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Is Fluid Consumption Necessary for the Formation of Context-Illness Associations? An Evaluation Using Consumption and Blocking Tests

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In two experiments, rats experienced two distinctive contexts, one of which was followed by an injection of lithium chloride and the other not. Half the subjects were allowed to consume water in the lithium-paired context, whereas for the remainder no fluid was made available. In the test phase of Experiment 1 all subjects received access to sucrose solution in the contexts. Those for whom water had been available on conditioning trials showed substantial suppression of sucrose consumption in the target context, relative to the nonpoisoned context. This effect was absent in the subjects that had not received access to water during training. Experiment 2, however, which employed a blocking procedure as the test for the associative strength of the context, found evidence for contextual conditioning in both groups of subjects. We argue that the blocking procedure provides a more accurate assessment of the associative strength acquired by contextual stimuli than does the traditional consumption test and is thus able to reveal the occurrence of context conditioning even in subjects given no access to fluid during training.

Demonstrations that rats can learn to associate contextual stimuli with illness have usually made use of the following procedure. The rats are given a number of trials in which they spend time in a distinctive environment before receiving an injection of some nausea-inducing substance such as lithium chloride (LiCl). During these trials the rats are thirsty and they are permitted to drink (usually a novel fluid, but in some experiments unflavored water). An aversion to the context is then revealed in a subsequent test phase

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in which the subjects will decline to drink a different (and usually familiar) flavored solution when it is presented in the training context (e.g., Best, Brown, & Sowell, 1984; Best, Batson, Meachum, Brown, & Ringer, 1985; Boakes, Westbrook, & Barnes, 1992).

It is well established that, for orthodox flavor-aversion learning, the opportunity to ingest at the time of exposure to the flavor will enhance the size of the aversion formed (e.g., Domjan, 1973; Domjan & Wilson, 1972). But in the case of context-aversion learning a more extreme position has been proposed—that ingestion is *necessary* for the aversion to be formed. According to the account offered by Garcia and his colleagues (e.g., Garcia, 1989; Garcia, Brett, & Rusiniak, 1989), gastric malaise can become associated with exteroceptive cues such as those provided by a context only in special circumstances. Such cues are dealt with by a ''skin-defense'' system and do not normally enter the ''gut-defense'' system that is concerned with taste and nausea. A strict interpretation of this suggestion would imply that context–illness associations will be formed only when the context is experienced along with gustatory stimuli as these serve to ''gate'' the contextual cues into the gut-defense system.

Experimental studies of the role played by gustatory stimuli have demonstrated that context conditioning seems to occur more readily when the rats are permitted to drink a novel flavor, rather than plain water, during the conditioning phase (e.g., Best *et al.*, 1984, Boakes *et al.*, 1992; Mitchell & Heyes, 1996). And it has also been shown that contextual conditioning will occur, to some extent, even when unflavored water is what is made available during conditioning. Thus Boakes *et al.* (1992, Experiment 1) and Mitchell and Heyes (1996, Experiment 1) compared rats given an injection of LiCl after drinking water in the training context with rats allowed to drink water but given no injection. Although not as marked as the effect shown by animals given flavored water during conditioning, animals in the former group showed suppression of consumption on test compared with the noninjected controls. The nature of the potentiation effect produced by the presence of a novel flavor during conditioning has been the subject of much theoretical and experimental attention. What has been little studied, however, is the more fundamental question of whether it is necessary for animals to consume fluid (flavored or not) for context conditioning to occur.

In order to answer this question it is necessary to assess the size of any context aversion acquired by subjects made ill after exposure to a context in which they were not allowed to eat or drink compared to control subjects that are given equivalent experience of the context but are not made ill (or are made ill elsewhere). Few studies have made this comparison and those that have done so have yielded varied results. Puente, Cannon, Best, & Carrell (1988; Experiment 1) found that rats given context-illness pairings were just as ready to consume water in the context as control subjects given unpaired experience of illness and the context (see also Best *et al.*, 1984, Exper-

iment 1). In contrast, Best, Best, & Henggeler (1977), who used a place-preference test of context aversion, found that rats tended to shun a black box associated with poisoning even though they had been given no opportunity to eat or drink in the black box during the conditioning phase (see also Best, Best, & Mickley, 1977; Garcia, Kimeldorf, & Hunt, 1961). And direct observation of the behavior of rats in a poison-associated context has produced results indicating that the context acquires new properties as a result of its pairing with illness; Parker, Hills, and Jensen (1984), for example, found that such a context tended to suppress the extent to which the rats engaged in washing and scratching and to generate an increased frequency of rearing (see also Meachum & Bernstein, 1992). Experiments using the consumption test procedure, therefore, point to the conclusion that it is necessary to allow ingestion during conditioning for a context aversion to form; other test procedures find evidence of context conditioning even in rats not given substances to ingest during conditioning.

