GENERALIZATION OF CONDITIONED SUPPRESSION[1]

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In Estes-Skinner conditioned suppression (Estes & Skinner, 1941), positively reinforced operant behavior is suppressed in the presence of an originally neutral stimulus (CS) if that stimulus has previously been paired with an aversive stimulus. Since aversive stimulation is known to have a disruptive effect on positively rewarded operant behavior, the suppression of behavior during the CS may be due to the conditioning of an aversive quality to the CS by virtue of the pairings. If a conditioning mechanism is involved here, the strength of the conditioned aversiveness, and hence the extent to which operant behavior is suppressed, may be expected to follow the law of stimulus generalization (Hull, 1943), and vary for different test stimuli depending on the degree of similarity between these stimuli and the CS. In the present study, the generalization of behavioral suppression along a sound-frequency dimension was investigated.

METHOD

Subjects and Apparatus

Three male albino rats, approximately 100 days old at the start of the experiment, served as subjects. The animals were trained in a sound-resistant chamber with a lever (10-gram force) in one wall, and a retractible dipper mechanism that presented a 0.1-cubic-centimeter liquid reward for 5 seconds. Originally, the reinforcement was tap water; and, as noted below, it was later changed to a mixture of three parts Borden's Eagle Brand Sweetened Condensed Milk to two parts tap water. Pain shock was delivered to the feet through a grid floor; 1.0 milliampere for 0.5 second was used in preliminary training, and later, the intensity was increased to 1.5 milliamperes. The sound stimuli were provided by a Foringer Multiple Stimulus Control Panel; the tone frequencies reported were measured by visualizing the output on an oscilloscope and matching the waveform with that produced by a Hewlett-Packard oscillator. The coarseness of the dial control on the stimulus panel limited the precision of resetting of any test frequency to between $\pm 5\%$.

The experimental procedures were programmed and recorded automatically. Noise from the control apparatus in an adjoining room was masked in the experimental room with white noise. Response frequencies in each stimulus period and during an equivalent period just prior to the onsets of the stimuli were recorded separately on impulse counters, and a cumulative recorder provided a continuous record of lever pressing.

Preliminary Training

Following habituation to once-a-day feeding, each *S* was given two sessions of dipper training, 650 reinforcements on CRF, one session of VI 30 seconds, three sessions of VI 1 minute, and four sessions of VI 2 minutes. The sequence of intervals in this last schedule, which served as the base line for conditioned-suppression training, was: 2, 5, 230, 120, 238, 200, 40, 83, 237, 166, 3, 40, 235, 10, 220, and 20 seconds. Within 10 minutes after the completion of their run, the *S*s were given lab chow pellets to maintain them at 80% of their free-feeding weight.

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Conditioned-suppression Training

Conditioned-suppression training was given under a discrimination training procedure in sessions of 100 minutes. Two 5-minute tones were used; an 1800-cycle-per-second signal, the S^D, was always terminated simultaneously with a pain shock to the feet, and a 200-cycle-per-second signal, the S^Δ, was never paired with shock. Each stimulus was presented four times in every daily session in the sequence shown in Fig. 1.

After 19 sessions a stable discrimination was established. Suppression was virtually complete in the 1800-cycle-per-second tone, and normal response rates were maintained in the 200-cycle-per-second tone. Pain shocks were then presented on a 50% reinforcement basis in order to minimize extinction effects during generalization testing. On this schedule, shocks followed only the first and third 1800-cycle-per-second tones, and the second and fourth 1800-cycle-per-second tones terminated without shock. Partial reinforcement training was continued (3 months) until the suppression levels (in both S^D and S^Δ) prior to the introduction of the partial procedure were recovered.[4] A representative record of this performance is shown in Fig. 1 to illustrate the base line on which tests for stimulus generalization were made.

