CONDITIONED SUPPRESSION OF FREE-OPERANT AVOIDANCE

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The responses of white rats were maintained on an unsignalled free-operant avoidance schedule. Superimposed on the avoidance schedule was a blinking white light followed immediately by response-independent electric shock. Duration of the light stimulus was either 1 or 3 min. Avoidable shock was 1.5 mA; response-independent shock was 7.5 mA. Suppression of responding during the light stimulus (both durations) developed over sessions. Responding immediately following the response-independent light-shock sequence was neither suppressed nor accelerated. The similarity is noted between the present result and findings of "positive conditioned suppression".

One approach to the elucidation of interactions between operant and respondent conditioning paradigms involving aversive stimuli is to observe the effect of stimuli paired with shock upon responding maintained by an unsignalled free-operant avoidance schedule. Studies using this general procedure have generally yielded acceleration of responding during the shock-associated stimulus (*e.g.*, Sidman, Herrnstein, and Conrad, 1957; Waller and Waller, 1963; Rescorla, 1967, 1968; Martin and Riess, 1969). It is of both practical and theoretical interest, however, to know whether operant behavior controlled by an unsuspended free-operant avoidance schedule can be suppressed by a superimposed respondent paradigm. This note reports a procedure to obtain such suppression.

METHOD

Subjects

Seven Sprague-Dawley male albino rats, about 150 days old at the beginning of the

procedure, were housed individually with constant illumination; food and water were continuously available.

Apparatus

Two Lehigh Valley operant conditioning chambers, Model 1316 (one bar extended), were used, in environmental cubicles (LVE 1417C); associated scheduling and recording equipment were located in an adjacent room. Depression of the lever allowed either avoidance or escape of the shocks of the free-operant avoidance schedule. Electric shock of 1.0 sec duration was delivered to the grid floor by an LVE Model 1531 constant current shock source with scrambler. Avoidable shock intensity was 1.5 mA. Intensity of the response-independent shock, which was unavoidable and inescapable, was 7.5 mA. These parameters and others described below were chosen on the basis of prior experimentation and the work of Perkins (1967), specifically to demonstrate the effect.

The white light (CS) preceding response-independent shock (US) was provided by the two stimulus lights on the end wall (with the bar) of the LVE 1316 operant chamber. The chamber, with no houselight, was completely dark except during the presentation of the CS, which blinked four times per second. Previous work (Perkins, 1967; Bryant, 1969) using white noise of 80 dB as the CS was less effective in producing suppression than the procedure reported here with light.

Procedure

Unsignalled free-operant avoidance responding was established during 15 sessions of 2 hr each, once every 12 hr, on consecutive days.

¹Reprints may be obtained from the author, Brain Research Institute, University of Tennessee Medical Units, 800 Madison, Memphis, Tenn. 38103. I wish to thank Martin M. Shapiro, in whose laboratory at Emory University the work was done as part of a Master's thesis, for personal interest and assistance and for many ideas concerning the conduct of behavioral experimentation; and Edward B. Downie, III, for introduction to the techniques of behavior circuitry. This work and the preparation of the manuscript were partially supported by an NDEA Title IV Predoctoral Fellowship awarded through Emory University; and by the Tennessee Department of Mental Health and a General Research Support Fellowship No. 243301-1575R from the University of Tennessee (USPH Grant R05423).

The shock-shock interval of the schedule (*i.e.*, the time between shocks if no response occurred) and the response-shock interval (the maximum time of delay of the schedule shock following a response) were set initially at 15 sec, being increased gradually during training to 20 sec, where they remained, equal. Stable responding for individual animals was between six and 12 responses per minute. During the fifteenth training session, 3-min presentations of the CS alone were given twice.

Four CS-US sequences, superimposed on the avoidance schedule, were presented during each of the 16 subsequent experimental sessions; US onset was simultaneous with CS termination. Intervals between CS-US sequences (20, 30, 40, 30 min) were ordered randomly for each 2-hr session. Duration of the CS was 1 min for the first eight experimental sessions for three rats (B1, B6, B7), after which it was 3 min; the other four rats (B2, B3, B4, B5) were begun with 3 min and shifted to 1 min.

RESULTS

Responses were counted during each CS presentation and the equal interval immediately preceding it. The data were used to compute a suppression ratio: Total number of responses during the CS / (Total number of responses during the CS + Total number of responses during the pre-CS interval). The value of this ratio is 0.50 when response rate is unaffected by presentation of the CS. When suppression occurs, the value of the ratio is < 0.50; values > 0.50 indicate acceleration. An analogous ratio was computed to compare responding before the CS with responding immediately after the US.

