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Introduction

A number of recent investigations have been concerned with the study of the effect of varying the length of delay of reward and of shifting this delay period on level of performance in instrumental conditioning (1, 2, 5, 6, 7, 8, 9, 11). In general, these studies have found level of performance at the asymptote to be some inverse function of the time of delay and that the length of delay that will still provide for learning appears to be a function of the effectiveness of secondary reinforcement in the situation (1, 6, 7, 10).

The experimental findings with regard to *shifts* in the delay of reward have shown that a shift from a given delay to a shorter one consistently leads to an increase in performance, the change being a fairly gradual, prolonged one. Shifts to a longer delay, on the other hand, have led to quite inconsistent results. Thus Harker (2) found that animals trained to depress a bar under a one second delay showed no decrease in performance level when shifted to a ten second delay. Logan (5), using a dual-response type of Skinner box, trained animals to respond to two bars, one followed by reward after one second, the other followed by reward after five seconds. When the delays were reversed a parallel reversal of response speeds was noted. In this case it is clear that a shift in the direction of a longer delay led to a decrease in performance level. Similar results were obtained by Seward and Weldon (8), using two and one-half and ten seconds as delays.

Shilling (9) trained animals to respond to a bar under a one second delay then shifted one-third of them to a five second delay, one-third to extinction conditions, the remaining one-third being continued as a control group with a one second delay. Whereas the extinction group showed a gradual decrement in performance level, the five second group showed no significant change. When the control group was later shifted to a ten second delay, a significant and gradual performance decrement occurred. In comparing the five and ten second groups Shilling noted that ". . . the five second animals almost invariably remained at the food cup during the delay interval making characteristic anticipatory movements . . ." whereas the ten second animals ". . . tended to turn away from the food cup . ."

The implication of Shilling's statement is that the responses of turning or moving away from the point of bar contact during the delay period competed with the previously learned response chain and thus led to its weakening. Apparently the animals were able to maintain their orientation towards the region of the bar for a five second period but not for ten seconds. Accepting Shilling's suggestion that the presence of such competing responses during the delay period is an important factor determining the level of performance, the present study attempted to investigate this factor further by comparing the performance of animals in two situations presumed to be differentially conducive to making the incompatible turning response. One situation involved a narrow, confining reaction chamber while the other consisted of a much larger, less restrictive box. On the assumption that confinement would reduce the likelihood of the occurrence of incompatible responses during the delay period, it would be expected that this condition would lead to a higher level of performance than the unconfined condition.

Experimental Method

Apparatus

The apparatus consisted of two compartments (a starting box and a goal box) separated by a manually operated brass guillotine-type door. The goal box could be used in either a confined or unconfined form. In the former, insertion of partitions reduced the goal box to a 6″ x 3″ x 2″ compartment. In the unconfined form the goal box was a 6″ x 17″ x 11½″ compartment. The goal box contained a retractible brass bar and a food cup. The floor of the apparatus was entirely of brass, the sides of pine painted flat black.

Raising the door started an electric timer. By touching the bar the rat completed a low-amp contact relay circuit (3) between the brass floor and the bar. Closure of this circuit stopped the timer, activated the bar mechanism which retracted the bar and fired an interval timer which determined the extent of delay between bar contact and delivery of the food pellet into the cup.

Procedure

Ten naive female hooded rats were randomly assigned to each of four groups designated in terms of type of goal box and delay of reinforcement condition: i.e., unconfined, immediate reinforcement (UC:0), unconfined ten second delay (UC:10), confined, immediate (C:O) and confined, ten second (C:10).

After preliminary explorations each of these groups was given 12 daily blocks of five training trials. On each trial *S* was placed in the starting box and the door was raised as soon as it had

faced the goal box. Upon entering the goal box, contacting the bar and eating the pellet that was delivered, the trial was terminated.

After the training trials under the confinement-delay conditions to which the *S*s had been originally assigned, 50 post-shift trials were run in daily blocks of five. Those animals that had been run under immediate reinforcement condition were shifted to a ten second delay; those originally trained under ten seconds delay to immediate reinforcement. No shift was made in confinement conditions.

