9-1-1967

Response Speed as a Function of Different Reinforcement Conditions and a Ready Signal

Anees A. Sheikh
Marquette University, anees.sheikh@marquette.edu

Accepted version. *Child Development*, Vol. 38, No. 3 (September 1967): 857-867. DOI.

Child Development, Vol. 38, No. 3 (September 1967): 857-867. DOI.

Response Speed as a Function of Different Reinforcement Conditions and a Ready Signal

Anees A. Sheikh
Psychology Department, Marquette University, Milwaukee, WI

80 preschool children were each administered 40 trials on a key-pressing apparatus. Marbles served as reinforcers. Ss given a ready signal performed faster than Ss not given a ready signal. There was no difference in the mean speeds of the partial reinforcement and the varied delay groups, but both of them performed faster than the constant delay group. The continuously and immediately rewarded group performed faster than the other three groups. The effect of a particular reward condition manifested itself on the immediately following trials. Interpretation in terms of competing responses was offered.

Amsel (1958) defines frustration as a primary motivational condition that contributes to general drive level. It is a consequence of nonreward after the anticipatory goal response (r_R) has been developed over a number of previously rewarded trials. In addition, a classically conditioned antedating form of frustration (r_t), together with its internal stimulus properties (s_t), is a temporary inhibitory factor in this hypothesis. Several animal studies (see Amsel, 1958; 1962; Spence, 1960) have shown the motivational and inhibitory properties of nonreward.

With a few modifications, the foregoing theory has been extended to situations involving children. For example, it has been suggested (Ryan, 1963; Ryan & Cantor, 1962) that the expectancy of reward develops much faster in children than in rats, and consequently the motivational increment due to frustration may be expected to occur after the early nonrewarded responses. The theory in this modified form has yielded predictions which have been repeatedly confirmed (e.g., Penny, 1960; Ryan, 1963).

Estes (1963) proposed that partial reinforcement may be regarded as a situation in which there is no delay (immediate reward) or a finite delay on a random half and an infinite delay on the remaining half of the trials. In contrast, varied delay of reward constitutes a situation in which there is either a relatively short or no delay on a random half and a longer but finite delay on the remaining half of the trials. Regarding partial reinforcements as the limiting case of varied delay of reward, Estes reasoned that it was feasible to develop similar predictions for varied delay as for partial reinforcement. He further proposed that with children it was possible that frustration would occur even under a constant delay of reward after each trial and that instructions, or generalizations from prior experiences to some aspect of the experimental situation, would perhaps be sufficient to make children expect an immediate reward. Delay would thwart such an expectation, thus leading to frustration.

If the assumption is accepted that the mechanism of frustration is operating in all the three reinforcement situations, the following questions arise: Does frustration manifest itself in the same manner in all three of these situations? If not, what are the differences?

Numerous studies with children have compared partial reinforcement with continuous immediate reinforcement (e.g., Ryan, 1963), varied delay with immediate reinforcement (e.g., Estes, 1963), and constant delay with immediate reinforcement (e.g., Estes, 1963; Rieber, 1961) but have failed to yield consistent results. These controversial findings suggest that the three conditions of reinforcement (partial reinforcement, varied delay, and constant delay) may be sufficiently different to have different effects. So far, however, no effort has been made to compare these conditions with one an- other. The chief purpose of the present investigation was to carry out such a comparison, since it might be crucial to the extension of Amsel's theory (1958; 1962) to a situation involving delayed reward rather than nonreward.

Another question of interest was whether, in experiments of this kind, giving a ready signal before the onset of each trial constitutes a significant variable. Ryan and Cantor (1962) found slower starting speeds under par- tial reinforcement than under continuous reinforcement. Ryan attributed this difference in results to the lack of ready signal in Ryan and Cantor's study. On the other hand, slower starting speeds under delayed reward than under immediate reward have been obtained, regardless of whether a ready signal is given (Rieber, 1961; Sheikh, 1966) or not (Estes, 1963). It could be that the ready signal plays a less crucial role in delayed reinforcement than in partial reinforcement. Consequently, investigating the interaction of the ready signal with the nature of reinforcement was included in the present study as a secondary objective.

METHOD

Subjects

The subjects were 80 preschool children, 41 boys and 39 girls, from a nursery school in London, Ontario.

