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The inhibitory effect of backward conditioning as a function of the number of backward pairings*

SHEPARD SIEGEL†
McMaster University, Hamilton, Ontario L8S 4K1, Canada

and

MICHAEL DOMJAN
University of Texas, Austin, Texas 78712

Independent groups of Ss received classical conditioning acquisition following 0, 5, 10, 25, or 50 preexposures to the conditioning stimuli in a backward-paired manner (the US preceding the CS). In both the conditioned suppression situation with rats and the eyelid conditioning situation with rabbits, backward preexposure retarded acquisition (in agreement with earlier findings). Furthermore, increasing backward-paired experience with the conditioning stimuli was associated with increasingly deleterious effects on acquisition performance. These results are contrary to suggestions that backward-conditioning-induced retardation of subsequent acquisition results only from extensive backward preexposures, with fewer such preexposures producing excitatory effects.

Recently, Siegel and Domjan (1971) reported that backward-paired presentations of a CS and US greatly retarded acquisition of the CR when these stimuli were subsequently presented in a forward-paired manner. Since this retardation of acquisition was more pronounced than that obtained following preexposure to the CS alone, the US alone, or both the CS and US presented in a noncontingent manner, the results suggested that the backward contingency produced inhibitory tendencies in excess of those expected simply on the basis of any nonassociative effects of adaptation to the CS and US.

The inhibitory effects of backward conditioning appear to be a robust phenomenon, having been demonstrated in a variety of conditioning preparations and species: conditioned suppression with rats (Siegel & Domjan, 1971, Experiment 1), eyelid conditioning with rabbits (Siegel & Domjan, 1971, Experiment 2), and conditioned modification of baseline Sidman avoidance behavior with dogs (Moskovitch & LoLordo, 1968).

In contrast with these results, Heth and Rescorla (1973) recently reported that, in rats, excitatory conditioning results from backward conditioning. Their conditioning preparation differed from that used in the earlier investigations in several respects: (1) in contrast with the usual parameters used in classical conditioning, the shock US was longer than the CS (4 sec and 2 sec, respectively), (2) the measure of conditioning was the extent to which the CS acted as a conditioned punisher of a previously trained operant response [in contrast with the anticipatory CR measure of Siegel and Domjan (1971) or the assessment of the degree to which the CS energizes Sidman avoidance performance (Moskovitch & LoLordo, 1968), and (3) relatively few (20) backward pairings were administered prior to assessing the punishing effects of the CS [in contrast with the 120 pairings, used by Moskovitch and LoLordo (1968), and the 50 pairings used in the conditioned suppression situation and 550 pairings used in the eyelid conditioning situation by Siegel and Domjan (1971)].

Although any of the procedural or parametric differences between Heth and Rescorla's (1973) conditioning preparation and those used by the earlier investigators may account for the apparently discrepant results, Heth and Rescorla suggested that the number of backward pairings was important. They proposed that backward conditioning may first produce an excitatory association, with inhibitory effects resulting only after a great number of backward pairings. Thus, earlier demonstrations of the inhibitory properties of the backward-paired CS may have resulted from extensive backward training. Heth and Rescorla's finding that relatively few backward pairings lead to the formation of excitatory associations may "represent preasymptotic values of CSs which would have been inhibitory had more training been given [Heth & Rescorla, 1973, p. 442]."

The purpose of the present investigation was to assess the backward-paired CS after various numbers of backward pairings in an attempt to determine whether the excitatory tendencies observed by Heth and Rescorla may be attributed to preasymptotic backward conditioning.

METHOD

In two experiments, independent groups of Ss received 0, 5, 10, 25, or 50 backward-paired presentations of a CS and a shock US prior to assessing acquisition of a classically conditioned

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†Requests for reprints should be addressed to Shepard Siegel, Department of Psychology, McMaster University, Hamilton, Ontario L8S 4K1, Canada.

response when the CS preceded the US. In the first experiment, the conditioned suppression preparation with rats was used, and in the second experiment the eyelid conditioning preparation with rabbits was used.

Conditioned Suppression Experiment

Subjects and Apparatus. Thirty-nine experimentally naive male albino rats, 200-250 g at the start of the experiment, were trained in Lehigh Valley Skinner boxes (Model 1316). The CS consisted of a 1-min presentation of a 1,400-Hz tone, interrupted four times/sec. Two cue lights pulsated on and off in synchrony with the interrupted tone. The US, a 1.0-mA 0.5-sec scrambled electric shock delivered to the grid floor of the Skinner box, was generated by a Lehigh Valley constant-current shock generator (Model 113-04).

Procedure. The Ss, reduced to 75% of ad lib weight for the experiment, were shaped to press the bar for .045-g food pellets and were weaned to a VI 1-min schedule of reinforcement during two 1-h sessions. The VI 1-min schedule then remained in effect for three additional 1-h preliminary barpress training sessions.