Results

The results of the experiment involve two classes of data: speed of response and observations of the animals' behavior in the goal boxes.

Figure 1 shows the means of the speed measures during initial learning computed for all animals in each group by blocks of five trials. As the figure reveals, the animals in both the immediate reward groups (confined and unconfined) learned at the same rate and reached the same performance level prior to shift, whereas the animals in the confined ten second delay group learned at a more rapid rate and reached a higher performance level than did those in unconfined ten second delay group.

The mean of the running speeds on the last ten trials of the initial learning period for each group were analyzed in a simple 2 x 2 factorial design (4). The results of this analysis indicated

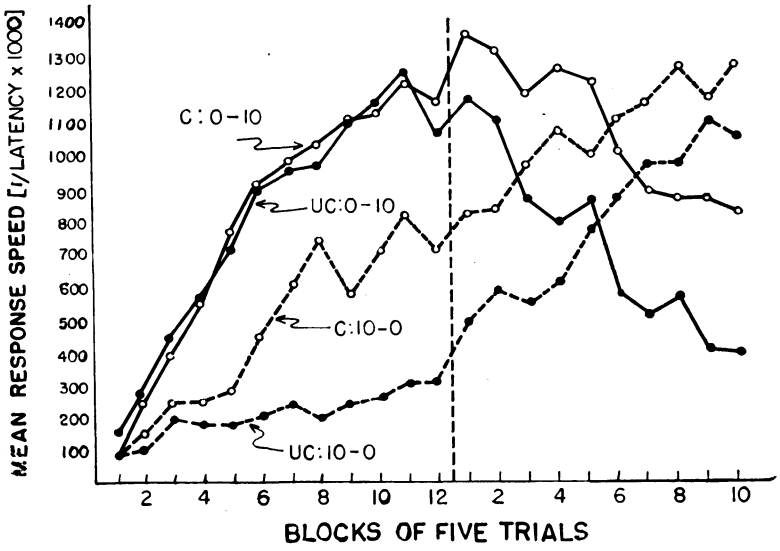

Fig. 1. Mean response speeds for each group computed by blocks of five trials for the initial learning and post-shift periods.

that both the confinement and delay effects were significant at better than the 5 per cent level. The simple effects of each of the two factors, at each level of the other, were also analyzed. This analysis indicated that the immediate reward groups had significantly higher performance levels in both the confined and unconfined conditions, and that the confined group's performance level was significantly higher than that of the unconfined group at the ten second delay level but that there was no difference between the confined and unconfined groups at the immediate reward level.

Figure 1 also shows the post-shift means of the speed measures computed for all animals in each group by blocks of five trials. The figure indicates that with a shift from immediate reward to a ten second delay there was a gradual decrease in performance to the level reached by the confined ten second delay group in the initial learning period. Similarly, the response speed of the corresponding unconfined group decreases to the level reached by the unconfined ten second delay group in the initial learning period. With a decrease in delay from a ten seconds to immediate reward there was a gradual increase in performance, the final level reached being virtually the same for both the confined and unconfined groups. This level approximated that reached by the immediate reward groups in the initial learning period.

The mean speeds measures on the last ten post-shift trials were also analyzed in a simple 2 x 2 factorial design (4). The results of this analysis demonstrated that both the confinement and delay effects were significant as they were in the initial learning analysis. The simple effects of each of the two factors were also analyzed. This analysis showed that the unconfined group shifted to a ten second delay has a performance level that is significantly lower than the corresponding confined group. As was the case in the analysis of the initial learning data, the immediate reward groups do not differ significantly whereas the effect of delay is significant for both the confined and unconfined conditions.

In observing the animals' behavior in the goal boxes it was noted that four of the animals in the unconfined group that had been shifted from immediate reward to ten seconds delay showed a marked tendency to wait at the bar position during the interval that followed bar contact. This was in contrast with the other animals that consistently moved away. This observation is similar to the one made by Shilling in comparing his five and ten second post-shift groups. To evaluate this effect the mean speeds on the last ten post-shift trials were computed for the four animals failing to show incompatible responses and for the six remaining animals, those showing incompatible responses. The difference in these means was evaluated by a test found to be significant at less than the 2 per cent level.

