The effects of response-dependent and response-independent methods on delayed alternation

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Two frequently used methods of producing delayed alternation were compared at two ITI levels, 20 sec and 6 min. One method alternated reward according to a fixed schedule (response independent), while the other demanded placement of reward opposite to the S's previous response (response dependent). The response-dependent method produced a higher number of correct responses and alternations at both ITIs. Increasing the ITI duration from 20 sec to 6 min produced reliable decreases in the number of correct choices and alternations produced by Ss trained according to either procedure.

Two distinct procedures have been developed to produce delayed alternation behavior. Carr (1917) alternated reward placements according to a predetermined schedule (L, R, L, R, . . .) independent of the S's response on any one trial. Subsequently, Elder and Nissen (1933) recognized inherent difficulties of scoring alternation behavior by this method and redesigned the paradigm so that reward placement was always alternate to the S's previous response regardless of whether this response had been correct or incorrect. Alternation behavior produced by either procedure has since been used as a dependent variable in a wide variety of comparative, physiological, and memory experiments (e.g., Petrinovich & Bolles, 1957; Pribram, Wilson, & Connor, 1962; Racine & Kimble, 1965; and Livesey & Trinder, 1966). However, none of these studies takes into account the differing behavioral consequences which might result from the two delayed alternation methods.

The purpose of the present research was to compare within a single study alternation behavior produced by these methods and to observe the possibility of a differential effect on alternation at an extended intertrial interval.

METHOD

Subjects

Ten 150-day-old male Long-Evans rats from the Virginia Polytechnic Institute and State University colony were individually housed with access to ad lib water in their home cages throughout the procedure.

Apparatus

The apparatus was a modified T-maze with 18-in. walls. A choice area (8 in. wide) proceeded from a removable startbox (7½ in. square x 8 in. high) for a distance of 7½ in., where it was laterally bisected by a partition into two adjacent alleys, each 4 in. wide and 18 in. long. At the ends of the sections, both alleys turned and proceeded in the opposite direction while adjacent to the first sections, the choice area, and the startbox for a distance of 36 in. At the end of the second section of alleyway, the goal areas (3½ x 8¼ in.) were set perpendicular to the direction of the alleys and passed behind the startbox so that the ends of each goalbox were opposite sides of the same wall. Each goalbox was equipped with a goal cup measuring 1½ in. in diam. Retracing was prevented, and forcing procedures were facilitated by removable barriers situated at the beginning of both alleys and both goal areas.

To maximize situational cues, the left alley, set at a 10-deg incline, had a sandpaper floor and was painted flat black in contrast to the right alley, which was set at a 10-deg decline, had a wire grid floor, and was painted flat white. All other sections of the apparatus were unpainted.

Procedure

The experiment was divided into two phases, each with handling, maze training, and testing stages. Throughout these two phases, Ss received 12 g of Purina Rat Chow daily. A 30-day period occurred between the phases; during this time, the Ss were not tested and were maintained on ad lib food and water.

Handling

During a 48-h food-deprivation period preceding the maze training stages of both phases, all Ss were handled for 5 min daily.

Maze Training

For Phase I, Ss were alternated for nine trials daily starting from the goal area on Day 1, the beginning of the second section of the alleys on Day 2, and from the startbox on Days 3 and 4, with the correct response being forced by blocking the entrance to the incorrect alley. The intertrial interval (ITI) was 20 sec, and the reward was two 45-mg Noyes pellets.

For Phase II, the same method of forced alternation was used, except that Ss were started immediately from the beginning of the second alleys on Days 1 and 2, from the beginning of the first section of the alleys on Days 3 and 4, and from the startbox on Days 5 and 6.

Maze Testing

Throughout the experiment, two distinct procedures were used to produce delayed alternation behavior. One method (response independent) alternated reward placements according to a fixed alternation sequence (L, R, L, R, . . .). The other technique (response dependent) required placement of reward for each trial in the goal area opposite to the one chosen by the S on the previous trial. For all Ss, two Noyes pellets were placed in both goal cups on the first of the nine daily test trials. The corresponding response, not counted in the number of correct responses or alternations, served as a basis for the subsequent pattern of reward placement for that testing day. Throughout the testing stages, a noncorrection procedure was used.

