Bulletin of the Psychonomic Society
1991, 29 (2), 133-135

Comparing the magnitudes of second-order conditioning and sensory preconditioning effects

ROBERT C. BARNET, NICHOLAS J. GRAHAME, and RALPH R. MILLER
State University of New York, Binghamton, New York

Water-deprived rats served in a conditioned lick-suppression experiment designed to test the hypothesis that second-order conditioning is more robust than sensory preconditioning with equivalent parameters. The second-order and sensory preconditioning paradigms are identical except for the ordering of Phase 1 and Phase 2. In second-order conditioning, S1 immediately precedes the US during Phase 1 (i.e., S1→US), and S2 immediately precedes S1 during Phase 2 (i.e., S2→S1). In sensory preconditioning, these phases are reversed, such that S2 precedes S1 during Phase 1 (i.e., S2→S1) and S1 precedes the US during Phase 2 (i.e., S1→US). Thus, in second-order conditioning, S1 becomes excitatory prior to S2-S1 pairings. This would suggest a positive bias toward attending to S1 during S2-S1 pairings in second-order conditioning but not in sensory preconditioning, a condition that might render second-order conditioning more effective. The results indicated the presence of both second-order conditioning and sensory preconditioning effects, but they did not support the hypothesis that second-order conditioning is a more robust conditioning phenomenon than sensory preconditioning.

Both second-order conditioning (see, e.g., Holland & Rescorla, 1975; Leyland, 1977; Rashotte, Griffin, & Sisk, 1977; Rizley & Rescorla, 1972) and sensory preconditioning (see, e.g., Brogden, 1939; Pfautz, Donegan, & Wagner, 1978; Prewit, 1967; Rizley & Rescorla, 1972) are now well established, and they have been investigated extensively. In the typical procedure for establishing either second-order conditioning or sensory preconditioning, animals are exposed to two successive training phases followed by a test phase. During Phase 1 training of second-order conditioning, an initially neutral stimulus event, such as a tone (S1), is forward-paired with the unconditioned stimulus (US). During Phase 2 training, a different neutral stimulus, such as a click (S2), is forward-paired with S1. Finally, during the test phase, S2 is presented alone, and second-order conditioning is observed when the magnitude of conditioned responding to S2 is large relative to responding to S2 seen in control groups (e.g., groups for which S2 and S1 are presented in an unpaired manner during Phase 2, and/or S1 and US are presented in an unpaired manner during Phase 1).

The typical procedure with which sensory preconditioning is established and assessed is identical to that of second-order conditioning, with one important exception. In sensory preconditioning, the S2-S1 pairings occur during Phase 1, and the S1-US pairings occur during Phase 2. Thus, these two paradigms are identical, apart from the ordering of Phase 1 and Phase 2.

Despite the similarities in procedure and in assessment of these two conditioning phenomena, very few investigators have compared the magnitudes of second-order and sensory preconditioning effects within a single report (e.g., Rizley & Rescorla, 1972). One rationale for such a comparison emerges from the possibility that, relative to sensory preconditioning, second-order conditioning is inherently more robust. In second-order conditioning, the pairing of S2 with S1 is antedated by the establishment of S1 as a conditioned excitatory stimulus. Because excitatory stimuli may command more attention than otherwise similar but neutral stimuli, S1 may command more attention during Phase 2 of second-order conditioning than it does during Phase 1 of sensory preconditioning.

In support of this possibility, Rizley and Rescorla (1972) reported that, in a series of conditioned barpress suppression experiments with rats, the magnitude of conditioned suppression to S2 was much less in sensory preconditioning (Experiment 4) than it was in second-order conditioning (Experiment 1). However, in this report, second-order conditioning was assessed according to the ability of nonreinforced presentations of S2 following training to suppress ongoing barpressing. In contrast, sensory preconditioning was assessed according to the rate of acquisition of conditioned barpress suppression in response to S2 following training with reinforced presentations of S2 (i.e., a savings procedure). Although these findings are suggestive, the relative magnitudes of these conditioning effects remain unclear in the absence of identical assessment techniques. To our knowledge, there have been no published reports of experiments in which identical assessment techniques have been used to investigate the

Support of this research was provided by National Institute of Mental Health Grant 33881 and the SUNY-Binghamton Center for Cognitive and Psycholinguistic Sciences. Thanks are due to Josh Sloat for his assistance in data collection and Steve C. Hallam for his comments on an earlier version of the manuscript. Requests for reprints should be addressed to Ralph R. Miller, Department of Psychology, SUNY-Binghamton, Binghamton, NY 13901.

magnitudes of both second-order and sensory preconditioning effects for the purpose of direct comparison. The present experiment was designed to provide such a comparison through the use of a single measure of conditioned responding—namely, lick suppression with rats.

