Journal of Experimental Psychology
1967, Vol. 75, No. 2, 151–157

DIFFERENTIAL CLASSICAL AND AVOIDANCE EYELID CONDITIONING[1]

DOMINIC W. MASSARO AND JOHN W. MOORE

University of Massachusetts

48 human Ss participated in an experiment comparing classical and instrumental avoidance eyelid conditioning in a differential conditioning paradigm. Significant avoidance differentiation was obtained, and analyses of CR frequency, latency, recruitment, and overlap revealed that the avoidance procedure produced CRs that differed from classical CRs but did not appear to be "voluntary" or reinforced by UCS omissions. The longer latency, shorter recruitment, and shorter duration (less overlap) of avoidance CRs suggest that these responses do not acquire the instrumental characteristics of CRs obtained in non-contingent eyelid conditioning and therefore resemble fractional components of the UCR rather than preparatory responses. In addition, the results of 24 Ss in a "mixed" classical-avoidance paradigm, in which the UCS was always paired with one CS but accompanied the other CS only when a CR failed to occur, suggest that it is not possible to condition 2 types of CRs by the 2 reinforcement procedures within the same S.

The purpose of this study was to compare classical and instrumental avoidance eyelid conditioning in a differential conditioning paradigm. In addition, a "mixed" classical-avoidance conditioning paradigm, in which the UCS was always paired with one CS but accompanied the other CS only when a CR failed to occur, was used for a within-*S* comparison.

Moore and Gormezano (1961) found simple avoidance eyelid conditioning inferior to the 100% UCS classical paradigm but superior to classical yoked controls receiving the same number and pattern of UCS occurrences. The higher level of conditioning of the avoidance *S*s compared to their yoked controls was attributed to the avoidance *S*s receiving the UCS whenever needed, i.e., whenever the CR failed to occur. This interpretation specified UCS *occurrence* rather than *avoidance* as the actual reinforcing mechanism for avoidance *S*s. However, the failure of Runquist, Sidowski, and Gormezano (1962) to obtain significant differential conditioning under an avoidance paradigm tends to throw doubt on this explanation since the failure to establish inhibitory control by CS− in that study could have resulted from complete generalization of the reinforcing effects of *avoidance* from trials on which the UCS does not occur. It is thus possible that some instrumental avoidance learning, based on nonoccurrence of the UCS following CRs, is a real component of instrumental avoidance eyelid conditioning.

Kimble (1964) has stated that the classically and instrumentally conditioned eyeblinks are different responses which probably obey different laws. Namely, the difference between these responses is that the instrumentally conditioned eyeblink is a voluntary blink having short latency, rapid recruitment, and protracted duration whereas classically conditioned CRs are presumably characterized by grad-

[1] This investigation was supported in part by United States Public Health Service Research Grant NIH-HD-00955-03.

ual lid closures, long latency, and shorter duration (cf. Spence & Ross, 1959). Against this are the observations of Moore and Gormezano (1961) and Runquist et al. (1962) that CR-latency tended to be longer in avoidance groups than classical yoked controls (Moore, 1964). The instrumental procedure may indeed produce a different type of response than the classical procedure, but not necessarily having voluntary response characteristics. Like voluntary responses, the characteristics of avoidance responses might be expected to have short latency and rapid recruitment since these are the features differentially reinforced or shaped by the avoidance contingency. Furthermore, responses of long duration would tend to undergo extinction under the avoidance paradigm since, unlike "voluntary" and "true" classically conditioned CRs, long duration should ultimately contribute nothing toward precluding the UCS. The mixed classical-avoidance group (CA) was employed to determine whether it is possible for two distinct types of responses to be conditioned by two reinforcement procedures with the same *S*.

METHOD

Subjects.—Of the 72 *S*s, 57 were undergraduate students recruited from the introductory psychology course at the University of Massachusetts and 15 were students paid $1.50 for their services.