For the first 5 days of Phase I maze testing, all 10 Ss were alternated according to the response-independent method. On Day 6, 5 Ss were assigned to the response-dependent method; the remaining 5 Ss were assigned to the response-independent procedure. Both groups were run according to their assigned procedure for the remainder of the Phase I and all of the Phase II

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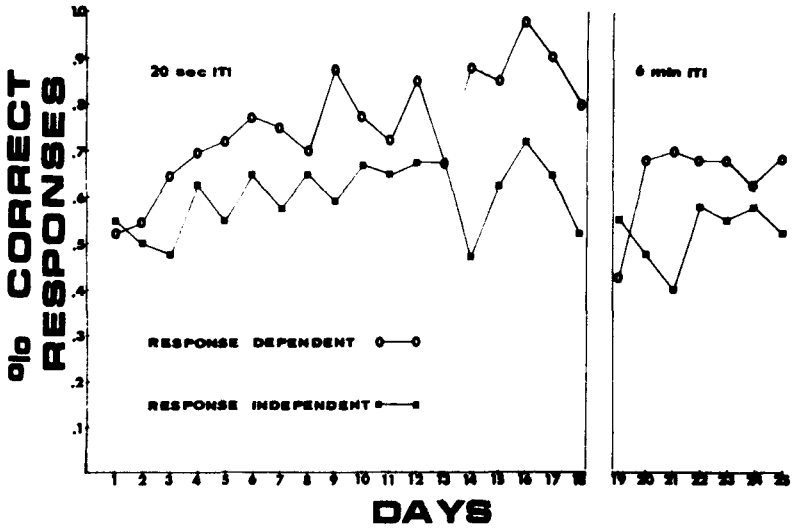

Fig. 1. Mean percentage of correct responses produced by the response-dependent and response-independent groups during the Phase II 20-sec and 6-min ITI sessions.

maze testing trials. A 20-sec ITI was employed throughout the days of Phase I and the first 18 days of Phase II. A 6-min ITI was used for the subsequent 7 test days of Phase II.

On the last test day (26th) of Phase II, a procedure controlling for olfactory or other intratrial cues was initiated; on the second trial of this day's testing, the two pellets were deliberately placed in the reward cup of the same goal chamber chosen by the S on the first trial. Therefore, Ss alternating correctly received no reward on the second trial, indicating that cues directly produced by the pellets were not guiding their alternation responses. Trials 3-9 on this test day were conducted in the usual manner.

RESULTS

The response-dependent and -independent methods did not produce statistically reliable differences in performance for the Phase I maze testing sessions. Figure 1 shows the percentage of correct responses as a function of Phase II test sessions. The response-dependent group produced a larger percentage of correct responses than did the response-independent Ss throughout the 20-sec ITI Phase II test sessions. An overall increase in the percentage of correct responses is apparent for both groups during this period. Analysis of variance revealed that the differences in percentage of correct responses between methods ($F = 7.86$, $df = 1,8$, $p < .025$) and between testing days ($F = 1.96$, $df = 17,128$, $p < .05$) achieved statistically reliable levels; however, the Methods by Days interaction effect did not.

Figure 1 also indicates that the percentage of correct responses produced by both methods decreased for Days 19-25 of Phase II when the ITI was increased from 20 sec to 6 min. Despite the drop in performance, the differences in the percentage of correct responses apparent during the first 18 test days of Phase II were maintained during the 19-25 test sessions. During the 6-min ITI test sessions, the response-dependent method produced a significantly larger percentage of correct responses than did the response-independent procedures ($F = 6.71$, $df = 1,8$, $p < .05$). The overall decrease in the percentage of correct responses initiated by increasing the duration of the ITI also proved to be statistically reliable.

Figure 2 shows the percentage of alternations as a function of days for Phase II of the experiment. For

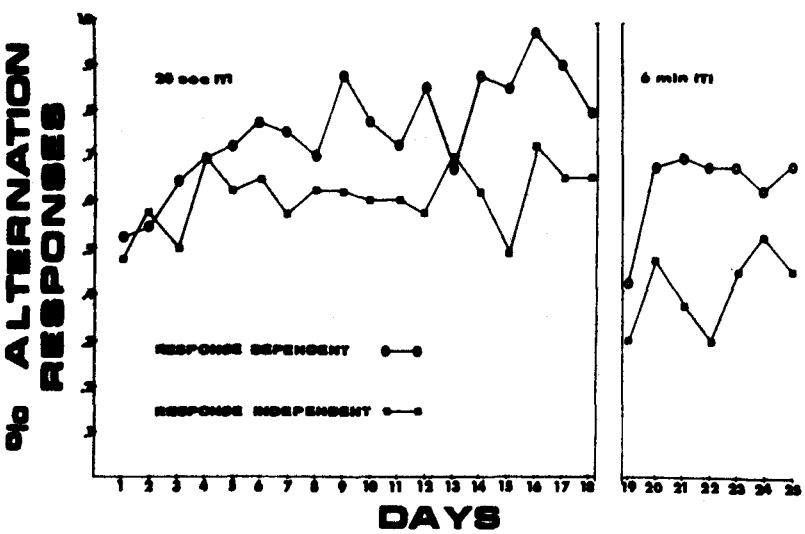

Fig. 2. Mean percentage of alternations produced by the response-dependent and response-independent groups during the Phase II 20-sec and 6-min ITI sessions.

