Auditory differential conditioning of the rabbit nictitating membrane response: III. Effects of US shock intensity and duration¹

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Forty-eight rabbits were employed to investigate effects of US intensity and US duration upon differential conditioning of the nictitating membrane response. It was found that the level of conditioning varied directly with increases in intensity and duration, while differential performance was influenced only by intensity. Results were attributed to the increasing noxiousness of the US and were discussed with reference to studies of human eyelid conditioning.

According to Spence's (1958) treatment of classical defensive conditioning, an increase in the intensity of the unconditioned stimulus (US) results in an increase of generalized drive, D, which, when combined multiplicatively with habit strength, H, results in a higher level of responding. Later studies by Spence and his associates suggested that US intensity also contributes to H directly by way of some unspecified mechanism. In the case of human eyelid conditioning, there is evidence to suggest that the habit component of the US derives, at least partially, from drive reduction accompanying an attenuation or termination of the noxious US. The drive reduction hypothesis predicts that an increase in US duration results in delay of reinforcement with respect to the CR and hence a slower rate of conditioning. Numerous studies of human eyelid conditioning have illustrated the direct relationship between CR performance and US intensity (e.g., Spence & Platt, 1966). A smaller number of studies have indicated poorer conditioning with a long (1000 msec) airpuff US compared with one of shorter duration (50 msec), thereby supporting the drive reduction viewpoint (Runquist & Spence, 1959; Meiselman & Moore, 1965; Dufort, 1967).

In the case of differential conditioning, Spence's (1958) theory predicts faster conditioning and better differentiation as US intensity is increased, and this prediction has been substantiated in two human eyelid conditioning studies carried out in his laboratory (Runquist, Spence, & Stubbs,

1958; Spence & Tandler, 1963). There have been no reports of the effects of US duration or of the possible interaction of US intensity and duration in differential conditioning. The present experiment sought to investigate these variables using the rabbit nictitating membrane response conditioned by electric shock to the region of the eye.

SUBJECTS

Subjects in the present investigation were 48 naive male and female New Zealand White rabbits, 90-120 days old at the outset of the experiment. All Ss were individually housed and maintained on ad lib food and water.

APPARATUS

A detailed description of the apparatus and technique for recording from the nictitating membrane has been provided in a previous report (O'Malley, Hupka, & Moore, 1969).

PROCEDURE

Rabbits were randomly assigned to one cell of a 2 by 3 factorial design combining US durations of 50 and 350 msec and US intensities of .5-, 2-, and 4-mA ac shock. It was feared that a US duration longer than 350 msec would produce poor conditioning through overarousal, particularly at the highest value of shock intensity. The shock USs were delivered to S via the wound clips attached near the right eye. Five sessions of differential conditioning were given, each

session consisting of 100 trials with an average intertrial interval of 60 sec (50-, 60-, and 70-sec intervals). A 400-Hz tone served as the CS+ for all Ss, while a 1000-Hz tone was the CS-. CS+ and CS- trials were randomly presented but equated in blocks of 20 trials for purposes of analysis. The interstimulus interval was 630 msec, and the CS+ terminated with the US. CS- was maintained for like durations. A conditioned response (CR) was defined as a positive deflection of the recording pen greater than 1 mm within the CS-US interval.

RESULTS AND DISCUSSION

Figure 1 depicts differential performance as a function of intensity and duration. An analysis of variance of per cent CRs for the five conditioning sessions yielded significant main effects of US intensity [$F(2,36) = 18.76, p < .001$] and duration [$F(1,36) = 4.44, p < .05$], indicating that responding bore a positive relation to increments of both variables. In addition to the main effects, a significant Intensity by Differentiation interaction [$F(2,36) = 4.97, p < .025$] indicated that differential performance improved with increases in US intensity. A failure to obtain significant interaction between US duration and other variables suggests that US intensity but not duration affected differentiation in the present experiment. Figure 1 further suggests that the downturn of responding to CS- did not occur until asymptotic performance was achieved to CS+. It seems likely, therefore, that a downturn of responding to CS- was absent in the .5-mA intensity groups because the CS+ curves were still climbing by the end of training.

The effects of US intensity observed in the present experiment using the nictitating membrane response of the rabbit are

Fig. 1. Acquisition and differential responding for combinations of US intensity and US duration as a function of days.

consistent with data from human differential eyelid conditioning in that increases in US intensity led to faster acquisition and differentiation. The observed facilitory effect of US duration, however, stands in opposition to data from simple human eyelid conditioning. The discrepancy might be reconciled by assuming that the nictitating membrane response does little to reduce the noxiousness of a shock US delivered to the region of the eye. This being the case, there would be little basis for treating the CR as being under instrumental control. With such instrumental control ruled out, it would be gratuitous to suppose that a delay of reinforcement operated in this situation. Nevertheless, it should be emphasized that the values of US duration employed with human Ss have been more extreme (e.g., 50 vs 1000 msec) than those employed in the present study, and this might account for the apparent discrepancy between the two preparations. Thus, a 350-msec airpuff might facilitate human eyelid conditioning compared with a US of shorter duration. Similarly, an electric shock US of 1000 msec could conceivably interfere with conditioning compared with shocks of shorter duration.

