference scores of Groups Sh and Na were much higher. An analysis of variance indicated a significant group effect [$F(2,14) = 122.42$, $p < .05$], and individual comparisons with the Student/Newman-Keuls procedure revealed that Group Li had a significantly stronger aversion to the saccharin than did Group Sh or Group Na throughout

the test session ($ps < .05$). The preference scores of Groups Sh and Na did not differ significantly at any test interval ($ps > .05$).

The present results confirm that lithium is more effective in conditioning an aversion to a saccharin solution than it is to light, whereas footshock is more easily conditioned to light than to saccharin. Thus, the cue-consequence specificity effect was again obtained, even though only one conditioning trial was administered and each subject received both types of unconditioned stimuli prior to testing. In contrast to the results of Experiment 2, Group Li showed no aversion to the light and Group Sh evidenced no aversion to the saccharin flavor. The slightly lower preference of Group Li for the light CS and of Group Sh for the saccharin CS seen in Experiment 2 may have been due to the conditioned aversiveness of the test chamber rather than to the existence of light-lithium and saccharin-footshock associations. Another possibility is that these weak aversions dissipated during the time that was involved in exposing subjects to the experimental chamber on three occasions after the noncontingent US presentation.

EXPERIMENT 4

In the present study, the cue-consequence relationship was obtained when rats were exposed to both light and saccharin CSs and to either lithium or footshock before the test session (Experiment 1) and when subjects received both unconditioned stimuli but only one CS before testing (Experiments 2 and 3). However, in none of these experiments were the rats exposed to both conditioned stimuli as well as both unconditioned stimuli before the test trial. Therefore, in Experiment 4, two groups of subjects were given a pairing of a light-saccharin compound and either footshock or lithium on the conditioning trial, followed by a noncontingent presentation of the US not administered at conditioning. Thus, because both groups were exposed to the same stimuli before the test session, stimulus-induced differential orientations could not explain the results.

Method

Eighteen female Sprague-Dawley rats, approximately 60 days old, were used as subjects. The apparatus and procedures were identical to those described in Experiment 3 in all unspecified details. At the conditioning trial, three groups of subjects ($n = 6$) of similar weights received a lick-contingent presentation of a light-saccharin compound CS paired with footshock (Group Sh), lithium (Group Li), or saline (Group Na). On the day following conditioning, Group Sh was given a lithium treatment, Group Li received a footshock, and Group Na was given a saline injection. Two days following the noncontingent US presentation, subjects received three daily 10-min background extinction sessions, which consisted of access to two drinking tubes containing tap water in the test chamber.

Figure 3. Mean preference ratios for the conditioned stimulus following nonreinforced exposure to the test chamber of subjects that received a pairing of footshock (Group Sh), lithium (Group Li), or saline (Group Na) with light (left panel) or saccharin (right panel). Subjects in Group Sh were given a noncontingent lithium administration before testing, and subjects in Group Li were given a noncontingent footshock before the test session.

To assess the aversions to the light and saccharin stimuli, each subject was given two 10-min choice tests, spaced 2 or 3 days apart. One type of test consisted of a choice between a drinking tube containing saccharin and a tube containing water. During the other type of test, the subjects had access to two drinking tubes containing tap water. In this latter test, one of the drinking tubes produced a light flash when licked. Three subjects in each group received the light test first, and the remaining three subjects in each group received the saccharin test first.

Results and Discussion

Mean preference ratios for the visual stimulus are displayed in the left panel of Figure 4. Group Sh demonstrated a substantially lower preference for the light stimulus than did Group Li or Group Na, whereas the preference scores of Groups Li and Na were highly similar. A repeated-measures analysis of variance on these data revealed a significant group effect [$F(2,15) = 4.75$, $p < .05$]. Individual comparisons with the Student/Newman-Keuls procedure showed that the preference scores of Group Sh were significantly lower than those of Groups Li and Na at every test interval ($ps < .05$). In contrast, Groups Li and Na did not differ in their preference for the light at any interval of the test ($ps > .05$).

