Second-order conditioning of fear¹

Dorothy E. McAllister and Wallace R. McAllister
SYRACUSE UNIVERSITY

Abstract

First-order classical fear conditioning trials (tone paired with shock) were interspersed with second-order classical conditioning trials (light paired with the tone). Subsequently, Ss (rats) learned to escape the light by jumping a hurdle. Comparison of this performance with that of two control groups allowed the conclusion that fear was conditioned at the second order.

Problem

Pavlov (1927, p. 33f) reported that a salivary response conditioned originally to an auditory stimulus (through pairing with food) could be elicited by a visual stimulus following the pairing of the visual and auditory stimuli. Subsequently, several instances of such second-order conditioning have been reported from American laboratories (Brogden, 1939; Brogden & Culler, 1935; Eccher & Culler, 1941; Finch & Culler, 1934; Murphy & Miller, 1957). These studies, however, seem to be subject to criticism on one or more methodological grounds; e.g., failure to control adequately for sensitization, pseudo-conditioning, and conditioning to environmental cues, or introduction of extraneous rewarding or punishing stimuli during the higher-order phase. Thus, alternative explanations of the results of these studies cannot be ruled out. Despite this lack of convincing evidence, the phenomenon seems to be widely accepted. The present research was designed to demonstrate second-order conditioning clearly by including appropriate control conditions.² Fear, the response conditioned, was measured through its influence on the learning of another response.

Method

So that Ss could be conditioned in pairs, two identical hurdle-jumping apparatus, wired in parallel, were used. Each consisted of a white grid (conditioning) box and a gray safe box, separated by a guillotine door (2 3/4 in high x 2 1/2 in wide), resting on a hurdle 2 1/4 in high. The boxes were 9 3/4 in long x 4 1/2 in wide x 5 in high. The walls of the grid boxes and the walls and floor of the safe boxes were lined with Luminex glass, backed appropriately with white or gray paper. Each grid box floor consisted of 21 stainless steel bars, diameter 1/8 in, placed 7/16 in apart, and each safe box floor was hinged to serve as a floor switch. Above each box was a hinged box, used as a lid, containing incandescent lamps for the intertrial illumination and for the second-order CS. The bottom of each lid was covered with hardware cloth, above which was inserted a pane of opal flashed glass.

Ss were 72 female, hooded rats, ranging in age from 89-114 days. They were randomly paired and the pairs randomly assigned to either an experimental group or to

one of two control groups (N = 24 each).

On each of the two days prior to conditioning, each S was handled for 20 min. and for 10 min. explored each side of the apparatus which had been randomly assigned for all experimental treatments. On the following three days, first- and second-order classical fear conditioning trials were administered.

For the experimental group (FC-CS), the first-order CS was a 1200 cps tone which raised the ambient sound level of the room from 52 db to 90 db. The UCS was an inescapable shock of 125 v, delivered through 100,000 ohm resistance in series with each S at a rate of two impulses per grid per sec. The stimuli were presented in a forward conditioning (FC) sequence. The tone, of 6-sec. duration, overlapped the shock for the last 2 sec., and both terminated simultaneously. A 2-min. intertrial interval (ITI) was used. The second-order CS was an increase in illumination from 1.5 to 20 ftc, while the tone served functionally as the UCS. These stimuli were presented in a FC sequence with the light, of 10-sec. duration, overlapping the tone for the last 6 sec., and both terminating simultaneously. A 2-min. 21-sec. ITI was used.

The number and sequence of first- and second-order conditioning trials on the first conditioning day were 20 Tone (T)-Shock (S), 5 Light (L)-T, 5 T-S; on the second day, 5 T-S, 10 L-T, 5 T-S, 10 L-T, 5 T-S; on the third day, 5 T-S, 5 L-T. Thus there was a total of 45 first- and 30 second-order trials. The time interval between first- and second-order phases was the same as the ITI of the preceding sequence of trials.

Ten sec. following the last conditioning trial each S was removed to a holding box adjacent to each apparatus. Five min. later the first of 25 hurdle-jumping trials was begun for one member of the pair. Thereafter, trials were given to Ss alternately with a minimum ITI of 30 sec. On the following day 25 additional trials were given. Each trial consisted of placing S in the grid box and 10 sec. later opening the guillotine door simultaneously with the presentation of the light CS and the activation of a timer (.01 sec. units). If S jumped the hurdle, depression of the floor switch terminated the light and the timer. After 10 sec. S was removed to the holding box. If no jump occurred within 60 sec., S was removed, and a 60-sec. latency recorded.