REFERENCES

DUFORT, R. H. Eyelid conditioning as a function

- of UCS duration with drive equated. *Journal of Experimental Psychology*, 1967, 74, 321-323.
- GORMEZANO, I. Classical conditioning. In J. B. Sidowski (Ed.), *Experimental methods and instrumentation in psychology*. New York: McGraw-Hill, 1966.
- MEISELMAN, H. L., & MOORE, J. W. The effects of percentage reinforcement, UCS duration, and experience with procedure on the conditioned eyelid response. *Psychonomic Science*, 1965, 3, 335-336.
- O'MALLEY, P., HUPKA, R. B., & MOORE, J. W. Auditory differential conditioning of the rabbit nictitating membrane response: I. Effects of mixed- and separate-phase training. *Psychonomic Science*, 1969, 15, 123-124.
- RUNQUIST, W. N., & SPENCE, K. W. Performance in eyelid conditioning as a function of UCS duration. *Journal of Experimental Psychology*, 1959, 57, 249-252.
- RUNQUIST, W. N., SPENCE, K. W., & STUBBS, D. W. Differential conditioning and intensity of the UCS. *Journal of Experimental Psychology*, 1958, 55, 51-55.
- SPENCE, K. W. A theory of emotionally based drive (D) and its relation to performance in simple learning situations. *American Psychologist*, 1958, 13, 131-141.
- SPENCE, K. W., & PIATT, J. R. UCS intensity and performance in eyelid conditioning. *Psychological Bulletin*, 1966, 65, 1-10.
- SPENCE, K. W., & TANDLER, B. F. Differential eyelid conditioning under equated drive as a function of the reinforcing UCS. *Journal of Experimental Psychology*, 1963, 65, 35-38.

NOTES

1. This research was supported in part by NSF Grant BG-5480.
2. Now at the University of Iowa.

Auditory differential conditioning of the rabbit nictitating membrane response: IV. Training based on stimulus offset and the effect of an intertrial tone¹

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In Experiment 1 each of two groups of 16 rabbits was given 5 days of differential conditioning in which the reinforced (CS+) and nonreinforced conditioned stimulus (CS-) were presented equally often in a random sequence. Tone onset was the CS for one group and tone offset was the CS for the second group. Both groups yielded similar rates of conditioning and differentiation. The effect on differentiation between an auditory CS+ and CS- when presenting an additional tone during the intertrial interval (ITI) was investigated in Experiment 2. Four groups of eight rabbits received 3 days of auditory differential conditioning in a 2 by 2 factorial design combining presence or absence of a 1000-Hz tone during the ITI with frequency separations (Δf) between

CS+ and CS- of 200 and 1400 Hz. Differentiation was obtained only with the Δf of 1400 Hz, and, in contrast to results with human Ss, the presence of the tonal ITI stimulus disrupted differentiation in rabbits.

The purpose of this experiment was to compare differential conditioning based on stimulus onset, the customary procedure, with differentiation established on the basis of the offset of an intertrial stimulus. Stimulus offset has been shown to be as effective as stimulus onset in simple conditioning situations (e.g., Mattson & Moore, 1964), and this technique has recently been applied successfully to differential eyelid conditioning with human Ss (Moore, Newman, & Glasgow, in press).

EXPERIMENT 1

Subjects

The Ss were 32 naive male and female

New Zealand White rabbits, 90-120 days old.

Apparatus

A detailed description of the apparatus and technique for recording from the nictitating membrane has been provided in a previous report (O'Malley, Hupka, & Moore, 1969).

Procedure

Two groups of 16 Ss received 5 days of conventional differential conditioning (i.e., the reinforced and nonreinforced CSs were presented equally often in a random sequence) for 120 trials/day with an average intertrial interval (ITI) of 60 sec and CS-UCS interval of 250 msec. Tones of 1700 and 300 Hz were used as the reinforced and nonreinforced CSs. The CSs were tone onset for one group and tone offset for the other. An intertrial tone occupied the entire ITI. A conditioned response (CR) was defined as any 1-mm positive deflection of the recording pen within the interstimulus interval. The UCS consisted of a 2-mA ac shock of 50-msec duration applied to wound-clip electrodes on the infra-orbital region of the right eye.

Results and Discussion

Figure 1 shows that good differentiation was obtained with both the tone onset and offset procedures ($F = 208.41$, $df = 1/28$, $p < .001$). The slightly better differentiation in the tone onset group, evident in the figure, was not statistically significant. Nevertheless, these data are quite comparable with those obtained with humans.

EXPERIMENT 2

The purpose of this experiment was to determine the effect of a single intertrial (ITI) tone upon differentiation to two other tones. Experiments in human eyelid conditioning have shown that the presence of a constant intertrial tone can enhance differential conditioning to tonal CSs compared with control groups which hear only white noise during the ITI (Moore & Newman, 1966). This result has been interpreted in terms of an accrual of inhibition to the intertrial tone and resulting positive induction effect which elevates responding to CS+. The contrast is enhanced further by a concomitant depression in responding to CS- which can be attributed to the generalization of intertrial inhibition. Alternatively, the intertrial tone seems to provide an anchoring stimulus which heightens the discriminability between CS+ and CS- at a perceptual level.

Four groups of eight Ss received a sequence of 60 CS+, 10 CS-, 20 CS+, 10 CS-, and 20 differential trials (i.e., CS+ and CS- were presented equally often in a random sequence) on Day 1. Ss were given 120 trials/day of conventional differential conditioning on Days 2 and 3. Each group formed one combination of a 2 by 2 factorial design. One dimension of the