Apparatus.—The eyelid-conditioning apparatus consisted of an experimental room adjoining a control room. The *S*s were seated in a dental chair facing a panel of two Omni-Glow neon lights (Model 1010A3) spaced 8 in. apart horizontally 4 ft. from *S*. A Grayson-Stadler noise generator (Model 455-C) provided a continuous white background of noise of 60-db. SPL which was delivered via a loudspeaker positioned behind *S*. Each *S* wore a Gormezano-type headgear supporting an airjet with a 1/16-in. orifice and a Minitorque potentiometer which picked up movements of *S*'s right eyelid (Gormezano, 1966). Signals from the potentiometer were recorded by a Grass Model 5 polygraph during the on-trial period. Under the avoidance procedure, a negative base-line voltage from the output of the power amplifier operated a plate circuit relay (Potter and Brumfield Model GB5D, 5,000 ohms) which controlled the UCS delivery circuit. A positive voltage drop equal to a 1-mm. deflection of the recording pen *during the avoidance interval* broke the plate circuit and resulted in omission of the UCS. Three Hunter interval timers controlled the duration of the CS, UCS, and the avoidance interval. The CS was the onset of one of the two lights. The *duration* of each CS was 700 msec. On reinforced trials, CS onset was followed 650 msec. later by the UCS, a 50-msec. puff of compressed nitrogen delivered to the right cornea. The intensity of the UCS was 2 lb/in^2 (102 mm. Hg). Under the avoidance procedure a blink that gave a positive deflection of the recording pen of at least 1 mm. in the interval between 200 and 580 msec. after onset of the CS would prevent the onset of the UCS.[2] The intertrial interval was randomly varied between 10 and 20 sec., averaging 15 sec.

Design and procedure.—The 72 *S*s were assigned randomly into three groups of 14 males and 10 females per group designated differential avoidance (DA), differential classical (DC), and "mixed" classical-avoidance (CA). Group DC received conventional differential conditioning such that the UCS always occurred with CS+ and never with CS−. In Group DA an eyelid response to CS+ precluded the occurrence of the UCS. On a CS− trial no puff was delivered regardless of any response. In the "mixed" classical-avoidance procedure one CS was always paired with the UCS independent of response, and the other CS was paired with the air puff only if *S* failed to respond in the avoidance interval. All groups received 80 trials on a random schedule whereby there were 5 trials per block of 10 to each CS and the same CS was not presented more than twice in succession. Light positions were counterbalanced between *S*s. Neutral instructions were read immediately before the experimental session, and afterwards each *S* was asked to describe the relationships between

[2] Given a nominal ISI of 650 msec., only responses occurring within 580 msec. after CS onset were found to preclude the UCS with a probability of 1.0.

(*a*) the position of the light and the occurrence of an air puff and (*b*) blinking to a light and the occurrence of an air puff.

Response criteria.—A CR was defined as an upward deflection of the response pen of at least 1 mm. occurring no sooner than 200 msec. after CS onset. Two different scoring intervals were used since a response under the avoidance procedure had to occur before 580 msec. after CS onset in order to preclude the air puff and yet UCR onset with a latency of about 50 msec. to the UCS did not occur until approximately 700 msec. after CS onset. In the avoidance interval, responses occurring between 200 and 580 msec. after CS onset were scored as CRs. In the total interval all responses occurring between 200 msec. and 700 msec. after CS onset were scored as CRs. All data were analyzed, using both the avoidance and total scoring intervals.

Latency was defined as the time between onset of the CS and onset of a CR. Response recruitment was defined as the time between onset of a CR and its maximum closure within the total scoring interval. Responses were scored as overlapping responses if the eye was at least partially closed 700 msec. after CS onset.

RESULTS

Verbal report.—Although all *S*s were able to state the relationship between the position of the light and whether the light was always, sometimes, or never followed by the air puff, no *S* was able to state the reinforcement contingency (CR avoids puff) of the UCS under the avoidance procedure.

