Bulletin of the Psychonomic Society
1987, 25 (2), 124-125

Within-compound associations between taste and contextual stimuli

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When rats are presented with a compound conditioned stimulus (CS) made up of two taste elements, they are able to form a within-compound association between the individual elements of the CS compound. The present experiment demonstrates that when a taste stimulus is presented in a distinctive context, subjects are able to form a within-compound association between taste and contextual stimuli. These data suggest that within-compound learning represents a general process by which subjects are able to associate stimuli from a variety of modalities. Implications of these data for explanations of taste-potentiated contextual aversions are discussed.

Contemporary theories of Pavlovian conditioning suggest that when a compound conditioned stimulus (CS) comprising two elements is paired with an unconditioned stimulus (US), the elements of the CS compete for associative strength (Rescorla & Wagner, 1972). Recent evidence suggests that the individual CS elements not only compete for association with the US, but that associations may also be formed between the individual elements of the CS compound.

The initial demonstration of these within-compound associations was provided by Rescorla and Cunningham (1978), using two taste stimuli. In their experiment, subjects were given a taste compound made up of two elements (i.e., sucrose and quinine). Following exposures to this taste compound, one of the elements (i.e., quinine) was paired with LiCl. Subjects were then given an opportunity to consume the unpoisoned element. A decrease in consumption of the unpoisoned element, relative to consumption of appropriate controls, provided evidence that a within-compound association was formed between the two elements. However, it has not been demonstrated that a within-compound association can be formed between gustatory and contextual stimuli. Therefore, in the following experiment, contextual cues were substituted for the unpoisoned taste element in order to assess cross-modal within-compound learning.

METHOD

Subjects

Subjects were 18 Sprague-Dawley male albino rats weighing 300-400 g. They were individually housed in a temperature/humidity-controlled colony room. All testing was conducted during the light phase of a 14 h:10 h light:dark cycle. Purina Rat Chow was available in the home cage throughout the experiment.

This research was supported in part by NIH grant NS21655. The authors would like to thank A. J. Nonneman for his helpful comments on an earlier version of the manuscript. Reprint requests should be sent to James S. Miller, 115 Kastle Hall, University of Kentucky, Lexington, KY 40506-0044.

Apparatus

Flavor preexposure and testing for place aversion was conducted in a rectangular chamber with three compartments separated by guillotine doors. The two end compartments measured 22×26×30 cm. One end compartment had white walls, and sawdust was beneath the wire-mesh floor. The other end compartment had black walls, and cedar chips were beneath the metal grid floor. Additionally, a 100-ml drinking tube could be mounted inside each end compartment. The middle chamber, which measured 22×14×30 cm, had gray walls and a solid wood floor that was also gray. The taste stimulus was a .06% (w/v) sodium saccharin solution.

Procedure

To establish a stable drinking baseline, on Days 1-6 we gave subjects 10 min access to water in a row of cages located above the animals' home cages. Beginning on Day 7, subjects were given 10 min access to the .06% saccharin solution in the white chamber, once every other day. On alternate days, subjects were given 10 min access to water in the black chamber. This treatment continued until all subjects received four exposures to each chamber in a counterbalanced order.

Following the final exposure, subjects were conditioned in the row of cages located above the animals' home cages. On Days 15 and 17, subjects were given 10 min access to the saccharin solution. Immedi-

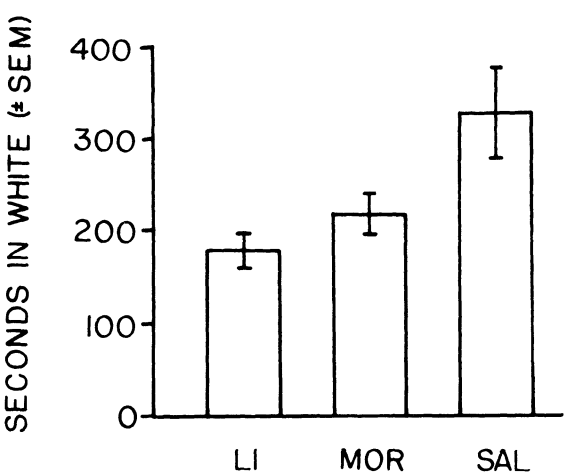

Figure 1. Mean time spent in the white chamber by subjects given pairings of saccharin with lithium (LI), morphine (MOR), or saline (SAL).

