Delayed response by squirrel monkeys under various delay lighting conditions¹

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Four squirrel monkeys were tested on direct delayed response problems with delays up to 60 sec. At delays of 5 sec. or more, performance was higher when the delay interval was lighted than when it was darkened. The presence of glo-lights at the response loci during the darkened delay was without discernible effect on performance.

Successful solution of spatial delayed response (DR) problems requires S to remember the position of a reward over a delay interval during which this location is not defined by any external cue. The degree of illumination prevailing in the delay interval frequently has a profound effect upon DR performance. However, the results of past research on the effects of placing S in complete darkness during the delay interval are rather complex with both improvement and decrement in performance being reported depending upon the particular DR technique, discriminanda, etc. (Malmö, 1942; McDowell & Brown, 1960).

Any theoretical interpretation of the effects of intervening darkness upon DR are necessarily somewhat equivocal since this procedure has at least two conflicting consequences. First, as emphasized by Malmö, the darkness eliminates extraneous visual stimulation and therefore increases the likelihood that the predelay association to the rewarded locus will be retained. But in addition, the darkness prevents S from maintaining visual orientation to the rewarded locus and would thus be expected to lower the strength of the predelay association.

The present experiment was designed to separate these two opposed effects by testing squirrel monkeys on spatial DR problems in which one of the following conditions prevailed during the delay: light, complete darkness, or darkness with illumination of the two response loci. The rationale for the latter condition was that it largely eliminated extraneous visual stimulation while permitting visual orientation to the rewarded locus.

Method

The Ss were two male and two female adult squirrel monkeys (*Saimiri sciureus*). All had extensive previous experience with discrimination problems but had not received any DR training.

The Ss were tested in a modified version of the WGTA. The stimulus tray was manually operated and contained two 7/8 in. diameter foodwells separated by 7 in. from center to center. On the front of the tray immediately beneath each of the two foodwells was a 1/7 w neon glo-light which emitted a soft orange light when acti-

vated. The stimulus tray was illuminated by an overhead 60 w incandescent light. The foodwells were covered by identical 1-1/2 in. by 1 in. by 1 in. white wooden blocks.

Each DR trial was initiated by the raising of the opaque screen which separated S's restraining cage from the stimulus tray. At this time the nonrewarded foodwell was already covered by a white block while the rewarded foodwell was uncovered. S's attention was directed to a raisin placed on the tip of a knife and the raisin was then conspicuously placed in the uncovered foodwell. This baited foodwell was then covered by a white block and, following the delay interval, pushed forward to within S's reach. If S failed to respond within 15 sec. after the tray was pushed forward, the tray was withdrawn and the above procedure repeated. The position of the reward was varied according to a Gellermann sequence.

One of the following conditions prevailed during the delay: (1) The overhead illumination of the stimulus tray remained on. (2) The overhead illumination was turned off leaving S in darkness until the end of the delay interval. (3) The overhead illumination was turned off and the glo-lights on the front edge of the tray underneath the two foodwells were turned on.

During phase 1, all Ss were tested with all nine possible combinations formed from the above three delay conditions and 1, 3, or 6 sec. delay intervals. Each daily test session consisted of 45 trials, five under each combination. The presentations were randomized with the restrictions that all nine combinations appeared in successive blocks of nine trials and that the same delay condition or delay interval did not appear on two successive trials. Phase 1 continued for 20 testing days or 900 trials.

Two days following the end of phase 1, phase 2 was begun. During this latter phase, the range of the delay intervals was extended to include 1, 5, 15, 25, 40, and 60 sec. intervals. As in phase 1, all possible combinations of delay condition and interval were randomly presented with the restrictions that all 18 possible conditions appeared in successive blocks of 18 trials and that no particular delay condition or interval appeared on two successive trials. All Ss received 54 trials per day over 40 test days for a total of 2160 trials.

Results

An analysis of variance for the data from phase 1 revealed that performance decreased with increasing delays ($F=62.0, df=2/6, p<.005$) and increased from the first to the second ten day block ($F=52.0, df=1/3$,

Fig. 1. Percent correct responses during phase 2 as a function of delay interval and lighting condition.

$p < .005$). At the 1 and 3 sec. intervals there was only a negligible difference among delay conditions, while at the 6 sec. interval orthogonal comparisons showed that the lighted condition was superior to the darkened and the glo-light conditions ($F=18.2$, $df=1/6$, $p < .01$) while there was no significant difference between the latter two conditions. The emergence of differences among delay conditions only after a 6 sec. delay was also reflected in a significant conditions by delay interaction ($F=4.7$, $df=4/12$, $p < .05$).

DR performance during phase 2 as a function of delay condition and interval is depicted in Fig. 1.

The only significant effects during this phase were delay intervals ($F=73.5$, $df=5/15$, $p < .005$) and delay conditions ($F=9.1$, $df=2/6$, $p < .025$). Orthogonal comparisons within this latter effect showed that, as with the 6 sec. delay in phase 1, performance was higher in the lighted condition than in the two darkened conditions ($F=18.2$, $df=1/6$, $p < .01$) with no significant difference between these latter two conditions. With a lighted delay, responding was above chance for all delays up to 60 sec. while above chance responding occurred only up to 25 sec. delays with the two darkened delays.

Discussion

This experiment showed that for delays greater than 5 sec. DR performance by squirrel monkeys was depressed when the delay interval was darkened and that the presence of glo-lights at the two response loci during

a darkened delay was without any apparent effect. The lower performance with darkened delays is in agreement with McDowell & Brown's results (1960) with rhesus monkeys and is not consistent with the hypothesis that a darkened delay will increase performance by minimizing the disruptive effects of extraneous visual stimuli. In fact, the sudden cessation of light after the predelay baiting of the foodwell may itself have served to distract S's attention from the rewarded locus. That a darkened chamber is an aversive stimulus for squirrel monkeys (Parker, 1966) may also have contributed to the inhibitory effects of this delay condition. The ineffectiveness of the glo-lights in appreciably affecting performance suggests that the lower performance during the darkened delay is not attributable to the failure of the response loci to be visually differentiated during the delay.

The differences among the lighted and the darkened delay conditions emerged at the 5 sec. delay and remained approximately constant for all longer delays while at the 1 and 3 sec. intervals, performance was virtually identical under all delay conditions. This discrepancy is consistent with the hypothesis that two processes mediate DR performance in squirrel monkeys, namely a short term process lasting up to about 5 or 6 sec. which operates independently of the lighting during the delay and, for longer intervals, a long term process which is highly susceptible to the lighting variable.

The demonstration that a variable significantly affects performance for only relatively long delays is not without precedent in the literature; Michels & Brown (1959) showed that additivity of object and spatial cues for raccoons occurred only at delays greater than 15 sec. It is therefore clear that testing under relatively long delays may be necessary to assess adequately the effect of a variable on DR performance.

References

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Note

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