In order to investigate this discrepancy we conducted two experiments, both assessing context aversion learning, but using different test procedures. In both experiments, all the subjects experienced two distinctive contexts in the training phase, one of which was associated with an injection of LiCl and one of which was not. Context conditioning would therefore be demonstrated if the reinforced context proved, in the test phase, to be more aversive than the nonreinforced context. For one group of subjects water was available in the reinforced context during training, whereas for a second group it was not. We anticipated, given the results mentioned above, that the animals given water during conditioning would show evidence of an aversion to the reinforced context. Such a result would confirm that our general procedures were indeed capable of generating a context aversion. The question of central interest, however, was whether such an aversion would also be present in the group that did not receive access to water. In Experiment 1 the test phase consisted of a standard consumption test of the sort described above. Our results, to anticipate, confirmed those of previous studies using this procedure. In Experiment 2 we attempted to assess the reliability of the effect demonstrated in Experiment 1 using a version of the blocking effect as the test.

EXPERIMENT 1

In this experiment, we employed a discrimination procedure (see also Mitchell & Heyes, 1996) followed by the consumption test that is commonly used to demonstrate contextual conditioning with illness as the unconditioned stimulus (US). All subjects received exposure to a target context, followed by an injection of LiCl. For half the subjects (Group W), water was made available on the context conditioning sessions, whereas the remaining subjects (Group NW) received no fluid on these sessions. All subjects also received experience with a second, nonpoisoned context in which they were

allowed to consume water before being returned to the home cage. A test phase followed in which the subjects were reexposed to the conditioned context and given access to a novel sucrose solution. The subjects were also tested for their consumption of sucrose in the nonpoisoned context.

It was anticipated that Group W would show suppressed consumption of the sucrose in the conditioned context, relative to the level of consumption seen in the nonpoisoned context. But if it is necessary for animals to drink during the conditioning phase, Group NW can be expected to consume the sucrose readily in both contexts.

Method

Subjects and apparatus. The subjects were 24 male Wistar rats, 90 days old at the start of the experiment and with a mean free-feeding weight of 302 g (range 267–339 g). The animals were maintained on a water deprivation schedule but were allowed continuous access to food throughout the experiment. Calibrated, 50-ml polycarbonate centrifuge tubes equipped with stainless steel ball-bearing tipped spouts were used to present measured amounts of unflavored tap water or a solution of 3.4 % sucrose. Fluid consumption was measured by weighing the tubes before and after fluid presentation and recording to the nearest 0.5 g. The unconditioned stimulus for the conditioning trials was an injection of 0.15 *M* LiCl administered intraperitoneally at 20 ml/kg of body weight.

Two sets of cages, both distinctively different from the home cage, served as the experimental contexts. The first set served as the lithium-paired or conditioned context (context A). These cages measured 47 × 26 × 20 cm and were located in a small room in a separate part of the laboratory from the home cages. The room was dimly illuminated by a 40-W bulb positioned in a corner close to the cages and contained a speaker supplying a background noise with an intensity of 50 db. The walls and floor of the cages were made of transparent plastic and the wire mesh roof included a section through which a drinking spout could be inserted. The floors of the cages were covered with commercially obtained cat litter and a dish containing approximately 3 ml of apple essence was placed nearby so as to provide a distinctive odor cue. A second set of cages served as the no-injection context (context B). These cages measured 42 × 27 × 16 cm and were located in a separate part of the laboratory. The walls and floors of these cages were made of opaque plastic and the roof of wire mesh, and this room was made distinctive by the presence of an intensive background illumination (approximately 75 lux). Noise was provided by the ventilation fans of the soundproof shells of a set of Skinner boxes that were located close to the cages.

Procedure. The initial stages of water deprivation were conducted with subjects housed singly in their home cages. During this period, the rats were allowed access to water in the drinking tubes for two daily 20-min sessions, initiated at 0900 h and 1300 h. Presentations of fluid continued to be given

at these times throughout the experiment. The subjects were assigned to two groups, Group W and Group NW ($n = 12$), matched for individual levels of water consumption.

