Differential eyelid conditioning as a function of the probability of reinforcement of the conditioned stimuli

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Differential eyelid conditioning was investigated with different schedules of reinforcement of CS1 and CS2. The reinforcement schedules employed were 100%-0%, 80%-0%, 100%-20%, and 80%-20%. Significant differentiation occurred in all groups. With the reinforcement schedule to CS1 constant at 100%, increasing the reinforcement schedule from 0% to 20% resulted in a decrease in responding to CS1. With reinforcement schedule of CS2 constant at 0%, decreasing the reinforcement schedule of CS1 from 100% to 80% resulted in increased responding to CS2. A stimulus generalization interpretation was offered.

Differential eyelid conditioning has typically involved 100% reinforcement of CS1 and 0% reinforcement of CS2 ($\pi = 1.00$, $\pi_2 = .00$). Newman (1967) has examined the effects of π values other than 1.00 and .00 in human eyelid conditioning. Generally, he found that significant differentiation obtained only when $\pi_2 = .00$. Of equal importance was the observation that when the π value associated with CS1 was held constant at 1.00 and the π_2 values were varied from .00, .25, .50, or .75, there was a decrease in responding to CS1 associated with increases in the π_2 value. Thus, although CS1 was always followed by the UCS, the probability of a CR to CS1 decreased with increases in the π value associated with CS2. The latter finding poses problems for reinforcement theories of the Hull-Spence variety, since they would predict either stable responding to CS1 (if no generalization occurred) or increases in CRs to CS1 with increases in π_2 due to generalization of excitation.

In a later study (Newman & Woodhouse, 1969) Ss were given 48 trials in which $\pi_1 = 1.00$ and $\pi_2 = .00$ before the π_2 value was shifted to .00, .25, .50, .75, or 1.00. The results clearly showed that with increases in π_2 there were orderly increases in the number of CRs to CS2. The degree of differentiation was a direct function of the difference between π_1 and π_2 , although statistical significance was obtained only when the π_2 values were .00 and .25. More recently, Peterson & Newman (1970) found significant differentiation with π_2 values of .50 and .75 following $\pi_1 = .00$ pretraining. Thus, it appears that differential responding can occur when the π_2 value is greater than .00 if Ss are pretrained

with $\pi_2 = .00$. In contrast to the first experiment, there was no decrease in responding to CS1 associated with increases in responding to CS2. Newman and Woodhouse's interpretation was "that the tendency to respond to each CS depends solely on the corresponding π value, independent of the reinforcement schedule of the other CS."

The present experiment asks three questions. (1) Can differentiation be demonstrated when $\pi_2 > .00$ without prior training? (2) With π_1 held constant at 1.00, will responding to CS1 decrease with increases in the π_2 value? (3) With π_2 held constant at .00, will responding to CS2 increase with decreases in the value of π_1 ?

METHOD

The Ss were University of Montana undergraduate volunteers who were fulfilling part of a laboratory requirement for an introductory psychology course. They were assigned randomly in order of appearance at the laboratory to one of four experimental groups. If S did not make at least two CRs in the last 20 trials, he was replaced by a new S. Nineteen Ss failed to reach this criterion and they were rather evenly distributed across the four conditions. Each group contained 16 males and 16 females.

The four experimental groups were defined on the basis of the differential reinforcement schedules (the π_1 and π_2 values). The schedules employed were 1.00/.00, 1.00/.20, .80/.00, and .80/.20.

Two Ss were run simultaneously in two identical 3 x 3 x 5 ft enclosures located in a well-lighted semisoundproofed room. Each S wore a headset containing a Giannini microtorque potentiometer and an air jet. The coupling to the potentiometer shaft was taped to S's right eyelid, and the movements were amplified and recorded by an Offner Dynograph (Model 542). The airjet was positioned

¼ in. below S's eyelash and was aimed directly at the right cornea. The UCS was a 50-msec puff of nitrogen with a static pressure of 110 mm Hg.

The CSs were two 7½-W red jeweled lights, 1 in. in diam, mounted 6 in. apart on a black panel. The CS duration was 800 msec, and the UCS occurred at CS offset. Event durations and intervals were controlled by Hunter timers. The position of CS1 and CS2 (left or right) was balanced within each group.

The Ss were given standard "neutral" instructions, followed by 100 conditioning trials with a mean intertrial interval of 20 sec. CS1 and CS2 were presented equally often and in a random order, with the restriction that within each block of 10 trials there were five presentations of each CS. The reinforcement schedules were constructed at random, with the restriction that the schedules be satisfied within each block of 20 trials.

RESULTS AND DISCUSSION

The percentage of CRs to CS1 and CS2 in blocks of 10 trials for each of the four experimental conditions is shown in Fig. 1. Within-Ss analyses of variance revealed significant differentiation for all groups, with $F_s(1,31) \geq 5.04$, $p < .05$.

The phenomena of primary interest are shown in Fig. 2. Figure 2a shows the percentage of CRs to two CSs, neither of which was ever followed by a UCS. The graph reveals that, as the probability of reinforcement to the alternate CS increases from .80 to 1.00, there is a corresponding drop in responding to a never reinforced CS. A between-Ss analysis of variance revealed the difference between the two response levels to be reliable, $F(1,62) = 5.05$, $p < .05$. Figure 2b presents the percentage of responding to two continuously reinforced CSs. As can be seen, responding to an always reinforced CS was less when the other CS was reinforced 20% of the time as compared with 0% of the time. This difference approached, but did not attain, statistical significance, $F(1,62) = 3.21$, $.10 > p > .05$ for the last two trial blocks.

The present experiment both confirms and extends Newman's findings. Like the Peterson & Newman (1970) data, the present results indicate that significant differentiation can occur with π values greater than .00 and without prior training. In addition, there was a clear decrease in responding to CS1 with increases in the π_2 value, and a suggestion of an increase in responding to CS2 with decreases in π_1 . The latter finding was reported by Newman (1967) but was not found in his more recent experiments (Peterson & Newman, 1970; Newman & Woodhouse, 1969). The source of the discrepancies is not apparent at this time.

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Fig. 1. Percentage of CRs to CS1 and CS2 in blocks of 10 trials for the four reinforcement schedules.

The present results are not compatible with a Hull-Spence interpretation without additional assumptions. The nature of the assumptions is suggested by existing literature. Wickens, Schroder, & Snide (1954) examined stimulus generalization gradients under partial or continuous reinforcement. They found a flattening of the generalization gradient with a partial reinforcement schedule. Essentially the same results were obtained earlier by Humphreys (1939). Both of these studies employed the conditioned GSR. More recently, Vandament & Price (1964), using eyelid conditioning techniques, examined stimulus generalization gradients under 50% or continuous reinforcement. Although the Test Stimuli by Reinforcement Schedule interaction failed to reach statistical significance, separate chi squares revealed significant differences between the test stimuli for continuous reinforcement, but no differences appeared with partial reinforcement.

These studies all suggest a flattening of an excitatory gradient with partial reinforcement. If one is willing to assume that the same effect occurs with an inhibitory gradient, the present results become interpretable. Partial reinforcement of CS1 causes greater spread of excitation to CS2, resulting in increased responding to that stimulus. Conversely, partial reinforcement of the CS2 results in greater spread of inhibition to CS1, resulting in a lower probability of responding to CS1.

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Fig. 2. Percentage of CRs in blocks of 10 trials when A $\pi_2 = .00$ and $\pi_1 = 1.00$ or .80, and B $\pi_2 = 1.00$ and $\pi_2 = .00$ or .20.