Theoretically, during first-order conditioning, fear would become conditioned to the tone. Elicitation of this fear during second-order conditioning by the tone should result in the conditioning of fear to the light, the second-order CS. Subsequently, fear elicited by the light should motivate, and its offset reinforce, the learning of the hurdle-jumping response.

Fig. 1. Mean reciprocal of latency as a function of blocks of five trials on the first and second day of hurdle jumping for the three groups.

A clear demonstration of second-order conditioning requires evidence that the light does, in fact, acquire the capacity to elicit fear through being paired with the tone. One source of fear, which has been shown to be important in accounting for learning following first-order conditioning in this situation, is that conditioned to the static cues of the apparatus (McAllister & McAllister, 1962). One control group, FC-NCS, used to evaluate this source of fear, was treated exactly the same as the FC-CS group except that during hurdle jumping the light CS was not presented. Presumably, the only factor which could account for a performance difference between the groups would be fear elicited by the light in the experimental, but not in the control, group. Since it might be argued that the mere presentation of the light could have a dynamogenic effect or could, through other learning, serve as a cue that the guillotine door was open and thus facilitate a more rapid escape response, another control group, BC-CS, was included. This group was treated exactly the same as the FC-CS group except that during the second-order conditioning trials the stimuli were presented in a backward conditioning (BC) sequence. That is, the 6-sec. tone was terminated 15 sec. before the onset of the 10-sec. light. These trials were presented with a 2-min. ITI in order to equate the length of time spent in the apparatus by Ss under the FC and BC conditions. Presumably, with BC procedures classical conditioning of fear to the light would not occur. Therefore, a difference in performance between the experimental group and this control group can be attributed to fear elicited by the light CS in the FC-CS group.

Results and Discussion

The mean reciprocal of latency in blocks of five trials is shown in Fig. 1 for each group. A trend analysis of variance was calculated over the 10 blocks of trials with the factors being Groups and Trial Blocks. Groups, Trial Blocks, and their interaction were all significant, $F(2/69, 9/621, 18/621) = 4.89, 16.60, 2.00$; $p < .025, .001, .025$, respectively. Because of the significant interaction, trends of performance on the first and on the second day of hurdle jumping were analyzed separately. On Day 1 only Trial Blocks was significant, $F(4/276) = 33.75$; $p < .001$. On Day 2 both Groups and Trial Blocks were significant, $F(2/69, 4/276) = 6.12, 10.25$; $p < .005, .001$, respectively. Further analyses with Tukey's test (Ryan, 1959) indicated that the per-

formance of the FC-CS group was significantly superior ($p < .05$) to that of both the FC-NCS group and the BC-CS group, while the latter two groups did not differ significantly.

The trends of the curves on Day 1, coupled with the results of the statistical analysis, indicate that learning of the hurdle-jumping response occurred for all groups. Presumably, for the two control groups this learning was based on fear conditioned to the static cues of the apparatus, while for the FC-CS group, fear to the second-order CS was also present. This additional source of fear led, on Day 2, to the significantly superior performance of the FC-CS group relative to both control groups. The group differences on Day 2 provide clear evidence for the second-order conditioning of fear. For all groups the significant decrease in performance over trial blocks on Day 2 probably reflects extinction of fear.

Pavlov stated that a necessary condition for obtaining second-order conditioning was the use of a trace conditioning procedure in which the offset of the second-order CS occurs at least 10 sec. prior to the onset of the second-order functional UCS. The present results indicate that, to the contrary, second-order conditioning can occur with delayed conditioning procedures in which the second-order CS overlaps the functional UCS.

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Notes

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2. A series of preliminary studies, all with negative results, preceded the present one. Comparison of the procedures of these studies with the present one suggests that crucial variables in this type of situation may likely be one, or a combination of, the following: number and sequence of first- and second-order conditioning trials, pattern of interspersing of these trials, number of conditioning days, and the time interval between conditioning and hurdle jumping.