Response frequency.—Avoidance differentiation was significant using the mean percentage of avoidance interval CRs for each *S* over the last 50 trials, F (1, 23) = 22.26, $p < .001$. Contrasting this with the results of Runquist et al. (1962) suggests that differentiation can be established using the instrumental avoidance procedure. The procedural difference accounting for this discrepancy may be the longer ISI employed in the present study (cf. Hartman & Grant, 1962).

Figure 1 shows that differentiation was much greater in Group DC than

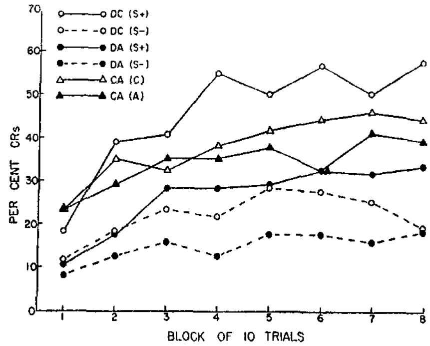

FIG. 1. Mean percentage of CRs within the avoidance scoring interval as a function of 10-trial blocks with reinforcement procedure as the parameter.

in Group DA, using percentage of CRs in the avoidance interval as the dependent measure, F (1, 46) = 5.26, $p < .025$. But using percentage of total interval CRs, differentiation was only slightly greater in the noncontingent response group (Fig. 2).

Figures 1 and 2 show that responding to the classically reinforced CS+ was higher in Group DC than in Group CA, especially with the total interval as the dependent measure, and although the difference was not statistically significant, the mean level of responding to the 100% reinforced CS

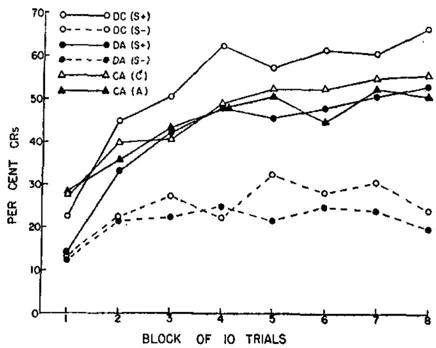

FIG. 2. Mean percentage of CRs within the total scoring interval as a function of 10-trial blocks with reinforcement procedure as the parameter.

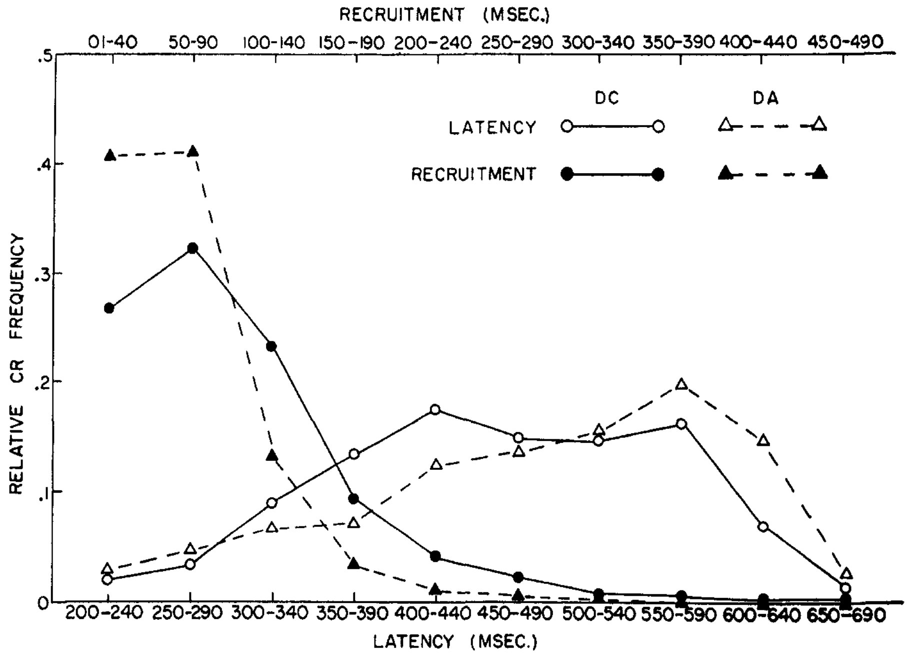

FIG. 3. Relative CR frequency as a function of latency and recruitment in the differential conditioning (DC and DA) groups.