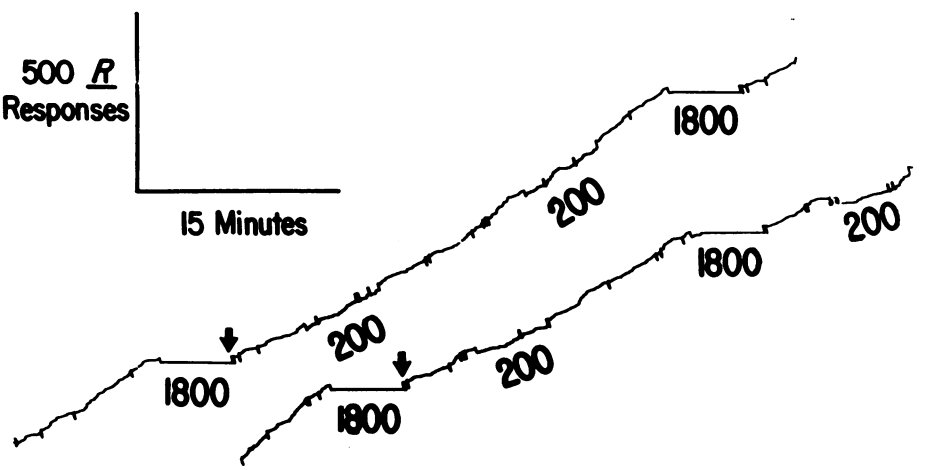

Figure 1. Conditioned discrimination showing partial reinforcement of suppression (arrows mark shocks). Sample cumulative record showing suppression during the 1800-cycle-per-second tones and normal responding in the 200-cycle-per-second tones.

Stimulus-generalization Testing

Four test tones were used, with frequencies intermediate between the 200- and 1800-cycle-per-second training stimuli: 560, 980, 1120, and 1500 cycles per second. Generalization testing was imposed on the conditioned-discrimination base line by substituting, on a particular test day, two presentations of one of the intermediate tones in place of the two nonreinforced 1800-cycle-per-second tones. For example, when 560 cycles per second was studied, the test sequence was: 1800 (shock), 200, 200, 560, 1800 (shock), 200, 560, and 200 cycles per second. Each animal had two test days with each intermediate frequency accord-

[4]One month after partial reinforcement was started and 2 months before generalization trials were begun, the performances of *Ss* C-4 and C-14 were studied following single IP injections of mescaline and of LSD-25. C-6 was injected once only with LSD-25. Following these drug experiments the reinforcement was changed to three parts Borden's Eagle Brand Sweetened Condensed Milk to two parts tap water, and the shock intensity was increased to 1.5 milliamperes.

ing to a cross-over design. The order of testing the generalization tones was mixed, and it differed for each subject.

RESULTS

Figures 2 and 3 show all the test data for two of the rats. Each cumulative-record segment shows the response rate in the 5-minute period preceding each stimulus presentation and (transposed downward) the rate in each stimulus period. The first column of segments contains the records of performance obtained in the initial exposure to the various test frequencies. Each succeeding column shows performance during each succeeding presentation of the stimuli, two presentations on Test Day 1 and two on Test Day 2.[5] For both animals,

