Human eyelid conditioning: The interaction of reinforcement schedule and CS-US interval length

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A tendency for the customary inferiority of partial reinforcement relative to continuous reinforcement performance to be greater with a long than with a short interstimulus interval was observed. Further, it was found that the drop in performance upon shifting from continuous to partial reinforcement was greater with a short than with a long ISI. The results were discussed in terms of a negative set which develops during nonreinforcement.

Fowler (1964) has obtained results indicating an interaction of percentage reinforcement and CS-US interval (ISI) length in classical eyelid conditioning. Specifically, in terms of percentage CR, the inferiority with partial (50%) as compared with continuous (100%) reinforcement was more pronounced with a long (1.1-sec) than with a short (.4-sec) ISI. This relationship was also evident with CR and UR magnitude. Kimble (1967), discussing the influences of set factors in conditioning, interpreted these findings in terms of two CS-cued processes, one excitatory and one inhibitory, with emphasis on the latter. The inhibitory process was assumed (1) to have a comparatively longer mobilization (recruitment) time after CS onset than the excitatory process (cf. Hartman & Grant, 1962), and (2) to be a consequence of S's set not to respond, which develops during nonreinforcement as a result of his feeling "tricked" into responding, or in reaction to instructions.

The main purpose of the present investigation was replication of Fowler's experiment. A second purpose was to extend that work through test of a prediction as to the consequences of a shift from continuous to partial reinforcement under long vs short ISI. The inhibitory process presumed to develop following the shift should exert a greater depressant effect on performance with the longer ISI. Thus, we might expect lower postshift CR strength with a long than with a short interstimulus interval.

SUBJECTS

Ninety-six male and female students from introductory psychology classes at Indiana University served as Ss in order to partially fulfill a course requirement. They were assigned to groups randomly in order of arrival.

APPARATUS

The S was seated on an adjustable chair in a well-lighted booth with flat white interior, located in a room separate from the control equipment room. White noise (56 dB, SPL) helped mask extraneous sounds. With his chin supported by a padded rest, S fixated on a dim pinpoint of light 4 ft directly in front of and level with his eyes. The CS was the illumination of a 1-in. translucent white plastic disc centered on the fixation point. The US was a 126-msec duration puff of nitrogen (120 mm Hg) delivered from a distance of 1 cm through a 2 mm orifice in a glass jet to the temporal right cornea. CS-US interval lengths, nominally .4 and 1.1 sec, were 450 msec and 1164 msec, $\pm 5\%$, with CS ending with US offset. Intertrial intervals were 10, 20, and 30 sec, randomly ordered and equiprobable.

Response recording methods were similar to those described by Hartman & Grant (1960). A padded aluminum plate holding the US jet and microtorque potentiometer was fixed to S's head by an elastic headband. A short length of piano wire, taped at one end to S's eyelid, was slip-fit into a section of hypodermic tube which in turn was coupled to the potentiometer shaft by a universal. Thus, lid motions rotated the shaft, generating electrical changes which, after amplification by a Brush dc amplifier, were recorded by a Brush ink-writing oscillograph at a paper speed of 130 mm/sec. Event sequences and interval lengths were controlled by conventional commercial units.

DESIGN AND PROCEDURE

After the necessary apparatus was attached, S was told, via tape-recorded instructions, that the experiment was concerned with the effects of airpuffs

on eyelid movements. He was to maintain his gaze at the fixation light, relax, and do nothing to control lid closures. The S then received four trials, two with CS alone and two with US alone, in order to check equipment and establish unconditioned blink rate to the CS.

One session of 150 trials was given, with only such infrequent pauses as necessary to remedy minor difficulties. For the first 100 trials, Ss were divided into four groups. Two groups, each with eight males and eight females, were trained with 100% reinforcement, one with .4-sec and the other with a 1.1-sec ISI. The remaining two groups, each with 16 males and 16 females, were run with 50% random partial reinforcement, one with .4-sec and the other with 1.1-sec ISI. Partial reinforcement consisted in a sequence of CS-US and CS-alone trials, randomly ordered with the following restrictions: (1) Trial 1 was reinforced, (2) run lengths did not exceed 4, and (3) equal numbers of CS-US and CS-alone trials within each 50-trial block.

From Trial 101 on, some groups experienced changed conditions. The two 100%-reinforcement groups were shifted to 50% reinforcement, without change of ISI. Each of the two 50% partial-reinforcement groups were divided into subgroups, each with eight males and eight females. One subgroup of each pair continued with unaltered conditions, and the other subgroup was given conditions unrelated to the present experiment.

