

Higher-order conditioning of fear (CER)¹

JOHN W. DAVENPORT

REGIONAL PRIMATE RESEARCH CENTER, UNIVERSITY OF WISCONSIN

Stable higher-order conditioning of an emotional response was found in a vast majority of rats given an extension of the CER suppression procedure. The phenomenon was demonstrated under a variety of conditions and frequently took the form of total suppression in the presence of a stimulus which had never been paired with shock.

Recently McAllister & McAllister (1964) have demonstrated that fear may be conditioned at the second order in rats tested in a hurdle-jumping situation. Working independently of the McAllisters but sharing their concern over the lack of convincing data on this neglected phenomenon, I have been studying higher-order conditioning of fear in the CER suppression situation. With this technique I have found that second-order conditioning of an emotional response appears in a particularly clear and stable form in rats over a fairly wide range of experimental conditions. In this report I will summarize the general findings of the first four of six higher-order CER conditioning studies conducted in the past three years.²

Method

Standard Gerbrands Model C rat test chambers, controlled by remote automatic programming devices, were used. The Ss were 52 adult male albino rats of the Sprague-Dawley-Holtzman strain.

In accordance with the usual suppression procedures, lever-pressing was maintained on a variable-interval reinforcement schedule on which were superimposed stimulus presentations constituted by the various conditioned stimuli (CSs) and the unconditioned stimulus (UCS). CSs used were a medium-intensity 800-cycle tone generated by a Signal Corps TG-34-A Keyer, a bare type 313 pilot light located above the top lid of the chamber, a 1/sec. pulsating buzzer, and a 6.8/sec. clicking sound produced by a Foringer 1293 Click Generator. The UCS was grid shock, delivered by a Grason-Stadler E1064GS Shock Generator.

Within a given study, experimental and control Ss underwent the same training and testing procedures up to the beginning of the second-order conditioning stage. After stable baselines of pressing were achieved, three to five unpaired test presentations of each of the CSs were given (one per day in many Ss, to rule out sensory preconditioning) as a check on their initial fear-eliciting properties and as a means of adapting out novelty effects. Following these test presentations the first-order conditioning phase was begun, with one of the neutral stimuli (CS₁) paired with the shock UCS, usually with the shock terminating a CS₁ presentation. Shock durations were .5 or 1 sec. and CS₁ durations ranged from 1 to 2 min. Shock intensities ranged from nominal

values of .5 to 3 ma. Sessions in which no stimulus presentations took place were frequently interspersed among first-order conditioning sessions to keep the rate of lever pressing near that of preshock days. Following the CS₁-UCS trials, additional sessions were devoted to testing for reinstated novelty effects and for stimulus generalization of the first-order conditioning to CS₂ and CS₃ (presented alone); in most cases only very slight or nonexistent suppression tendencies were found on these test trials.

The second-order conditioning trials were given to the experimental Ss in paired presentations with the onset of CS₂ preceding the onset of CS₁ and with the shock omitted. Control Ss received equal numbers and durations of presentations of the same stimuli, but in a backward order 2 to 12 min. apart. The CS₂-CS₁ temporal arrangements in second-order conditioning included pairings in which the two stimuli were overlapping (60-30-30 and 60-45-15) and nonoverlapping (30-30-30, 60-60-30, and 90-90-10), where the numbers in each of these designations refer to the duration in seconds of CS₂, the time between the onsets of CS₂ and CS₁, and the CS₁ duration, respectively. Most of the possible combinations of the four neutral stimuli were represented in the CS₂-CS₁ presentations and the scheduling of trials varied from one trial per daily 20-min. session to 12 trials per 80-min. session.

Measures of suppression were based on the number (f_d) of lever responses occurring during a stimulus presentation in relation to the number (f_p) occurring in the immediately preceding baseline period of equal duration. The suppression ratio was defined as $f_d/(f_d + f_p)$.

Results

Second-order conditioning was readily obtained in all four studies. Of 36 rats given the experimental procedure, 32 displayed second-order conditioning in the form of at least partial and consistent suppression in the presence of CS₂ alone, a stimulus which had never been paired with shock. Of these conditioned animals, 13 showed complete suppression to CS₂ on at least two trials and usually for many consecutive trials. In contrast, none of the 16 control Ss exhibited even partial suppression consistently, and it was typical of the controls to show a small increase in their suppression ratios from the starting level of about .5. In addition, when eight control rats were given paired CS₂-CS₁ or CS₃-CS₁ trials following this performance on unpaired trials, six of them showed clearcut evidence of second-order conditioning, bringing the record to 38 successes and 6 failures in 44 second-order conditioning attempts. Two of four Ss in which third-order conditioning was

attempted showed partial suppression having enough consistency to warrant the conclusion that third-order conditioning is attainable in this situation.