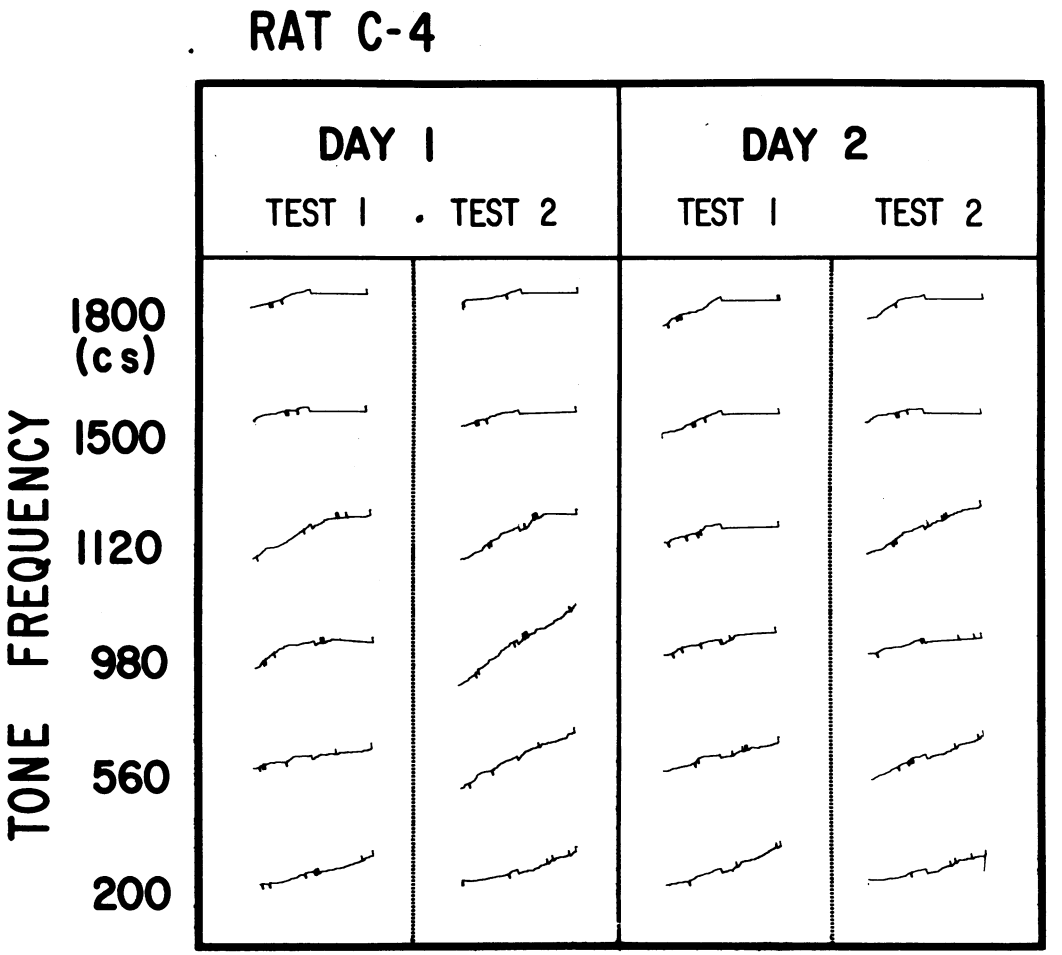

Figure 2. Individual data for Rat C-4 under all testing conditions. Each section of the cumulative record shows the 5 minutes just prior to stimulus onset, and, indicated by the offset in the record, the 5 minutes of stimulus. *S* was trained to suppress in the 1800-cycle-per-second tone and to respond normally in the 200-cycle-per-second tone.

[5]The records shown for the base-line stimuli, 1800 and 200 cycles per second, were selected arbitrarily from the first day of generalization testing for the Test Day 1 portion of the figure, and from the first day of the second testing cycle for the Test Day 2 portion. Since the base line was stable, these records are quite representative of behavior in these stimuli throughout generalization testing.