The right panel of Figure 4 presents the mean preference ratios for the saccharin solution. The preference scores of Group Li were near zero, whereas Groups Sh and Na showed much higher preferences for the saccharin solution throughout the test. A significant group effect was indicated by a repeated-measures analysis of variance [$F(2,15) = 5.04$, $p < .05$], and Student/Newman-Keuls comparisons at each test interval revealed that the saccharin preference scores of Group Li were significantly lower than those of Groups Sh and Na ($ps < .05$) but that Groups Sh and Na did not differ significantly at any interval.

Figure 4. Mean preference ratios for the light (left panel) and saccharin (right panel) following a pairing of a light-saccharin compound stimulus with footshock (Group Sh), lithium (Group Li), or saline (Group Na). Subjects in Group Sh were given a noncontingent lithium administration before testing, and subjects in Group Li were given a noncontingent footshock before the test session.

The cue-consequence relationship was again obtained despite the fact that Groups Li and Sh received both CSs and both USs before the test sessions. Therefore, the two groups differed only in which unconditioned stimulus was paired with the light-saccharin compound. Exposing Groups Li and Sh to the same stimuli prior to testing should have prevented the occurrence of stimulus-induced differential orientations at the test trial. Nevertheless, selective aversions to the taste and visual stimuli were observed.

GENERAL DISCUSSION

The results of the present study do not support the suggestion that differential orientations induced by internal malaise and footshock mediate selective association effects. The present study demonstrates that the selective association of a saccharin CS with lithium toxicosis and a light CS with footshock can be obtained with a single conditioning trial. In Experiment 1, a compound conditioned stimulus consisting of a light and saccharin solution was paired with either footshock or lithium administration. Although footshock conditioned a very strong aversion to the light CS, there was no evidence that footshock resulted in an aversion to the saccharin solution. In contrast, those animals for which lithium was the unconditioned stimulus showed a strong aversion to the saccharin solution, but not to the light CS.

The fact that the present experiments used only one conditioning trial precludes the possibility that differential orientations induced on the first trial influenced which stimuli became conditioned on subsequent conditioning trials. In addition, in Experiments 2, 3, and 4, subjects were exposed to both footshock and lithium toxicosis before the test session, although only one of these was paired with the target conditioned stimulus. This procedure minimized the likelihood that, even though equal aversions may have been learned to both conditioned stimuli, differential orientations acting at the test allowed the expression of an aversion to only one of these stimuli. In Experiment 4, Groups Li and Sh were exposed to the same stimuli prior to the test session, and thus should not have differed in their orientations at testing. However, an aversion to the light was seen only in animals that had received footshock paired with the light-saccharin compound (Group Sh), whereas saccharin was avoided only by animals given lithium paired with the light-saccharin compound (Group Li). This result strongly indicates that a nonassociative mechanism is inadequate to account for the selective aversions shown by Groups Li and Sh.

In Experiment 2, there was evidence of a slight

aversion to the saccharin CS in footshock-conditioned rats and a slight aversion to the visual CS in lithium-conditioned subjects. However, Experiments 3 and 4 demonstrated that these were not enduring effects. When subjects were given three exposures to the test chamber following conditioning and the noncontingent US presentation, there was no suggestion that footshock conditioned an aversion to the saccharin CS or that lithium conditioned an aversion to the light stimulus.

Although the present study failed to find evidence that differential orientations of the sort proposed by Rescorla and Holland (1976) mediate the selective association effect, previous research has indicated that such differential orientations may in fact occur. Miller and Domjan (1981) found that the prior administration of lithium enhances the reaction of rats to a novel saccharin solution, but not to a novel auditory or visual stimulus. Conversely, it was found that prior footshock sensitized rats to a novel auditory or visual stimulus, but not to a novel saccharin solution. However, an important feature of the sensitizing effects of footshock and lithium toxicosis is that they are transient. Footshock-induced sensitization was found to dissipate within a few minutes after footshock administration, and lithium-induced sensitization was shown to last less than 6 h after lithium treatment. All of the previous demonstrations of the cue-consequence specificity effect had used intertrial intervals of at least 24 h (Domjan &

Wilson, 1972; Garcia, McGowan, Ervin, & Koelling, 1968; Garcia & Koelling, 1966). Therefore, it is not likely that the selective sensitization effects observed by Miller and Domjan (1981) contributed to the results of these experiments.

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