The next four days constituted the conditioning phase. On each of these days, subjects in Group W were placed in context A at 0900 h where they received access to 20 ml of water for 20 min. They were then removed from the context and immediately given an injection of LiCl before being returned to their home cages. Subjects in Group NW received access to 20 ml of water in the home cage for 20 min before being placed in context A for 20 min where no fluid was available. On removal from the context they received an injection of LiCl before being returned to the home cage. At 1300 h, all subjects were placed in context B where they received access to 20 ml of water for 20 min before being returned to the home cage.

On the day following the final conditioning session, all animals received a 20-ml presentation of sucrose for 20 min in their home cages in order to familiarize them with the flavor and to reduce the effect of neophobia. Supplementary water was given to the subjects in their home cages for 20 min at 1300 h. The next two days constituted the test phase. On each of these days all subjects received the test sessions in which they were given a 20-min presentation of sucrose at 0900 h, first in context A and then in context B.

Results and Discussion

By the end of the water deprivation period, all animals drank all of the water on each of the two daily exposures to the fluid in the home cages. The data from the conditioning phase of the experiment are shown in Fig. 1. From the upper panel, it is clear that animals in Group W showed a decrease in water consumption in the context (A) that was paired with LiCl. The lower panel shows the amount of water drunk in the home cage prior to each context conditioning trial by Group NW. Data were lost for the first of these trials, but it is none the less apparent that there was no marked decline in consumption. An ANOVA (analysis of variance) was conducted on the data for trials 2–4 with group and conditioning day as the factors. The rejection level adopted for this and all subsequent analyses was $p < .05$. This analysis revealed there to be a significant effect of group, $F(1, 22) = 119.28$ and of day, $F(2, 44) = 25.43$, and a significant interaction between these two factors, $F(2, 44) = 6.63$. The mean intake of water in the nonpoisoned context (B) are also displayed in Fig. 1. For both groups these scores are low, presumably as a direct consequence of the effects of the LiCl injection given approximately 4 h previously. There is some sign, however, that Group W was less willing to consume water in context B than was Group NW. An ANOVA conducted on these data revealed a significant effect of group, $F(1, 22) = 21.66$ and of day, $F(3, 66) = 23.4$, but no interaction between these two factors, $F(3, 66) = 2.32$.

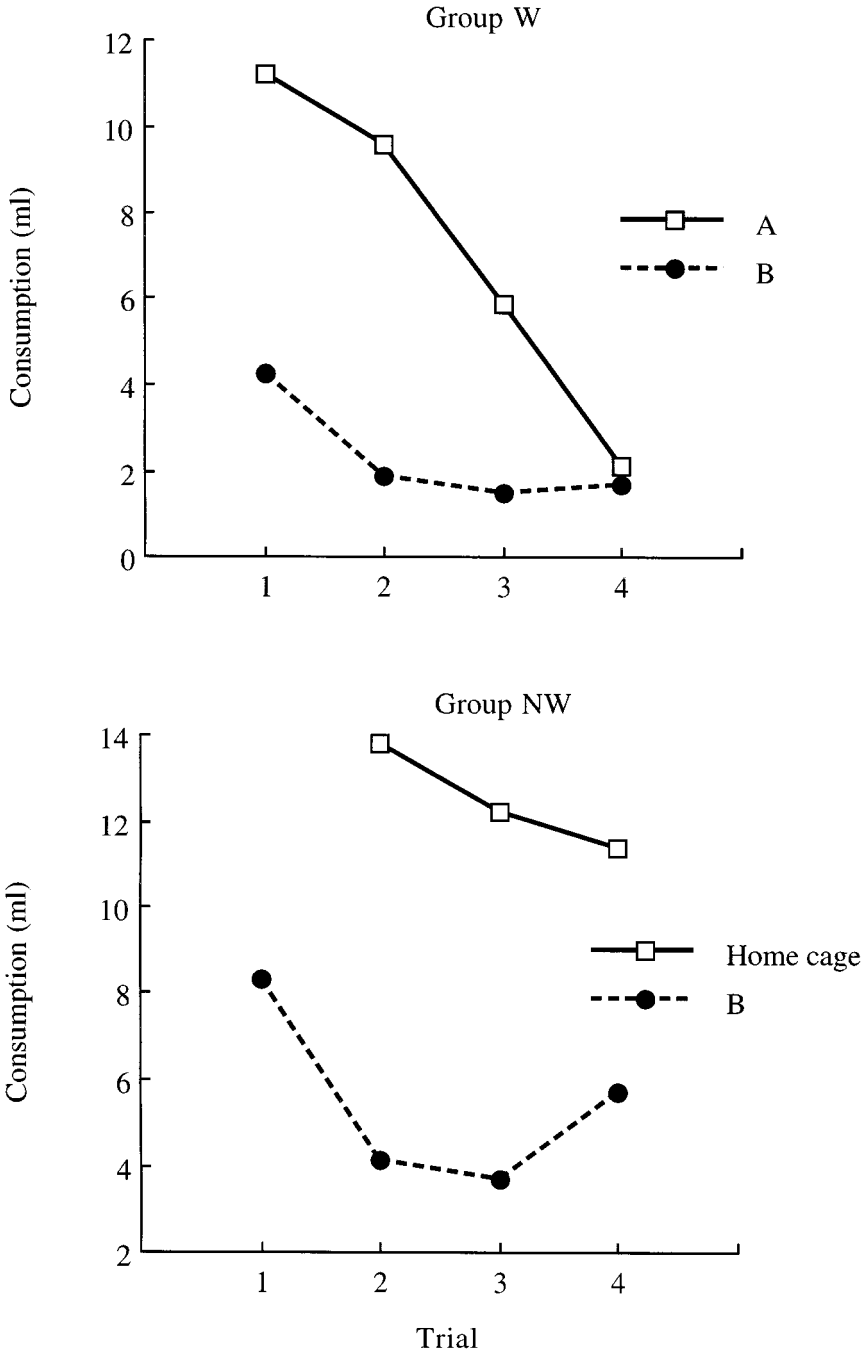
Group W
Consumption (ml)
12
10
8
6
4
2
0
1
2
3
4
A
B
Group NW
Consumption (ml)
14
12
10
8
6
4
2
1
2
3
4
Trial
Home cage
B