both groups, an alternation was scored if the S chose the goal area not chosen on the previous trial regardless of whether the previous response had been rewarded. Therefore, the percentage of alternation responses and the percentage of correct responses were equivalent for the response-dependent group but not for the response-independent Ss. Figure 2 indicates that the response-dependent group alternated on a larger proportion of the 20-sec and 6-min ITI test sessions; the switch from a 20-sec to a 6-min ITI initiated an overall decrease in the percentage of alternations produced by both groups.

Analysis of variance indicated that the differences in the percentage of alternation responses produced by the response-dependent and -independent groups did not achieve statistically reliable levels at either ITI duration. The decrease in the percentage of alternation responses produced by increasing the duration of the ITI was statistically reliable ($p < .01$).

The percentage of correct responses for the response-independent group was well above chance for the 20-sec ITI but not for the 6-min ITI test sessions. The percentage of alternations for the response-independent group was above chance at the 20-sec ITI level; at the 6-min ITI level, however, the group performed significantly below chance, indicating a tendency to perserverate responses. In marked contrast, the response-dependent group showed above chance percentage of correct responses and alternations at both ITI durations.

The last (26th) day of Phase II constituted a control procedure. On the second trial of this test session, reward placement was deliberately perseverated rather than alternated for all Ss. For this trial, all 10 Ss chose the goal area opposite the one entered on the previous trial (alternated), thus committing "an error." During the next (third) trial, all 5 Ss of the response-dependent group and 4 of the 5 Ss of the response-independent group alternated their choice of goal area again.

DISCUSSION

Substantially different requirements for a correct response are inherent in each of the two methods of alternation. The response-dependent method requires that Ss always make a response alternate to the previous response; the response-independent method requires that Ss alternate their responses only after a previously correct response but perseverate after an incorrect response. The fact that no significant differences in frequencies of alternations occurred between the two methods suggests that all Ss acquire the alternation requirement common to both procedures, but fail to meet the additional requirement of the response-independent method of perseverating after an incorrect response. Another test is provided by the control day data. On the second trial of this session, Ss alternating their response after the first always-rewarded trial received no reward. All 10 Ss alternated on the second trial, indicating that pattern of reward placement and not olfactory or other cues directly produced by the pellets were the basis for Ss' responses. On the third trial, all 5 Ss of the response-independent group entered the goal area opposite the one chosen on the previous trial.

The effect of increasing the ITI from 20 sec to 6 min was to reduce the percentage of correct responses and alternations produced by both alternation procedure groups. The response-dependent Ss maintained above chance levels of alternation and correct responding at the extended ITI. In marked contrast, the response-independent group showed perseveration. Perseveration responses produced by the response-dependent rats were invariably nonreinforced. For the response-independent group, however, repeating the same response on every trial resulted in reinforcement on 50% of the trials. Apparently, this frequency of reinforcement was sufficient to maintain their perseveration behavior.

Given that both methods of delayed alternation produce similar behavioral effects, the results of the present study indicate, in accord with Elder and Nissen (1933), that the response-dependent method of producing alternation is the procedure of choice for experiments which use delayed alternation as a dependent variable, especially those which employ extended intertrial intervals.

REFERENCES

Carr, H. A. The alternation problem. Journal of Animal Behavior, 1917, vii, 365-384.

Elder, J. H., & Nissen, H. W. Delayed alternation in raccoons. Journal of Comparative Psychology, 1933, 16, 117-135.

Livesey, P. J., & Trinder, J. The rat and cat in the delayed alternation problem. Psychonomic Science, 1966, 5, 437-438.

Petrinovich, L., & Bolles, R. Delayed alternation: Evidence for symbolic processes in the rat. Journal of Comparative & Physiological Psychology, 1957, 50, 363-365.

Pribram, K. H., Wilson, W. A., & Connor, J. The effects of lesions of the medial forebrain on alternation behavior of rhesus monkeys. Experimental Neurology, 1962, 6, 36-47.

Racine, R. J., & Kimble, D. P. Hippocampal lesions and delayed alternation in the rat. Psychonomic Science, 1965, 3, 285-286.

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