Following preliminary training, Ss received backward conditioning trials with the bar retracted and no food delivered during two daily 6.5-h sessions. The Ss in Group 0 (N = 8) were simply placed in the Skinner boxes during both 6.5-h sessions, receiving neither CS nor US presentations. Ss in Groups 5 (N = 8), 10 (N = 8), and 25 (N = 7) also received neither CS nor US presentations during the first 6.5-h session but received the appropriate number of backward conditioning trials during the second session. Backward conditioning trials, consisting of the shock US presented for the first 0.5 sec of the 1-min CS (as in Siegel & Domjan, 1971), were delivered every 15 min and were scheduled so that the last trial for each group occurred 15 min prior to the end of the second 6.5-h session. Group 50 (N = 8) received 25 backward conditioning trials during each 6.5-h session.

Starting the day following the second 6.5-h session, Ss received conditioned suppression training during three daily 1.5-h sessions, with the bar again extended into the Skinner box and the VI 1-min schedule in effect. Three conditioning trials, consisting of the US presented immediately after the CS, were presented during each acquisition session, the intertrial interval being 30 min.

Eyelid Conditioning Experiment

Subjects and Apparatus. Each of 59 experimentally naive male New Zealand white rabbits, weighing 2-3 kg, was trained in one of six identical sound-attenuated chambers while confined in a restraining box within the chamber. The outer eyelid response was recorded with a modification of the technique described by Gormezano (1966) (see Siegel & Domjan, 1971).

The US, a 100-msec 200-V shock, was delivered through a pair of chronically implanted electrodes, mounted approximately 1 cm apart and 1 cm below the left eye. The CS was a 500-msec 2000-Hz tone at 82 dB above .002 dyne/cm^2.

Procedure. Each S participated in the experiment for four daily 100-min sessions. On Days 1 and 2, Ss were systematically adapted to the restraint and eyelid recording apparatus. The 11 Ss assigned to Group 0 were further restrained in the conditioning apparatus for the first 50 min of the Day 3 session. The 12 Ss in each of Groups 5, 10, 25 amd 50 received the appropriate number of backward conditioning trials during this first half of the Day 3 session. Backward conditioning trials, consisting of the 100-msec US immediately followed by the 500-msec CS, were presented at intervals of 0.5, 1.0, or 1.5 min (average: 1 min), the different intervals presented in a mixed order. For each group, the backward pairings were initiated at different intervals after the start of the Day 3 session so that the last such backward pairing occurred halfway through the session for all Ss.

Following the last US-CS trial (or the 50th min of restraint for Group 0), acquisition started for all Ss; the US was presented immediately upon termination of the CS. Ss received 50 such acquisition trials during the second half of the Day 3 session, and 100 additional acquisition trials on Day 4.

RESULTS

Conditioned Suppression Experiment

During acquisition of conditioned suppression, Ss' performance on each trial was expressed as a "suppression ratio," calculated according to the formula A/(A + B), where A is the number of barpresses during the 1-min period in which the CS was presented, and B is the number of barpresses during the l-min period immediately prior to CS onset. Thus a suppression ratio of 0.50 indicates that the CS has no effect on response rate, and lower ratios indicate increasing amounts of CS-elicited response suppression. The overall mean acquisition suppression ratio for each S provided a measure of acquisition of the conditioned suppression response, the median value of which, for groups given different numbers of backward conditioning trials prior to acquisition, is shown in Fig. 1. As may be seen in Fig. 1, increasing amounts of prior backward conditioning are associated with increasingly retarded acquisition performance. A nonparametric Kruskal-Wallis analysis of variance on suppression ratio data summarized in Fig. 1 indicated that the effect of the number of preacquisition backward pairings was significant ($H = 11.54$, $p < .05$). A Mann-Whitney U-test indicated that the group given the most backward preexposure trials, Group 50, evidenced significantly less conditioned suppression than the group given no backward preexposure ($U = 10$, $p = .02$, two-tailed).

Eyelid Conditioning Experiment

The overall acquisition percent CR of each S was computed, and the median value for groups given various numbers of backward conditioning preexposure trials is shown in Fig. 2. As indicated in Fig. 2, increasing amounts of prior backward conditioning are associated with increasingly poorer acquisition performance. A Kruskal-Wallis analysis of variance indicated that the overall effect of the number of backward preexposure trials approached conventional levels of statistical significance ($H = 8.90$, $.05 < p < .10$). The group given the most extensive backward-paired experience with the CS and US prior to acquisition, Group 50, evidenced significantly fewer acquisition CRs than Group 0 ($U = 28$, $p = .02$, two-tailed).