FIGURE 1

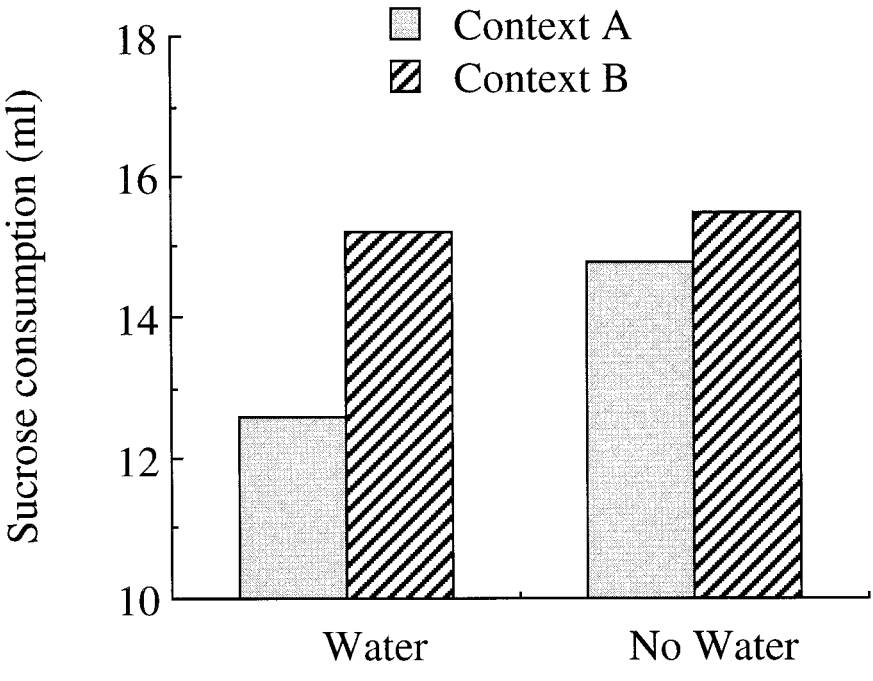

FIGURE 2

The groups also differed in their consumption of the sucrose solution on the first familiarization session in the home cages (Group W: 12.7 ml; Group NW: 15.5 ml), although an ANOVA conducted on these data showed that the difference was only marginally significant, $F(1, 22) = 4.17$; $p = 0.053$. The results of central interest, however, are those of the two sucrose test sessions, displayed in Fig. 2. It is clear from this figure that subjects in Group W consumed substantially less sucrose in context A, the poisoned context, than in context B, the nonpoisoned context. Group NW, on the other hand appeared to consume similar amounts of sucrose in both contexts. An ANOVA conducted on the data shown in the figure, with group and context as the factors, revealed there to be no significant effect of group ($F < 1$), a significant effect of context, $F(1, 22) = 9.36$, and a significant interaction between these two factors, $F(1, 22) = 4.54$. Separate t tests were then conducted on the sucrose intakes for each group in both contexts. These analyses revealed that subjects in Group W drank significantly less sucrose in context A than in context B, $t(11) = 4.04$, and that there was no significant difference between the amounts consumed in these contexts for subjects in Group NW, $t(11) = .61$.