Pen deflections of at least 1 mm in the direction of lid closure occurring in the proper latency range (.4 ISI: 200-425 msec; 1.1 ISI: 200-1125 msec) were counted as CRs.

RESULTS

For each group, mean percentage CR for each of the 15 10-trial blocks are shown in Fig. 1. As may be seen, our results accord with Fowler's. Averaged across Trials 1-100, the performance differences between continuous and partial reinforcement conditions was greater with the 1.1-sec ISI (68%-40%) than with the .4-sec ISI (59%-43%). The effects were slightly larger during Trials 51-100: 72%-42% for the 1.1-sec and 65%-53% for the .4-sec ISI.

However, the differences proved not statistically reliable, as evaluated by a 2 by 2 by 10 analysis of variance of Trials 1-100 data. The F associated with the pertinent interaction, Reinforcement Schedule by Interstimulus Interval (R by I), was 1.37, which has an approximate probability of .25. Nor was the Blocks by R by I interaction term significant ($F < 1$). The analysis was repeated using data from Trials 51-100, with comparable results regarding the R by I interaction ($F = 2.15$; $df = 1/88$; p approximately .15) and the B by R by I interaction ($F < 1$).

In the data from Trials 1-100, the main effects for Blocks ($F = 22.60$; $df = 9/828$; $p < .01$) and Reinforcement Schedules ($F = 15.76$; $df = 1/88$; $p < .01$) were highly significant. It may be of some interest that the B by I interaction was significant ($F = 5.92$; $df = 9/828$; $p < .01$). This reflects the fact that, while performance levels with the 1.1-sec ISI were initially superior to those with the .4-sec ISI, this advantage disappeared by the end of 100 trials. No other effects were significant. All analyses were repeated with the sex variable included without change in the above conclusions.

A 2 by 2 by 5 analysis of variance was performed on the data from Trials 101-150. As shown in Fig. 1, the two groups continued on partial reinforcement continued at the same level of performance, with the .4-sec group somewhat superior to the 1.1-sec one. Note, however, the results obtained from the two groups shifted from continuous to partial reinforcement. The 1.1-sec group dropped rapidly to a level above that for the group run under those conditions from the outset. In contrast, the .4-sec group dropped quickly to a level below that for the group given partial reinforcement with .4-sec ISI from the outset. The I by R interaction which should be sensitive to such effects was marginally significant ($F = 3.14$; $df = 1/56$; p approximately .07). No other effects were significant except the I by B term ($F = 2.88$; $df = 4/225$; $p < .05$).

Fig. 1. Mean percentage CR for each 10-trial block for each group. Sample size for Groups PP .4 and PP 1.1 were reduced from 32-16 for Trials 101-150.

DISCUSSION

Taken together the data obtained provides neither robust support nor an outright contradiction of Kimble's view that a negative set develops during partial reinforcement which, by virtue of a longer mobilization time, more effectively depresses performance with a longer ISI. First, the proposition that ISI and percentage reinforcement interact in controlling CR performance in classical conditioning has received only the weakest confirmation. Though the relative mean performances for the four groups were comparable to those observed by Fowler, the pertinent statistical comparisons failed to reach acceptable significance levels. Second, the evidence from shifting from continuous to partial reinforcement runs counter to simple-minded expectations based on Kimble's views. The observed performance drop was less rapid and less pronounced for the longer ISI, which presumably should allow more time for inhibitory effects to be manifest. On the other hand, other evidence recently published is less in conflict with those views. Ominsky (1968) has shown that performance differences between facilitatory and inhibitory instructions were greater with a long than with a short ISI.

Very probably the difficulty lies in the fact that so little is known of the conditions which induce positive, negative, or neutral sets, and how such sets interact with other experimental conditions. For example, we assumed that partial reinforcement would produce the same negative set whether that procedure followed continuous reinforcement or was in force from the outset. This assumption is probably unwarranted given the likelihood that the nature of the set induced by particular conditions would depend upon contextual factors such as instructions, prior experience, etc. Finally, very little is yet known about the consequences of

shifts of percentage reinforcement to values other than zero (extinction). Our results conflict with the two prior investigations of this issue (Ross, 1959; Runquist, 1963). In both, performance for groups shifted from continuous to partial rapidly came to match that for groups run at that reinforcement percentage from the outset. Only in the case of a very weak US (Runquist) is there an apparent exception. There seems little one can say by way of explanation until the interaction between US intensity, reinforcement percentage, and percentage of shift is more completely delineated.

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NOTE

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