References and Notes

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Discriminative Control of "Attention"

Abstract. *Three pigeons were trained to discriminate between two tones differing in frequency in the presence of light of one color (A), and not to discriminate between the tones in the presence of light of another color (B). Generalization functions that were determined in the presence of light A showed control of behavior by the frequency of the tone; those determined in the presence of light B did not.*

Our experiments were done to find out whether "attention" to a dimension of stimuli can be brought under discriminative control. We adopt the noncommittal definition of attention suggested by Skinner (*1*). An organism is said to attend to a dimension of stimuli if variations in the value of the stimulus produce variations in behavior, otherwise he is said not to attend. Thus, whether a subject is or is not attending to a stimulus dimension can be determined by analysis of an empirical function relating stimulus values to behavior, such as a gradient of stimulus generalization. If the "stimulus generalization" function is a horizontal line, it indicates that the subject is not attending to the stimuli that are being varied; any other shape indicates that he is attending.

The subjects were three White Carneaux pigeons that had not been experimented upon before. They were trained to peck at two translucent disks located in a test chamber that also contained a loudspeaker and a device for presenting food. Two sets of stimuli were manipulated during the experiment: the two disks were illuminated from behind by either red or green light, and a sinusoidal tone having a frequency of either 300 or 1000 hz was sounded.

Training sessions were divided into a series of trials that were separated from each other by intervals ranging from 10 to 35 seconds. The onset of a trial was marked by the introduction of one of the four possible combinations of sound and light stimuli. For each of the stimulus combinations one of the disks was defined as correct and the other as incorrect. A single peck to either disk caused the removal of the visual and auditory stimuli and ended the trial. In addition, a response to the correct disk led to reinforcement, a 2.5-second period of access to a tray of mixed grain.

The general plan of the training procedure was as follows. When the disks had one color, the frequency of the tone determined which of the two responses was reinforced, but when the disks had the alternate color a response to only one of the disks was reinforced regardless of the frequency of the tone. For example, if the disks were red, a peck at the right-hand disk was reinforced only in the presence of the 1000-hz tone and a peck at the left-hand disk was reinforced only in the presence of the 300-hz tone. On the other hand, if the disks were green, a peck at the right-hand disk was reinforced regardless of which tone was present, whereas a peck at the left-hand disk was never reinforced. The two conditions will be referred to as tone relevant (TR) and tone not relevant (TNR), respectively. Which color was associated with conditions TR and TNR, and which disk (left to right) was correct for each frequency in condition TR, varied from subject to subject.

The discrimination was taught in stages. The subjects were first trained to discriminate between the colors in the presence of only one of the tones. Next they were trained to discriminate between the tones in the presence of the color used in condition TR. After this, the four combinations of color and tone were presented in a random sequence during each training session. All correct responses were reinforced until a stable asymptotic performance was attained. Then the number of reinforcements was gradually reduced until only 50 percent of the correct responses, selected at random, were reinforced.

The final part of the experimental procedure was a test for generalization along the dimension of tonal frequency. The method used in the generalization tests was identical with that just described for the very last stage of training, except for one modification: on those trials on which no reinforcement was given, the training tone was replaced by a tone having a frequency of 450, 600, 800, 1350, 1800, 2400, or 3200 hz. Generalization tests were done in four sessions during which each of the seven new tones was presented in combination with each of the two colors a total of 16 times.

The results for three birds are presented in Fig. 1, which shows the proportion of responses to the disk that was correct for the 1000-hz tone (under both conditions TR and TNR) plotted against the frequency of the tone. In the presence of the color used in condition TR, the frequency of the tone strongly influenced the proportion of responses to each of the disks, whereas in the presence of the color associated with condition TNR the frequency of the tone had no influence on the choice of disks. Clearly, attention to a stimulus dimension can be brought under discriminative control.

The sort of discrimination learned by our subjects is often referred to as

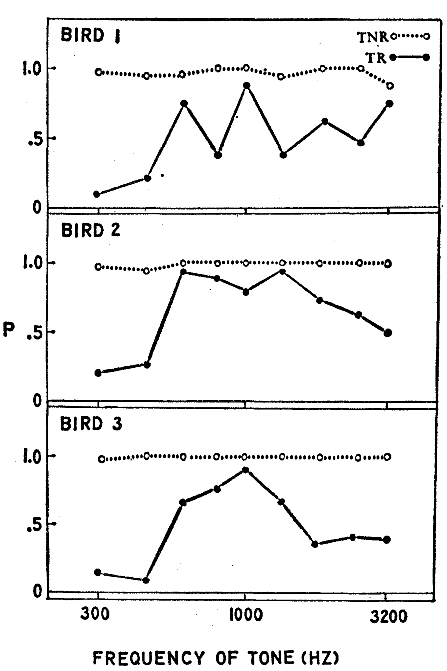

Fig. 1. The effect of the frequency of the tones presented during the generalization tests upon the proportion (P) of trials on which the birds pecked the disk that was "correct" for the 1000-hz tone. The points obtained when the disks had the color used in condition TR are connected by the solid line, those obtained when the disks had the color used in condition TNR are connected by the dotted line.

a "conditional discrimination," a term that unfortunately lacks a precise definition. That various animals can be trained to make discriminations of this sort has been demonstrated by a number of investigators [for example (*2*)]. The most significant feature of our results, however, is not that pigeons can make a "conditional discrimination," but that the auditory dimension which controls behavior under condition TR seems to be completely without influence on behavior under condition TNR. The conclusion that auditory dimension is irrelevant to behavior under condition TNR rests upon the results of the generalization test and does not follow from the data obtained in training.