The results for Group W confirm that animals allowed to consume water in a distinctive context prior to an injection of LiCl show an aversion to that context as measured by their reluctance to consume an otherwise palatable substance in that context. Subjects given no water during conditioning (Group NW) showed no context-aversion by this measure. These results are thus consistent with the previous findings of Puente *et al.* (1988) and of Best *et al.* (1984) and with the notion that the ingestion of a fluid during contextual conditioning may be necessary for the context to acquire aversive properties; that is, the opportunity to consume the water during conditioning for Group W may have ''gated'' the contextual cues into the gut-defense system in a way that was not possible for Group NW.

Another interpretation of these data is, however, possible. We have assumed that the suppression of sucrose consumption shown by Group W in the conditioned (A) context provides a measure of the strength of a context–illness association. But we should acknowledge the possibility that this suppression might simply reflect the generalization to the test solution of the aversion that was acquired to water (or to the drinking spouts that were used to present it) during training. The data from the conditioning phase are consistent with this possibility—Group W+ showed a reduction in water consumption over the course of conditioning, an effect that was seen both in context A and, to some extent, in the nonpoisoned context B. This is not to say that the target context acquired no properties as a result of this training procedure. The suppression of consumption on the sucrose test was seen only in context A and not when the sucrose was presented in context B. But it has been demonstrated that aversions acquired to flavors (e.g., Bonardi, Honey, & Hall, 1990) and, for the case we are considering, to water (see Boakes, Westbrook, Elliot, & Swinbourne, 1997; Puente, Cannon, Best, & Carrell, 1988) will show context-specificity so that they emerge in full strength only in the presence of the context in which they were established. In short, the results of this experiment can be explained in terms of the acquisition of a context-dependent aversion to water in Group W that generalizes to the test solution. There is no requirement to assume that any context–illness association is formed at all.

These considerations make it clear that assessing the level of a contextual aversion by means of a simple consumption test is an unsatisfactory procedure (see also Symonds & Hall, 1997). Accordingly, in Experiment 2 we made use of a different procedure for assessing the development of the context–illness association, a procedure that was designed to avoid the confound inherent in the use of the consumption test.

EXPERIMENT 2

Symonds and Hall (1997) reported a series of experiments that made use of a blocking procedure in order to measure contextual conditioning. In the

first phase of training rats received an injection of LiCl after they had consumed water in a target context. In the next phase, they received trials in which they were allowed to consume a novel flavor in their home cages before being placed in the target context. An injection of LiCl followed these trials. In a subsequent test phase in which the flavored solution was presented in the home cage, it was found that this training regime generated only a weak aversion to the test flavor. It was concluded that an association between the context and illness formed in the first phase of training had blocked the acquisition of an aversion to the novel flavor.

Symonds and Hall (1997) argued that this ability of the target context to block further flavor-aversion learning provides a useful measure of contextual conditioning. In particular, the critical test takes place in the absence of the conditioned context, and good learning about the context is indexed by more, rather than less, consumption of a flavor during the test phase—any direct generalization from water present during the conditioning phase could not, therefore, generate the result. We have argued for Experiment 1 that Group W might show suppressed consumption on test when Group NW does not simply because only in the former group is there the possibility of generalization from water. But such a process could not be responsible for the results obtained when context aversion is assessed by means of the blocking procedure and a difference between the groups on this test could thus be unambiguously interpreted in terms of the role played by water consumption during training in controlling the formation of context aversions.