Figure 1 shows suppression ratios comparing each animal's responding before and during the CS. Avoidance responding during the CS decreased over sessions for all animals but Rat B5; this decrease was observed despite the fact that the avoidance schedule remained in force during the CS presentation. Figure 1 also shows pre-test suppression ratios, based on the two presentations of the CS during the fifteenth training session plus the first presentation of the CS during the first experimental session. Suppression was observed during the CS over experimental sessions for animals with either CS duration. The shift in CS duration

made little difference, except for Rat B1, which showed transient acceleration when shifted from the shorter to the longer CS. Responding immediately following the CS-US sequence was neither suppressed nor accelerated and did not change systematically over sessions for any animal.

DISCUSSION

That a CS paired with an aversive US may under certain conditions suppress operant behavior in the face of ongoing aversive contingencies that otherwise maintain that behavior, is of interest in view of the following remark by Skinner:

Although the biological advantage of avoidance is obvious, the emotional pattern of anxiety appears to serve no useful purpose. It interferes with the normal behavior of the individual and may even disorganize avoidance behavior which would otherwise be effective in dealing with the circumstances (1953, p. 178).

Whether this observation could be demonstrated clearly in the laboratory has been some time in doubt. When the Estes and Skinner (1941) "anxiety" procedure was first used with an aversively maintained baseline, the discovery was made that the ongoing avoidance behavior was not suppressed but facilitated during the "anxiety"-provoking CS (Sidman, *et al.*, 1957). This finding and similar ones led to the semi-formalized view that shock-associated stimuli suppress positively maintained behavior and facilitate avoidance responding. The view was apparently first put forward by Herrnstein and Sidman (1958). With regard to the Estes-Skinner "anxiety" procedure, they wrote: "At no time will animals . . . responding to avoid shock show the suppression in responding . . . demonstrated for food (or water) reinforcement (p. 380)." The finding of response suppression in the present procedure qualifies their statement.

Except when adapted to the shuttlebox (Rescorla, 1967, 1968; Martin and Riess, 1969), the typical free-operant avoidance schedule employs a very short avoidable shock which is inescapable. In the present study, the avoidable shock was longer (1 sec) and escapable. This difference from the typical schedule meant that suppression of responding, when it

Fig. 1. A: Averages of seven animals for both CS durations for CS suppression ratios (solid dots), pre-test CS ratio (asterisk), and ratios comparing response rates immediately after the CS-US sequence with rates immediately before (open squares), over blocks of two sessions each. B(1-7): Mean pre-test CS ratios (asterisks) and mean CS suppression ratios (solid dots) for individual rats over individual sessions. Rats B (1), B(6), and B(7) were shifted from a 1-min to a 3-min CS after Session 8 (arrow); remaining rats were shifted from 3 min to 1 min.

occurred, occurred in the presence of the continued possibility of both avoidance and escape of the shocks of the schedule. Animals failing to avoid received at least a short shock

and possibly the entire 1-sec duration, depending on the degree of suppression.

The present result is most directly related to published results in which some evidence of

suppression was found by either suspending the shock-avoidance schedule during the CS (Roberts and Hurwitz, 1970) or by allowing relatively long intervals of shock-free time with a brief CS (Pomerleau, 1970). In the present procedure, suppression was observed without suspension of the avoidance schedule and with CS durations that were relatively long (1 and 3 min). Perkins (1967), in a procedure basically similar to the present one, failed to find acceleration during the CS when the US was 4.0 mA, although acceleration was observed with smaller US intensities. It is unclear to what extent the present result, obtained with a procedure which is the Estes and Skinner (1941) "anxiety" or "conditioned suppression" procedure used with an aversively-maintained baseline, is related to results from a variant procedure where respondent conditioning is carried out separately from operant responding, with the CS presented later during avoidance or avoidance extinction (Rescorla, 1967, 1968; Martin and Riess, 1969).

Finally, the present result may be of interest as regards findings concerning the effects of a positively conditioned stimulus on an appetitively maintained baseline. In this case, as in the case of shock-associated stimuli and free-operant avoidance, the initial discovery was of some facilitation of responding (Estes, 1948; Herrnstein and Morse, 1957). Nonetheless, Pliskoff (1961) found suppression of responding for food during a 3-min stimulus preceding a high-frequency period of response-dependent reinforcement; and Azrin and Hake (1969) subsequently reported "positive conditioned suppression". The Azrin and Hake result is in some ways analogous to the present one in that a member of one class of stimuli (positive or negative), when paired with a neutral stimulus, was found capable of suppressing behavior maintained by contingencies involving that same class of stimuli. The Azrin and Hake result and the present finding, taken together, suggest the hypothesis that in both positive and negative cases, intense USs will yield suppression of responding. That is, either intense positive USs used with a positively maintained baseline or intense negative USs used with a negatively maintained baseline, should lead to suppression. This hypothesis, if it proves to be essentially valid, should aid in the further delineation of a general model of conditioned rate change.

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Received 8 July 1971.

(Final acceptance 25 October 1971.)