DISCUSSION

In both the conditioned suppression situation with rat Ss and the eyelid conditioning situation with rabbit Ss, extensive backward-paired presentations of the CS and US retarded subsequent acquisition performance [in agreement with our previous findings (Siegel & Domjan, 1971)]. Examination of the deleterious effects of backward conditioning as a function of the frequency of backward pairings (Figs. 1 and 2) suggests that the relationship is monotonic, with no evidence that some minimal

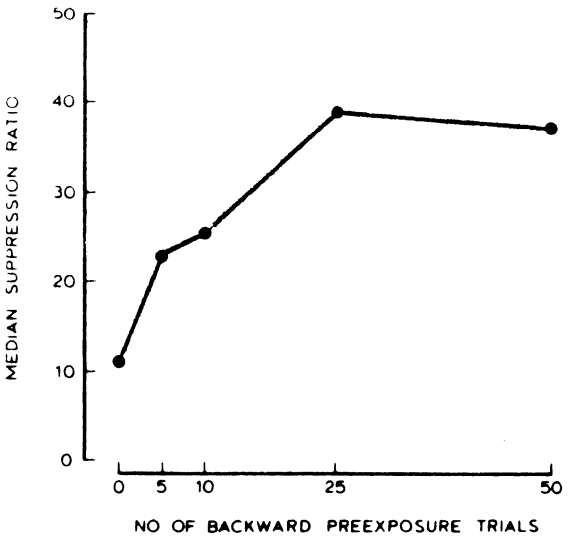

Fig. 1. Median acquisition suppression ratios for groups of rats given various numbers of backward-paired US and CS presentations prior to conditioned suppression acquisition.

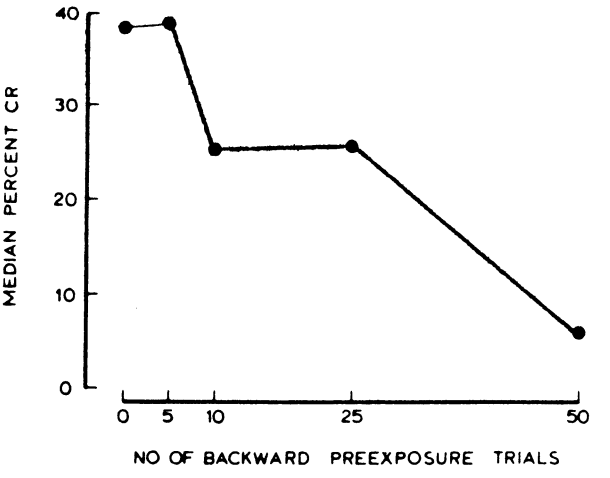

Fig. 2. Median acquisition percent CRs for groups of rabbits given various numbers of backward-paired US and CS presentations prior to eyelid conditioning acquisition.

experience with the conditioning stimuli in a backward-paired manner facilitates acquisition performance.

These results argue against Heth and Rescorla's (1973) suggestion that Siegel and Domjan (1971), although obtaining inhibitory effects with extensive backward training, would have obtained excitatory effects following fewer backward trials. The present results also suggest that the excitatory backward conditioning effects observed by Heth and Rescorla (1973) were probably produced by some factor other than the small number of backward conditioning trials presented.

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Replication: The persistent locomotion of immature rats*

PAUL M. BRONSTEIN† and TERRY DWORKIN
Brooklyn College of the City University of New York, Brooklyn, New York 11210

In both cross-sectional and longitudinal experiments, 15-day-old domesticated rats were shown to locomote persistently in a maze. Thirty-day olds displayed a within-trial decrement in activity typical of adult patterns of ambulation. These data are consistent with the conclusion that 15-day olds may be behaviorally similar to adults with hippocampal lesions.

Recent evidence suggests that the 15-day-old rat is behaviorally similar to the adult following hippocampal lesions (Douglas, 1972). Compared to the animals aged 30 days or older, the 2-week-old rat shows (1) inferior acquisition of a passive-avoidance response (Riccio & Schulenburg, 1969), (2) lower levels of spontaneous alternation (Douglas, Peterson, & Douglas, 1973), and (3) more persistent nose-poking behavior (Feigley, Parsons, Hamilton & Spear, 1972). Bronstein, Neiman, Wolkoff, and Levine (1974), while skeptical about this central-nervous-system-based theory of behavioral development, did extend the known similarities between the juveniles and the lesioned adults. It was shown that the locomotion and rearing behaviors of the 15-day olds did not attenuate in open-field trials of 30 min duration. Animals as little as 6 days older, however, did demonstrate the activity decrements typical of adult rats.

The current investigation is an attempt, first to

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†Reprints: Paul M. Bronstein, Department of Psychology, Brooklyn College of the City University of New York, Brooklyn, New York 11210.