was 53.4% in the differentiation group (DC) and 45.9% in the classical-avoidance (CA) group. If it is assumed that voluntary responding to the avoidance CS generalizes to a 100% reinforced CS and if Kimble's view that the avoidance paradigm generates voluntary responding is correct, then performance on the 100% reinforced CS might be expected to have been higher when paired with an avoidance CS than with a CS that is never reinforced. This is because voluntary responding is characterized by fast learning rates and high asymptotes (Ross, 1965), even under partial reinforcement (Moore & Gormezano, 1963). On the other hand, if the avoidance CS is thought of merely as a CS that is partially reinforced, this result agrees with Newman's (1966) finding in differential eyelid conditioning that a partially reinforced CS *depresses* responding to a 100% reinforced CS more than does a CS− that is never reinforced.

Figures 1 and 2 also show that responding to the avoidance CS was lower in Group DA than in Group CA, but only with the avoidance interval as the dependent measure. Using the avoidance interval, mean level of responding to the avoidance CS was 34.1% in Group CA and only 26.5% in Group DA. Evidently the classically conditioned response to the noncontingent stimulus in Group CA, characterized by a shorter latency (cf. Table 1), improved performance on the avoidance CS relative to Group DA by generalizing shorter latency responses to that stimulus, whereas the CS− in Group DA tended to inhibit short latency responses to the avoidance CS.

Response topography.—Figure 3 and Table 1 show that the noncontingent reinforcement procedure (Group DC) produced more short latency responses than the contingent reinforcement procedure (Group DA), however, this difference was not significant using mean latencies of individual *S*s as the dependent measure. Nevertheless, the trend was in the opposite direction to that predicted by Kimble and therefore consistent with the "avoidance" studies of Moore and Gormezano (1961) and Runquist et al. (1962). Figure 4 and Table 1 show that CR latencies to the classical and avoidance CSs in Group CA did not differ from one another and were somewhat greater than those of the two differential conditioning groups.

Table 1 shows that mean latency increased from the first 40 trials to the second in both differential groups, $F(1, 46) = 10.73$, $p < .005$. The fact that response latency increased under

TABLE 1

GROUP MEANS OF RESPONSE LATENCY RECRUITMENT, AND OVERLAP OVER 80 TRIALS AND 40 TRIAL BLOCKS

Group	80 Trials	1st 40 Trials	2nd 40 Trials
Latency (msec.)			
DC	485.0	404.0	485.4
DA	510.4	454.8	512.0
CA(C)	500.8	455.0	515.6
CA(A)	501.0	500.5	508.9
Recruitment (msec.)			
DC	94.1	78.8	100.4
DA	71.3	68.7	72.0
CA(C)	79.9	78.9	80.2
CA(A)	82.5	82.8	81.5
Overlap (%)			
DC	64		
DA	52		
CA(C)	86		
CA(A)	81		