The blocking test procedure has been used a number of times previously as a means of assessing context conditioning (Best *et al.*, 1984; Krane, 1980; Rudy, Iwens, & Best, 1977; Westbrook & Brookes, 1988; Willner, 1978). Only two of these reports, however, include the condition of interest here (that for subjects given no water in the conditioning context) and both of these contain features that make proper interpretation problematic. Rudy *et al.* (1977) found that, for rats given an injection of LiCl in association with confinement in a black box, learning about saccharin was attenuated when the animals were subsequently given experience of the box preceding a saccharin–LiCl trial. It seems unlikely, however, that this result constitutes a genuine blocking effect as it was also found that the pretraining procedure was capable of attenuating the aversion to saccharin even when the black box was not experienced on the saccharin conditioning trial. In an experiment of similar design Krane (1980) also found that the development of a flavor aversion was restricted in animals given exposure to a pretrained context immediately prior to the reinforced trial with the flavor. This result was interpreted as an instance of blocking but unfortunately the relevant control condition (subjects given compound conditioning in the absence of pretraining with the context) was not included; it is not possible to be confident, therefore, that the restricted development of an aversion to the flavor was indeed a consequence of the acquisition of associative strength by contextual cues.

TABLE 1
Design: Experiment 2

Group	Phase 1	Phase 2 (HC)	Test (HC)
E-W	A(W) → Li	Suc → A → Li	Suc
	&		
C-W	B(W) → 0	Suc → B → Li	Suc
E-NW	A → Li	Suc → A → Li	Suc
	&		
C-NW	B → 0	Suc → B → Li	Suc

Note. E and C are Experimental and Control groups; A and B designate distinctive contexts, different from each other and from the home cage (HC); Suc refers to a sucrose solution (presented in the home cage); Li indicates an injection of lithium chloride. Phase 1 consisted of four trials in each context; W indicates that water was available and NW indicates that no water was available in the Phase 1 contexts. Phase 2 comprised two trials.

The design of Experiment 2 was intended to avoid these problems and is summarized in Table 1. All subjects received Phase 1 training in which the experience of a distinctive context (A) was followed by an injection of LiCl. In addition, the subjects received no-injection trials in which they experienced a second context (B) before being returned to the home cage. Half the subjects (the water, W, groups) were given the opportunity to consume water in both the illness-paired and no-injection contexts; for the remainder (the NW, no water, groups) no fluids were made available during this phase of training. In the blocking phase (Phase 2), the experimental groups (Groups E-W and E-NW) were assessed for the extent to which context A would block the acquisition of an aversion to sucrose by presenting that context immediately after the animals had been given access to sucrose and immediately before an injection of LiCl. For the control groups (Groups C-W and C-NW) the context B was presented after the target flavor on the compound conditioning trials. It was anticipated, on the basis of the results reported by Symonds and Hall (1997) that subjects in Group E-W would acquire a weaker aversion to the sucrose than Group C-W, as only the illness-paired context should be able to block conditioning to sucrose. But if the opportunity to consume water in the target context is necessary for contextual conditioning, then Groups E-NW and C-NW should not differ and both groups should readily acquire the aversion to sucrose.

Method

The subjects were 32 male hooded Lister rats with a mean free-feeding weight of 449 g (range: 410–500 g). They had previously served as subjects in an appetitive conditioning experiment but were naive to all aspects of the current stimuli and procedures.

The procedures employed followed those described by Symonds and Hall (1997). Two sets of cages, both distinctively different from the home cage,

served as the experimental contexts. The first set of cages, made of transparent plastic, was located in a small room dimly lit by a single 60-W red lamp. A speaker supplied a constant background white noise, with an intensity of 75 db measured next to the cages. The floor of the cages was covered with commercially obtained cat litter. The cages in the second set were larger, measuring 42 × 35 × 16 cm, and were located in a brightly lit colony room situated in a separate part of the laboratory. The walls and floor of the cage were made of translucent white plastic and the wire mesh roof included a section through which a drinking spout could be inserted. The tubes and drinking spouts used to present the fluids were the same as those described for the previous experiment.

After an initial period of water deprivation, the subjects were assigned to four groups, E-W, C-W, E-NW, and C-NW, matched for baseline levels of water consumption. The next eight days constituted the conditioning phase. On day 1, all subjects were put into the conditioning context for 30 min at 1200 h. During this time, subjects in group E-W and C-W received access to 10 ml of water. For the remaining subjects (groups E-NW and C-NW),no water was available. All subjects were then removed from the context and given an injection of LiCl (.15 M, 10 ml/kg) before being returned to the standard housing racks. On the same day, the subjects were allowed, in the home cage, 30 min of free access to water in the standard bottles at 1700 h. On day 2, the subjects were placed in the no-injection context at 1200 h and again received either water or nothing, according to their group assignment. The subjects were then returned to the standard home cages, no injection having been given. Upon returning to the home cage, the subjects who had not received water in the no-injection context received access to water for 10 min in the standard bottles. Again, all subjects were given free access to water in the home cage at 1700 h. This two-day cycle was then repeated an additional three times. Whether the large or small cages served as the conditioning or no-injection context was counterbalanced.