Current theories of "stimulus generalization" are either too incomplete to be applied to our situation or they yield incorrect predictions. Further study of the phenomenon described here may aid greatly in the formulation of an adequate theory of behavior.

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Retrograde Amnesia Produced by Electroconvulsive Shock after Reactivation of a Consolidated Memory Trace

Abstract. *Rats had a memory loss of a fear response when they received an electroconvulsive shock 24 hours after the fear-conditioning trial and preceded by a brief presentation of the conditioned stimulus. No such loss occurred when the conditioned stimulus was not presented. The memory loss in animals given electroconvulsive shock 24 hours after conditioning was, furthermore, as great as that displayed in animals given electroconvulsive shock immediately after conditioning. This result throws doubt on the assertion that electroconvulsive shock exerts a selective amnesic effect on recently acquired memories and thus that electroconvulsive shock produces amnesia solely through interference with memory trace consolidation.*

Impaired retention of responses learned shortly before electroconvulsive shock (ECS) stimulation is commonly called retrograde amnesia (RA), and is attributed to interference with consolidation, a process considered responsible for the structural encoding and consequent long-term storage of memory traces. Uninterrupted completion of this process presumably makes the memory trace relatively permanent and insusceptible to disruption by ECS. Experiments of the single training trial, single ECS paradigm show that RA diminishes and eventually disappears as the time between training trial and ECS increases. Theoretically, memory is consolidated between the time of the training trial and the last time ECS produces some RA. This interval has been thought to last several hours (*1*), or just several seconds (*2*).

Our investigation of the temporal factor in RA was to determine: (i) whether ECS operates solely by interference with memory storage; and (ii) specifically, if ECS, given soon after the selective reactivation of a memory trace laid down at the time of learning, could produce RA long after the learning event. Our subjects were 100 male Sprague-Dawley rats (220 to 270 g), purchased from a commercial supplier. They were kept in individual cages and fed 12 g of food daily.

Fear conditioning was given in a lick chamber with a grid floor, two aluminum walls, two transparent Plexiglas walls, and a Plexiglas ceiling. At the center of one wall, 2.5 cm above the floor, in a 1.5-cm hole, was a glass drinking tube. A drinkometer circuit was completed whenever the subject licked the tube. The chamber was lit by a 10-watt bulb and was in a sound-attenuated compartment with a white interior.

A floorless black plywood box, used during trace reactivation, fit snugly into the lick chamber. A red bulb lit the interior, and a piece of black plastic replaced the Sanicel bedding used beneath the grids at other times. Through a 1.5-cm hole in both the chamber and box, earclips, through which a 0.5-second, 40 ma of ECS was delivered, could be attached to the subjects.

During 5 days before the first treatment, subjects were adapted to earclips for 21 minutes (20 minutes in home cage, 1 minute in black box). Gloves were worn when the clips were attached and removed; the adaption period began 10 to 15 minutes after feeding. Three days before the first treatment, all subjects were deprived of water. After 24 hours of deprivation, the subjects were placed in the lick chamber and allowed to make 110 licks. The drinking tube then protruded 1.5 cm into the chamber; if the subject did not locate and lick the tube in 5 minutes, it was directed to the tube and allowed to make 110 licks. The subjects received their food ration 45 minutes later, with water available for 10 minutes. The session on the following day was similar except that the drinking tube was 3 mm behind the inner-wall surface; the subject remained in the chamber until it located the tube and made 110 licks; no gloves were used to handle the subjects; water was available for the next 24 hours.

After the second session, the subjects were randomly divided into five groups of 20 subjects each, and the next day they all received their first treatment, which was the same for all groups except group 1, a "typical RA group" that served as a control. For this treatment, each subject was removed from its home cage with a gloved hand 10 to 15 minutes after feeding and was taken to the lick chamber where earclips were attached. The chamber was modified, with a white panel over the aluminum wall where the tube had been. After 47 seconds, the conditioned stimulus (CS), an 80-db white noise, was presented for 10 seconds. A 1.3-ma shock was delivered, simultaneously with noise offset, to the grids for 3 seconds. All except group 1 were removed to home cages after footshock; group 1 received ECS immediately after footshock and was then removed to home cages. Water bottles were removed after this treatment.

The next day in the black box, the CS used the day before was presented briefly to reactivate in 40 subjects a memory trace laid down at the time of learning. Afterward, ECS was given to 20 of these subjects and also to 20 other subjects that had not received the brief CS. Thus, CS (a 2-second, 80-db white noise) and ECS were manipulated factorially in terms of occurrence or nonoccurrence. Group 2 was presented the CS and then immediately given ECS. Group 3 received only CS. Group 4 received only ECS, and group 5 received nothing. Groups 1 and 5 received the same treatment in the black box. All subjects were handled without gloves,