Discussion

The present experiment has corroborated earlier experiments in showing that level of performance (speed of response) in a simple instrumental learning situation is lower with delay of reward than when reward is immediate. The increase in performance obtained with shift from delayed to immediate reward was also in agreement with the findings of past investigations. The decremental effect on performance following immediate reward to a delay of ten seconds was similar to that obtained by Logan (5) and Seward and Weldon (8), and in the case of Shilling's (9) *S*s that were shifted from one to ten seconds delay. They were in disagreement with the findings of Harker (2) and Shilling's results with his five second delay group. No decrement in performance occurred following shift to a longer delay in these latter instances.

That the conflicting results of shifting to a longer delay of reward connot be accounted for exclusively in terms of the obsolute length of delay is shown by the fact that Harker's animals were changed from one to a ten second delay and yet they showed no effect of the shift. On the other hand, Logan obtained a decrement in response strength when the reward delay was increased from one to only five seconds. Undoubtedly an important factor in Logan's study was the fact that his situation involved two bars, one of which was being reinforced with only a one second delay of reward during the same period of training.

Shilling's experimental situation, it should be noted, consisted of a part of that used by Logan, the response chamber involving only one of the response bars. Whereas Logan found a decrement upon shift to a five second delay of reward, Shilling did not. One possible explanation is that Logan's animals tended to turn away from the long delay bar to the short delay bar during the delay interval whereas Shilling reported that *S*s in his five second group did not.

It is interesting to note in this connection that Harker's situation did not involve entering the reaction box from a starting box and responding to the bar on successive, discrete trials. His animals remained in the reaction box at all times and waited for the insertion of the response bar into the box along side the food cup. Under these conditions the animals tended to learn to orient and remain directly in front of the food cup and bar, awaiting its insertion. Furthermore, they did not move away, but maintained their orientation throughout the delay interval.

The present experiment has provided further evidence suggesting that an important factor determining performance level in delayed reward situations is the degree to which responses incompatible with the learned response sequence occur during the period of delay. Under the confined condition of the present exper-

iment, which presumably tended to restrain turning away from the food cup during the delay period, the performance level was significantly superior to that in the unconfined situation. Furthermore, it was found in the post-shift period that *S*s in the unconfined condition that exhibited little or no incompatible responses during the delay interval performed at a significantly faster rate than *S*s that did show such responses.

Summary

A factorial type experiment was run to study the effect of physical confinement on the performance of animals trained to respond under different delays of reward. The effect of shifting reward delays and the relation of these effects to confinement were investigated in a second experimental period.

During the initial learning period of 60 trials, 40 animals, randomly divided into four equal groups, were trained to enter a box and depress a bar. Two of the groups received food reward immediately after making the bar response, the other two received the reward after a ten second delay. One of the immediate reward groups was run under conditions of physical confinement, the other under unconfined conditions. Similarly, there was a confined, ten second delay group and an unconfined, ten second delay group. In the second period of the experiment the animals that had been trained under immediate reward conditions in the first period were shifted to a ten second delay of reward while those initially trained under ten second delay conditions were shifted to immediate reward. No shift in confinement conditions was made.

Acquistion curves in terms of speed of response indicated that the confined immediate and unconfined immediate reward groups improved at the same rate and reached the same final performance level, this level being higher than that attained by either of the ten second groups. The confined ten second group improved at a faster rate and reached a higher final level of performance than the corresponding unconfined group.

When the ten second groups were shifted to immediate reward their performance increased gradually to approximately the same final level, one comparable to the level of the immediate reward groups in the initial learning period. Shift from immediate reward to a ten second delay resulted in a progressive decrease in speed with the unconfined group showing a more rapid drop to a lower level than that of the confined group.

The fact that the confinement condition led to a higher level of performance under delayed reward was interpreted as being due to restrictions it placed on the making of acts during the delay period that were incompatible with those involved in the learned

reaction chain. Supporting evidence for this interpretation was the finding that in the unconfined group shifted to ten second delay, *S*s that were observed to make incompatible responses during the delay period performed at a significantly lower level than did animals that exhibited few of such responses.

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