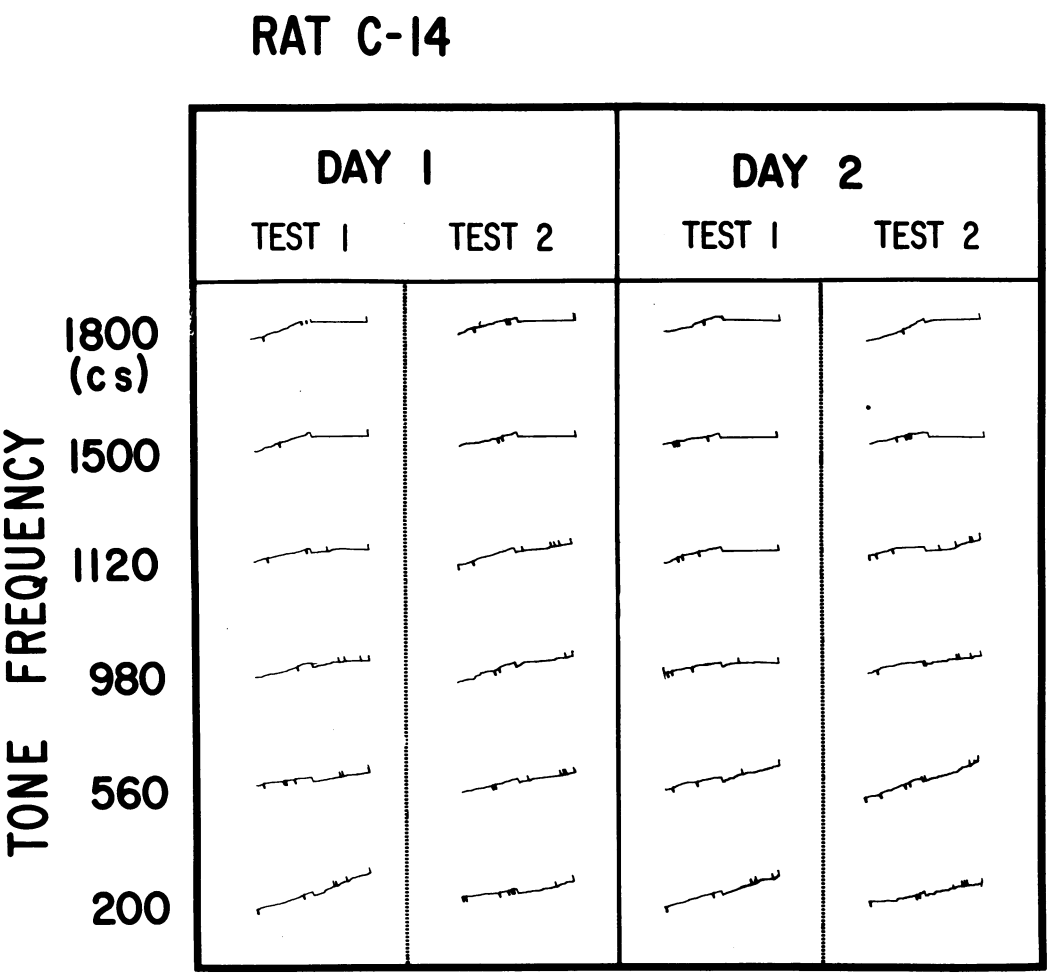

Figure 3. Individual data for Rat C-14 under all testing conditions. Each section of the cumulative record shows the 5 minutes just prior to stimulus onset, and, indicated by the offset in the record, the 5 minutes of stimulus. *S* was trained to suppress in the 1800-cycle-per-second tone and to respond normally in the 200-cycle-per second tone.

the strength of suppression in the test stimulus clearly is directly related to its similarity to the 1800-cycle-per-second CS.

Figure 4 summarizes the test data for all three animals as conventional generalization gradients. The ordinate gives mean suppression scores for a test day, calculated by averaging the two suppression ratios obtained on that day for the test frequency. The circles are for Test Day 1 and the crossed circles for Test Day 2. Suppression scores for the base-line stimuli for all eight test sessions are also shown. For Rat C-4 and Rat C-14, the relative response rate in the stimulus is a smooth, inverse function of frequency. For these animals, the strength of suppression generalized to the test stimuli appeared to be quite stable, as evidenced by the close correspondence in suppression ratios between the two test days.

The data for Rat C-6 were characterized mainly by their variability. This may be due partly to the fact that this animal did not suppress well in the CS prior to and during the generalization tests.

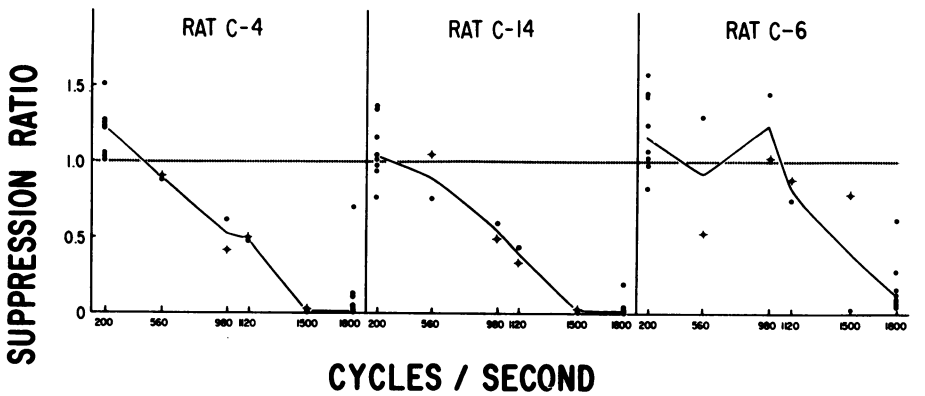

Figure 4. Suppression ratios for training and generalization frequencies. Summary data for all *S*s showing rate during stimulus/rate just prior to stimulus for the training frequencies (200 and 1800 cycles per second) and for the generalization test frequencies (560, 980, 1120, and 1500 cycles per second). Circles are for the first test day, crossed circles for replication.

Finally, it is worth noting that in all cases the median suppression ratios for the 200-cycle-per-second tone exceed 1.0, indicating that on the average the lever-pressing rate in this stimulus exceeded the rate between stimulus presentations. This was seen in the base-line sessions; and, also, this finding has been reported previously (Stein & Brady, 1957). In a personal communication, Cumming pointed out that the rate in the periods between stimulus presentation may be slightly suppressed (in the Estes-Skinner sense) by the fact that these periods occasionally terminate with the onset of the CS (a conditioned aversive stimulus), while terminations of the 200-cycle-per-second tone are always relatively "safe," i.e., they never lead into a CS.

SUMMARY

This study investigated the generalization of conditioned suppression along a sound-frequency dimension. Working for milk on VI 2 minutes, three rats were trained to discriminate between a high-frequency tone which was paired with shock and a low-frequency tone not associated with shock. After suppression had stabilized in the high tone with normal response rates in the low tone, stimuli of intermediate frequency were presented for generalization testing. The amount of responding in these test frequencies was an inverse function of their similarity to the conditioned stimulus.

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