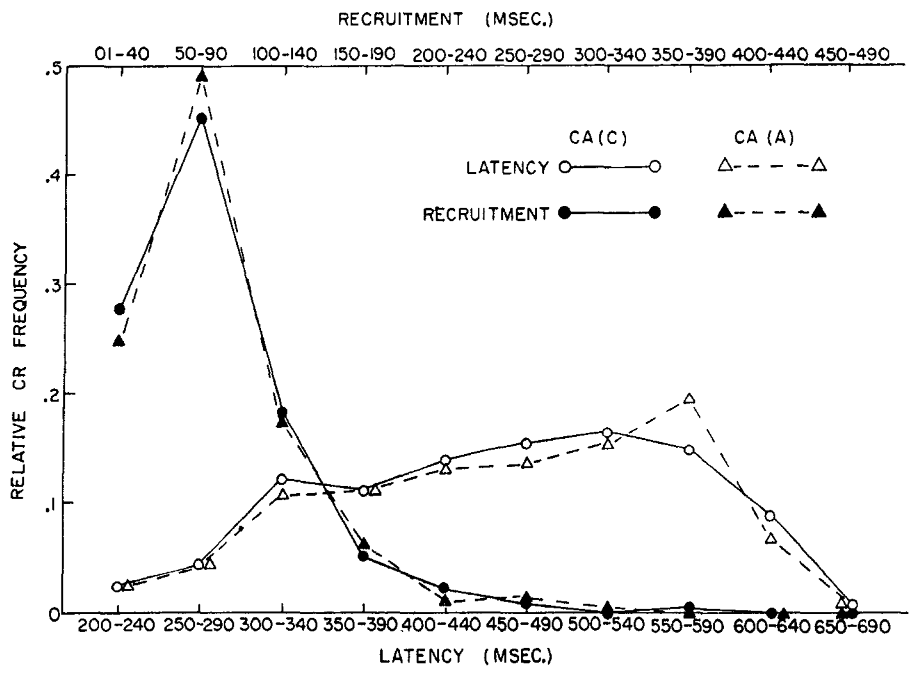

FIG. 4. Relative CR frequency as a function of latency and recruitment in the "mixed" classical-avoidance conditioning (CA) group.

the avoidance schedule would not be expected if UCS avoidance shapes anticipatory eyelid closure. Table 1 shows that mean latency also increased from the first 40 trials to the second in Group CA, F (1, 46) = 4.73, $p < .05$, especially to the noncontingent stimulus.

Figure 3 and Table 1 show that Group DA had CRs with shorter recruitments than Group DC. The effect of reinforcement contingency was significant, using the mean recruitment of individual *S*s as the response measure, F (1, 46) = 6.38, $p < .025$. This finding appears to support both Kimble's voluntary responder hypothesis and the hypothesis that UCS avoidance shapes responding. In Group CA, mean recruitment did not differ under the two reinforcement procedures and was between the means of the other two groups. Recruitment increased over training in the differential groups using mean recruitment per *S* for each 40 trial block, F (1, 46) = 7.66, $p < .01$, but Table 1 and the significant Trials × Reinforcement Contingency interaction, F (1, 46) = 4.12, $p < .05$, show that this effect was due almost entirely to the noncontingent reinforcement (DC) group.

Using percentage of overlapping CRs of individual *S*s based on all trials as an index of response duration, Table 1 shows that the noncontingent reinforcement (DC) group gave an average of 12% more overlapping CRs than the contingent reinforcement (DA) group. Using the arc sine transformation of the percentage of overlapping CRs for individual *S*s, this difference was significant, F (1, 46) = 4.5, $p < .05$. The mean percentage of overlapping CRs in Group CA was greater to the noncontingent stimulus (86%) than to the contingent stimulus (81%), but this difference was not significant.

Discussion

The present results indicate that if the instrumental procedure does produce a different type of response, it does not have the short latency and prolonged duration which characterize "voluntary" responses in eyelid conditioning.[3] It may be that the shorter recruitment and lower likelihood of response overlap of CRs in Group DA were the product of the *reinforcing* effects of UCS avoidance per se. However, the fact that *S*s could not describe the avoidance contingency suggests another interpretation, namely, that this topography is simply that of a CR *lacking* the instrumental features attributed to CRs in noncontingent eyelid conditioning. Thus, the increased recruitment over trials and higher likelihood of response overlap of CRs in Group DC might reflect instrumental components shaped by reducing the aversiveness of unavoidable puff stimulation (cf. Prokasy, 1965). There is no way in which such instrumental components can be shaped under the avoidance contingency since most anticipatory responses precluded the UCS. Such an interpretation would not be inconsistent with Moore and Gormezano's (1961) view that UCS occurrences rather than avoidance per se are responsible for the development of eyelid CRs under an avoidance contingency.