Following the procedure used by Symonds and Hall (1997), context conditioning was followed by a six-day recovery phase spent in the home cages. All subjects were given access to water, presented in the drinking tubes, for 30 min at 1200 h each day. Supplementary water continued to be provided from the standard drinking bottles for 30 min at 1700 h each day.

There followed two blocking trials. On each, the subjects received access to 10 ml of a 10% sucrose solution for 15 min in the home cage. They were then transferred to one of the experimental contexts (the illness-paired context for the E groups and the no-injection context for the C groups) for 30 min, after which they were removed, given an injection of LiCl, and then returned to their home cages. Each compound-conditioning day was followed by a recovery day on which the rats remained in their home cages and received access to water for 30 min at 1200 h and 1700 h. Finally, there

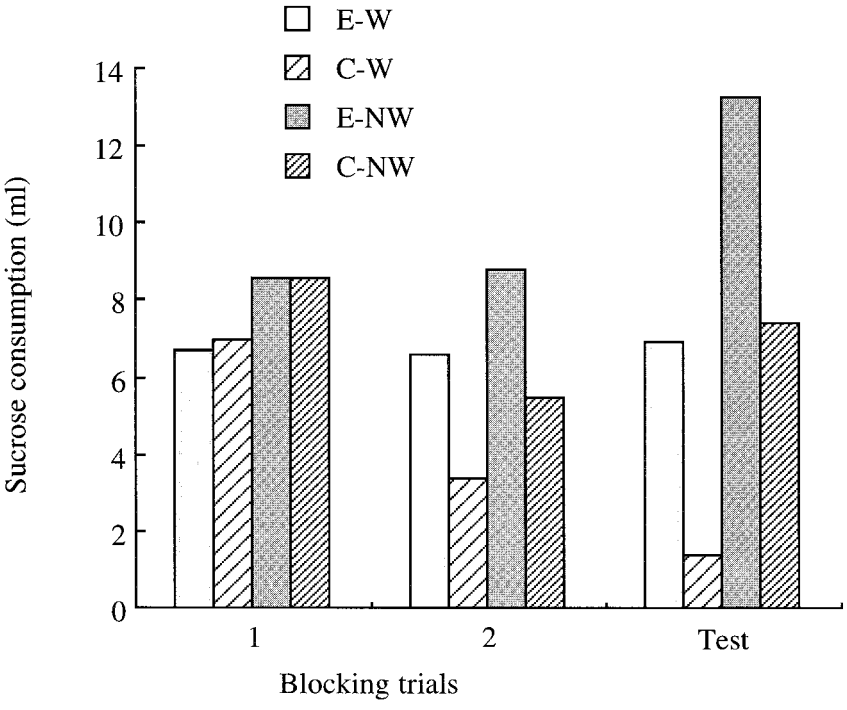

FIGURE 3

was a nonreinforced test in which free access to the sucrose solution was given in the home cage at 1200 h.

Results and Discussion

Over the first three context-conditioning trials, subjects for whom water was made available in the contexts showed little sign of developing an aversion, consuming nearly all of the water offered. On the fourth trial, however, the animals in the W groups showed a reduced level of consumption in both contexts. This effect was context-specific to some extent in that the amount consumed in the illness-associated context (with a group mean of 4.7 ml) was less than that consumed in the other context (group mean: 5.9 ml). These scores differed reliably, $F(1, 15) = 5.7$.

Figure 3 shows the group mean quantities of sucrose consumed in the home cage on each of the two blocking trials and on the test trial. It is clear that on all these trials the animals given water during context conditioning tended to drink somewhat less than those that did not receive water, an effect consistent with the possibility that an aversion to water (or to the drinking

tubes in which it was presented) generalizes to the sucrose presented in this stage. The critical comparison, however, is between the E and C groups. These did not differ on the first trial (i.e., before the first LiCl injection of this stage), but thereafter the C groups drank substantially less than the E groups. This was true both for the W groups and for the NW groups. A factorial ANOVA was conducted on the data summarized in the figure, with water (W or NW), context (E or C context), and trial as the factors. This confirmed the reliability of the effects just described. There was no main effect of trial, $F(2, 56) = 2.60$, but there were significant main effects of whether water was present on the conditioning trials, $F(1, 28) = 19.6$, and of which context was presented on the blocking trials, $F(1, 28) = 14.8$. The only significant interactions were for Water $\times$ Trial, $F(2, 56) = 5.67$, and for Context $\times$ Trial, $F(2, 56) = 8.40$; for the other interactions, Fs > 1.