Representative individual curves of experimental and control performance are shown in Fig. 1. These curves were taken from an experiment in which the 90-90-10 temporal arrangement was employed in the second- and third-order stages and trials were given at the rate of one per day. The curves are representative in showing: (a) the basic difference between experimental and control Ss in the second-order phase, (b) the results of two attempts at third-order conditioning, (c) the rapidity with which second-order conditioning may be obtained with an auditory CS₁, and (d) the relative difficulty of obtaining higher-order conditioning when the second-occurring CS is a visual stimulus (all but one of the second- and third-order failures had a light as the second-occurring stimulus). The high resistance to extinction of the fear to CS₁ revealed in all six panels is typical of one-trial-per-day and four-trial-per-day studies.

The typical form of the suppression pattern in instances of highly successful second-order conditioning may be seen in Fig. 2, which shows the cumulative lever response records for the first eight CS₂-CS₁ trials of a single S. In indicating that lever responses tend to drop out in the earliest portion of the CS₂ presentation first, this S's record was characteristic of about three-fourths of the second-order conditioned Ss.

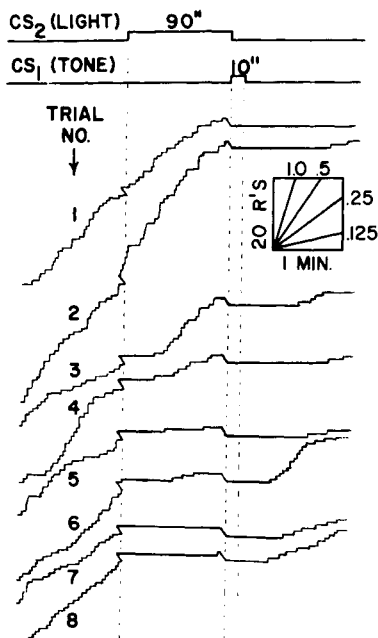


Fig. 2. Cumulative response records obtained on the first 8 second-order conditioning trials given to a single S in 8 successive daily sessions.

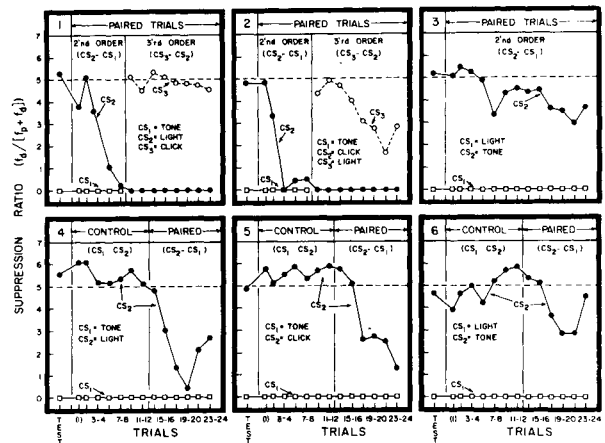


Fig. 1. Performance curves of 6 Ss showing conditioning of suppression at the second-order ("paired" phases of all 6 panels) and at the third-order (panel 2, failure of attempt in panel 1), and typical control performance ("control" phases, panels 4-6).

In general, second-order conditioning showed the greatest stability and strength when first-order shock intensity was high, CS₂ duration in the second-order stage was long in relation to CS₁ duration, CS₁ was an auditory stimulus, and conditioning trials were widely distributed. In view of the suggestion in McAllister & McAllister's (1964) footnote that the demonstration of second-order conditioning in the hurdling-jumping situation may be difficult to obtain unless first- and second-order trials are intermixed and criterion testing is done immediately after the intermixed trials, the present finding of stable conditioning on a one-trial-per-day regimen involving no intermixture offers considerable comfort to those who believe in the authenticity and importance of this phenomenon.

Reference

McAllister, D. E., & McAllister, W. R. Second-order conditioning of fear. *Psychon. Sci.*, 1964, 1, 383-384.

Notes

- Supported by grant G-13265 from the National Science Foundation and grants M-4991 and FR-0167 from the National Institutes of Health.
- Following the four successful demonstrational studies summarized here, I found little or no second-order suppression in the 24 Ss of the fifth study. Though other procedural differences may have been responsible, this anomaly seems to have been due to excessive exposure to the CS₂ when presented alone in pretests prior to the first-order stage and in generalization tests between the first- and second-order stages—there were approximately six times as many test presentations as in the studies reported here. The second-order conditioning phenomenon was recaptured in a sixth study, in which the number of test presentations was returned to the necessary minimum.