It is interesting that the avoidance contingency actually produced a CR that resembled the UCR more than the noncontingent procedure in that both the avoidance CR and the UCR are characterized by rapid recruitment, short duration, and long latency (its temporal occurrence relative to the CS). Hence, the CR produced by the avoidance schedule might be viewed as a fractional component response, whereas the CR shaped by the noncon-

[3] This finding does not agree with Hansche and Grant's (1965) observation of a high proportion of voluntary form responses in avoidance eyelid conditioning. However, it is not known to what extent *S*s in that study could verbalize the avoidance contingency. It is thus possible that "aware" *S*s do yield "voluntary" form responses in avoidance eyelid conditioning.

tingent reinforcement schedule suggests a preparatory response (cf. Kimble, 1961).

It can be concluded that although UCS nonoccurrence does not reinforce eyelid closure (increase the probability of a CR) in an avoidance situation, it does produce response characteristics that differ from those obtained in noncontingent eyelid conditioning but the two responses evidently cannot develop simultaneously within the same *S*. The conditions under which one response type or the other becomes dominant in a "mixed" or CA paradigm remains to be determined.

REFERENCES

Gormezano, I. Classical conditioning. In J. B. Sidowski (Ed.), *Experimental methods and instrumentation in psychology.* New York: McGraw-Hill, 1966. Pp. 397–401.

Hansche, W. J., & Grant, D. A. A comparison of instrumental reward and avoidance training with classical reinforcement technique in conditioning the eyelid response. *Psychon. Sci.*, 1965, 2, 305–306.

Hartman, T. F., & Grant, D. A. Differential eyelid conditioning as a function of the CS-UCS interval. *J. exp. Psychol.*, 1962, **64**, 131–136.

Kimble, G. A. *Hilgard and Marquis' conditioning and learning.* (2nd ed.). New York: Appleton-Century-Crofts, 1961.

Kimble, G. A. Categories of learning and the problem of definition: Comments on Professor Grants' paper. In A. W. Melton (Ed.), *Categories of human learning.* New York: Academic Press, 1964. Pp. 35–37.

Moore, J. W. Comparisons of classical and instrumental eyelid conditioning: A reply to Kimble. *Psychol. Rep.*, 1964, **14**, 966.

Moore, J. W., & Gormezano, I. Yoked comparisons of instrumental and classical eyelid conditioning. *J. exp. Psychol.*, 1961, **62**, 552–559.

Moore, J. W., & Gormezano, I. Effects of omitted versus delayed UCS on classical eyelid conditioning under partial reinforcement. *J. exp. Psychol.*, 1963, **65**, 248–257.

Newman, F. L. Differential human eyelid conditioning as a function of probability of reinforcement. Unpublished doctoral dissertation, University of Massachusetts, 1966.

Prokasy, W. F. Classical eyelid conditioning: Experimenter operations, task demands, and response shaping. In W. F. Prokasy (Ed.), *Classical conditioning: A symposium.* New York: Appleton-Century-Crofts, 1965. Pp. 215–223.

Ross, L. E. Eyelid conditioning as a tool in psychological research: Some problems and prospects. In W. F. Prokasy (Ed.), *Classical conditioning: A symposium.* New York: Appleton-Century-Crofts, 1965. Pp. 250–257.

Runquist, W. N., Sidowski, J., & Gormezano, I. Yoked comparisons of classical and avoidance conditioning in differential conditioning of the eyelid response. *Psychol. Rep.*, 1962, **11**, 43–50.

Spence, K. W., & Ross, L. E. A methodological study of the form and latency of eyelid responses in conditioning. *J. exp. Psychol.*, 1959, **58**, 376–381.

(Received August 26, 1966)