The results for groups E-W and C-W replicate the finding of Symonds and Hall (1997) that context–LiCl pairings allow the context to block the subsequent acquisition of an aversion to a novel flavor (sucrose) that is conditioned in compound with the target context. The results of central interest, however, are those from groups E-NW and C-NW. These subjects received formally equivalent training to groups E-W and C-W, except that they were not allowed to consume water in the training contexts. In contrast to the results of Experiment 1, this manipulation made no difference to the outcome; that is, subjects in Group E-NW acquired the aversion to sucrose less readily than those in Group C-NW, thus indicating that animals can learn the association between a context and illness even when they are not afforded the opportunity to consume water in the target context. The difference between the W and NW groups in their absolute levels of consumption on the blocking and test trials makes it difficult to compare the size of the difference between the two pairs of E and C groups, but there is nothing in the results presented in Fig. 3 to indicate that the blocking effect was any less substantial in the NW condition than in the W condition.

GENERAL DISCUSSION

The experiments described above attempted to determine whether the formation of an association between an environmental context with an illness critically depends on subjects having the opportunity to consume a fluid (in this case, water) in the trained context. We made use of two different measures of contextual conditioning, and these gave apparently discrepant results. In Experiment 1, we found, in line with the results of previous experiments that have used this consumption test measure, that subjects not given access to water during the conditioning trials consumed a sucrose solution in the illness-associated context no less readily than in a control context (those given water during conditioning showed a context-specific suppression of sucrose consumption). By this suppression-of-consumption measure, therefore, it appears to be necessary for water to be available during context

conditioning. In Experiment 2, on the other hand, we found that the illness-associated context was able to block the acquisition of a conditioned flavor aversion whether the subjects had received access to water during context conditioning or not. The results of this experiment thus accord with those of experiments using place-preference tests or direct behavioral observation to assess context conditioning.

Our suggested resolution of this discrepancy is as follows. An injection of LiCl following exposure to a distinctive context will establish a context–illness association whether water is available in that context or not. The existence of such an association will be evident on place-preference tests and in direct observation of behavior; it will also allow the context to block the formation of further associations that employ illness as the reinforcer (the results of Experiment 2). It will not, however, mean that the consumption of palatable substances in that context will necessarily be suppressed. The results of Experiment 1 are thus not to be interpreted in terms of the effects of the context–illness association (which will be formed in both groups). Rather, we suggest that the suppressed consumption shown on test by the group given water during conditioning reflects the generalization of an aversion formed to water during conditioning. The fact that this aversion is evident only in the pretrained context is entirely consistent with the findings of previous studies demonstrating that conditioned aversions tend to be context-dependent even in the absence of a direct context-illness association (e.g., Boakes *et al.,* 1997; Bonardi *et al.,* 1990; Puente *et al.,* 1988).

This interpretation of our results has implications for the study of context–illness associations more generally. First it casts doubt on the suggestion that such aversions operate by special rules, different from those that govern the formation of orthodox classically conditioned associations. In particular, there is no reason, given these results, to suppose that contextual cues can gain access to a separate ''gut-defense system'' only in special circumstances. The pairing of contextual cues with illness appears to be enough for the association to be formed. Next, it requires us to reconsider the evidence that has led to the proposal that the presence of a novel or salient flavor during contextual conditioning will potentiate the formation of a context–illness association. We have argued that the suppression-of-consumption test (as employed in Experiment 1) is an unsatisfactory way of demonstrating a context aversion, given the likelihood of generalization between the fluids presented during the conditioning and test phases. It should be noted that most demonstrations of the potentiation effect make use of this test procedure.

This is not to deny the possible reality of potentiation effects. Given the evidence from other training procedures, there is reason to suppose that, under some circumstances, the presence of one cue may potentiate learning about another cue with which it is presented at the time of conditioning (e.g, Durlach & Rescorla, 1980). And some theories of potentiation might predict

that a novel, salient flavor cue would potentiate learning about a context for reasons that do not require an explanation in terms of the ''gating'' mechanism postulated by Garcia and his colleagues (see LoLordo & Droungas, 1989, for a review). But our results clearly suggest that, whatever may be true of these other cases, the phenomenon of taste–context potentiation should be reexamined, using a less questionable measure of contextual learning. One candidate for such a procedure would be the blocking design that we presented in Experiment 2.

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