ately following this saccharin exposure, the subjects (n=6/group) received an injection of morphine (10 mg/kg, sc), lithium carbonate (100 mg/kg, ip), or saline. On Days 16 and 18, subjects were given 10 min access to water in the drinking cages to allow for recovery from conditioning treatments. On Day 19, to assess within-compound learning, we placed each animal in the gray middle chamber of the place-conditioning apparatus with the guillotine doors open. An observer who was unaware of the animals' individual treatment recorded the total duration each animal spent in each compartment during a 15-min test period. No liquid was present in the chambers during the test period. A decrease in time spent in the white chamber by subjects receiving either morphine or lithium relative to saline control subjects would provide evidence that a taste-context within-compound association had been formed. Since the animals never received a direct pairing of the context and US, place aversions would necessarily be mediated by an association of the context with the now aversive taste cue. Additionally, the magnitude of the reduction in time spent in the white chamber should be related to the strength of the acquired taste aversion in each group. Therefore, on Day 20, all subjects were given 10 min access to saccharin in the row of drinking cages so that we could assess the degree of conditioned taste aversion in each group.

RESULTS AND DISCUSSION

The context preference data are presented in Figure 1. Subjects in the morphine group (MOR) spent less time in the white chamber during the preference test than did subjects in the saline-injected control group (SAL) [$t(10) = 2.00, p < .05$]. Similarly, subjects in the lithium group (LI) spent significantly less time in the white chamber on the test day than did those in the control group [$t(10) = 2.78, p < .01$], also demonstrating within-compound learning. This demonstration of conditioned place aversion, despite the fact that the white chamber was never paired directly with a US, indicates that animals are able to form within-compound associations between a taste cue and the context in which it is presented.

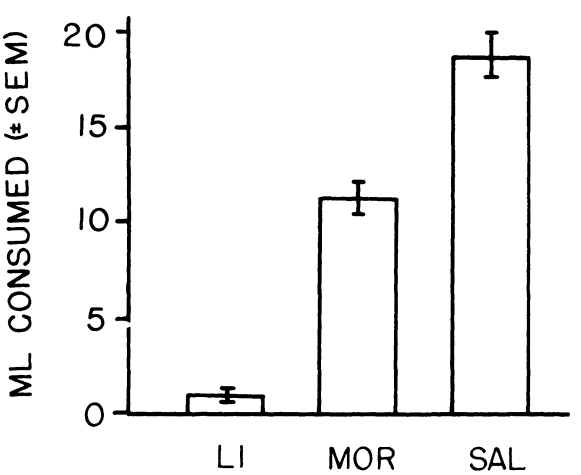

Figure 2. Mean milliliters of saccharin consumed by subjects given pairings of saccharin with lithium (LI), morhine (MOR), or saline (SAL).

Analysis of saccharin consumption (Figure 2) on the test day indicates that subjects injected with morphine consumed significantly less of the saccharin solution than did saline controls [$t(10) = 5.34, p < .01$]. Subjects injected with lithium also consumed significantly less saccharin than did the controls [$t(10) = 15.85, p < .01$]. Thus, an acquired taste aversion was evident in both morphine- and lithium-injected subjects. Furthermore, the strength of aversion to contextual and taste cues appeared to be related. That is, subjects in the LI group acquired the strongest saccharin aversion and also spent the least time in the white chamber. In contrast, subjects in the MOR group acquired a weaker taste aversion and spent an amount of time in the white chamber that was intermediate between that of subjects in the LI and SAL groups.

These data suggest that within-compound learning represents a general process by which subjects are able to associate stimuli from a variety of modalities. Within-compound taste-context associations are of additional importance because they seem to provide the basis for the phenomenon of taste-potentiated contextual aversions. In the potentiation situation subjects given access to saccharin in a lithium-associated context acquire a strong contextual aversion, whereas subjects receiving only water in the lithium-paired context show no contextual aversion (Best, Batson, Meachum, Brown, & Ringer, 1985; Miller, McCoy, Kelly, & Bardo, 1986). Additionally, Best et al. (1985, Experiment 4) demonstrated that postconditioning extinction of the taste aversion prior to testing eliminated the potentiated contextual aversion. Thus taste-potentiated contextual aversions are dependent on a within-compound association between the context and an *aversive* taste cue. Given the relative difficulty of forming an association between external cues and an illness-inducing US, these within-compound associations provide a mechanism by which animals may learn to avoid a location in which an illness-associated taste has previously been experienced.

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(Manuscript received for publication October 6, 1986.)