METHOD

Subjects

The subjects were 24 adult, naive, male and female Sprague-Dawley-descended rats bred in our colony from Holtzman stock (Madison, WI). Body-weight ranges were 280-360 g for males and 180-270 g for females. Subjects were assigned to four treatment groups counterbalanced for sex, litter of origin, body weight, and baseline lick performance prior to differential treatment (ns = 6). All animals were individually housed in hanging wire-mesh cages, in a vivarium that was maintained on a 16:8-h light:dark daily cycle. Experimental manipulations occurred near the midpoint of the light portion of this cycle. Purina Laboratory Chow was freely available in the home cages. One week prior to the initiation of the study, all subjects were progressively deprived of water, and by Day 1 of the study they were limited to 10 min per day of home-cage access to water provided 18-22 h prior to any treatment scheduled for the following day. All subjects were handled thrice weekly for 30 sec, from weaning at 22 days of age until the initiation of the study.

Apparatus

The experiment was conducted in 12 identical enclosures. These were rectangular boxes that measured 24.1 × 12.7 × 20 cm (length × width × height), each of which was housed in its own environmental isolation chest. Three of the walls of the enclosures were made of white Plexiglas, and the ceiling and remaining sidewall were made of clear Plexiglas. There was no illumination in the enclosures. The chamber floors consisted of stainless steel rods, 0.5 cm in diameter and 1.3 cm center to center, interconnected with NE-2 neon bulbs that permitted administration of constant-current footshock. The enclosures were each equipped with a water-filled lick tube that extended 1 cm into a cylindrical niche that was 4.5 cm in diameter, left-right centered with its bottom 1.75 cm above the floor of the apparatus, and 5.0 cm deep. An infrared photoemitter and detector were mounted 1 cm in front of the tip of the lick tube, so that an animal had to break the light beam in order to drink. Stimulus S1 was a 5-sec click train (3 clicks/sec) 10 dB(C) above a 70-dB(C) background, and Stimulus S2 was a 5-sec, 1500-Hz tone 12 dB(C) above background. The US was a 0.7-mA footshock of 2.0-sec duration.

Procedure

Adaptation. On Days 1 and 2, all subjects spent 30 min in the training apparatus. No CSs or USs were presented. On this and all subsequent days, latencies to complete the first and second 5 cumulative seconds of licking were recorded.

Phase 1. On Day 3, all subjects spent 1 h in the training apparatus. The second-order conditioning group (Group T+-CT) and its control (Group T+-C/T) both received four pairings of the tone with footshock (T+), with footshock onset corresponding to tone offset. The sensory preconditioning group (Group CT-T+) was exposed to four pairings of the click train with the tone (CT), with tone onset corresponding to click offset. The sensory preconditioning group control (Group C/T-T+) received four tone presentations and four click-train presentations explicitly unpaired (C/T).

Phase 2. On Day 4, all subjects again spent 1 h in the training apparatus. Groups CT-T+ and C/T-T+ received four pairings of the tone and shock (T+) identical to those experienced by Groups T+-CT and T+-C/T on Day 3. Group T+-CT received four click-tone pairings (CT) identical to those received by Group CT-T+ on Day 3. Group T+-C/T received four tone presentations and four click-train presentations explicitly unpaired (C/T) identical to those experienced by Group C/T-T+ on Day 3.

Baseline recovery. On Day 5, each subject was placed in the apparatus for 1 h and permitted to drink ad lib. No nominal stimulus was presented. This was intended to reestablish stable rates of drinking.

Testing. On Day 6, all subjects were tested for suppression of ongoing licking in the presence of the clicks. Upon completion of the first five cumulative seconds of licking, the click train was presented and stayed on until 5 additional seconds of licking were completed.

RESULTS AND DISCUSSION

No difference between groups was found on the adaptation day, the Phase 1 day, the baseline recovery day, or during the first 5 cumulative seconds of licking on Day 6 ($ps > .10$). Mean latencies to complete 5 cumulative seconds of licking in the presence of the clicks (i.e., S2) are shown in Figure 1. The second-order conditioning group (Group T+-CT) and the sensory preconditioning group (Group CT-T+) displayed more suppression in response to the clicks than did the two control groups [$Fs(1,20) = 4.96, ps < .05$], evidencing the presence of second-order and sensory preconditioning effects. There was no statistically reliable difference in suppression in response to the clicks between the second-order conditioning group and the sensory preconditioning group or between the two control groups ($Fs < 1.00$).

At least under the circumstances of the present study, these findings do not support the notion that S1 receives more attention on the S2-S1 trials when it has already been made excitatory than it does prior to its being made excitatory. If differential attention to S1 did occur on the S2-S1 trials in second-order conditioning and sensory preconditioning of the present study, this difference in attention to S1 clearly did not differentially control the magnitude of the second-order conditioning and sensory preconditioning effects observed.

There is reason to believe, however, that procedural variations in the number of S2-S1 trials used here might promote a divergence in the magnitude of second-order conditioning and sensory preconditioning effects. In both types of paradigms, S2-S1 pairings presumably result in the establishment of an association between S2 and S1. Note that these pairings may also have other effects. In

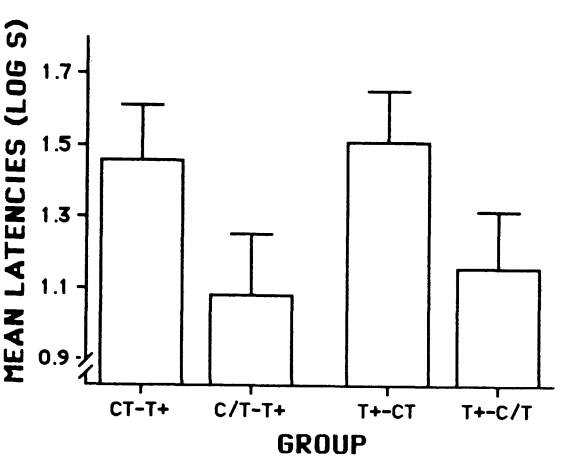

Figure 1. Mean latency to drink from the lick tube for 5 cumulative seconds in the presence of the clicks (S2), as a function of treatment group. Brackets represent standard errors.

the case of second-order conditioning, these pairings may extinguish S1. In the case of sensory preconditioning, these pairings may produce an S1-preconditioning effect (i.e., latent inhibition). Thus, in both cases, increasing the number of S2–S1 pairings should result in a decreased ability of S2 to control behavior. However, equal increases in the number of extinction and latent inhibition trials (i.e., S2–S1 pairings) might not result in the same rate of diminishing stimulus control by S1. It is possible, therefore, that with a different number of S2–S1 pairings, a superiority of either second-order conditioning or sensory preconditioning might have emerged.

REFERENCES

BROGDEN, W. J. (1939). Sensory preconditioning. *Journal of Experimental Psychology*, **25**, 323-332.

HOLLAND, P. C., & RESCORLA, R. A. (1975). Second-order conditioning with food as the unconditioned stimulus. *Journal of Comparative & Physiological Psychology*, **88**, 459-467.

LEYLAND, C. M. (1977). Higher-order autoshaping. *Quarterly Journal of Experimental Psychology*, **29**, 607-619.

PFAUTZ, P. L., DONEGAN, N. H., & WAGNER, A. R. (1978). Sensory preconditioning versus protection from habituation. *Journal of Experimental Psychology: Animal Behavior Processes*, **4**, 286-295.

PREWIT, E. P. (1967). Number of preconditioning trials in sensory preconditioning using CER training. *Journal of Comparative & Physiological Psychology*, **64**, 360-362.

RASHOTTE, M. E., GRIFFIN, R. W., & SISK, C. L. (1977). Second-order conditioning of the pigeon's keypeck. *Animal Learning & Behavior*, **5**, 25-38.

RIZLEY, R. C., & RESCORLA, R. A. (1972). Associations in second-order conditioning and sensory preconditioning. *Journal of Comparative & Physiological Psychology*, **81**, 1-11.

(Manuscript received August 31, 1990.)