Apparatus

The apparatus consisted of a response-key board, a stimulus-light box, a Stoelting timer, and 28 X 18-inch black screen at the bottom of which a marble container was located. The screen was placed between the *E* and the S. The stimulus-light box and the response-key board were placed on the Ss side of the screen, and the Stoelting timer was on the *E's* side. In the upper portion of the screen some holes were drilled so that *E* could see ***S*** well, while only *E's* head was visible to S. The whole apparatus was placed on two nursery school tables joined together. A black hand pattern was located on the S's side of the table. The key board was about 17 inches away from the hand pattern.

A red light was the signal to press the response key. The Stoelting timer measured S's response latency. The timer was activated simultaneously with the onset of the stimulus and deactivated when S pressed the key. There was no automatic reinforcement-dispensing device and no automatic control of the interval between the depression of the key and the delivery of the reward. The *E* had to put a marble into a glass tube from which the marble was ejected in a fraction of a second into the container situated at the bottom on the S's side of the screen. The S had no way of knowing that *E* was putting in the marbles. To control the delay interval in the case of delay trials, *E* had to use a stopwatch. A piece of clear plastic allowed S to see the accumulation of marbles but prevented him from from handling them. Additional material included a number of 10-15-cent toys.

Procedure

The teacher introduced each child individually to *E* and explained to him that there was a "game" he was invited to play. Subsequently, the child accompanied *E* from the classroom to the experimental room where he was shown a selection of five sex-appropriate toys spread on the table, and was asked to select the toy he would like to try to win. The chosen toy was placed on the right-hand side of the response-key board. The child was seated before the apparatus and instructed as follows:

> **This** is a game we play with only one hand. We just use this hand [preferred hand] and never this hand [nonpreferred hand]. Okay? In this game, if you win many marbles here [E points to the marble container], you can win this toy [E points to the toy]. Okay? Now I will tell you what you do to win a marble. When I say, "Read y on the black hand," put this hand [preferred hand] on this black hand [E points to the hand pattern on the table]. When the red light comes on here [E points to the stimulus box], press this key down very quickly. Okay? Always press it quickly. Remember, you won't win the toy unless you win many marbles here [*E* points to the marble container].

The children in the group not given the ready signal were told in the beginning to put their hand on the ''black hand" and to put it back there after pressing the key. Before the beginning of each trial, *E* made sure that the child had placed his hand on the hand pattern.

The Ss were randomly divided into four groups: continuous immediate reinforcement group (IM) received a marble every time and immediately after the depression of the key; partial reinforcement group (PR) received a marble only on a random 50 per cent of the trials, but it was delivered immediately after the depression of the key; varied delay group (DV) received a marble every time, but on a random 50 per cent of the trials it was delivered immediately, while on the remaining 50 per cent it was delivered with a delay of 14 seconds; and constant delay group (DC) received a marble every time, but with a delay of 14 sec onds.

Each of the groups (IM, PR, DV, and DC) was subdivided into two additional groups according to whether the Ss were given a ready signal (group S) or not given a ready signal (group N) before the onset of each trial. Each of the eight reinforcement subgroups (IMS, IMN, PRS, PRN, DVS, DVN , DCS, and DCN) consisted of ten Ss. The distribution of the sexes was approximately equal.

Each *S* was given two nonrewarded practice trials which were followed by forty test trials. The rewarded and the nonrewarded trials for the groups PRS and PRN were randomly ordered with the following three restrictions: in every block of four trials, two were rewarded and two nonrewarded; (b) no more than three rewarded or nonrewarded trials occurred consecutively; and (c) in the first block of four trials, the first two were rewarded and the second two nonrewarded. The order in which delayed and the immediately rewarded trials occurred for groups DVS and DVN was exactly the same as the order of the nonrewarded and the rewarded trials for groups PRS and PRN.

The interval between successive stimuli was kept constant for all the groups and was 25 seconds in duration. The time interval (2 seconds) between the ready signal and the onset of the stimulus for group S was constant from trial to trial.

RESULTS

All data for the response time were converted to speeds (1/T seconds) . The mean reciprocal response speeds were then computed for each block of four trials for each S, and group means were obtained from these individual means. Figure 1 shows the mean response speed as a function often blocks of four trials each for all the eight subgroups. It may be mentioned that the definition of response speed here is quite analogous to the definition of starting speed in some of the other studies discussed in this paper (e.g., Estes, 1963; Ryan, 1963).

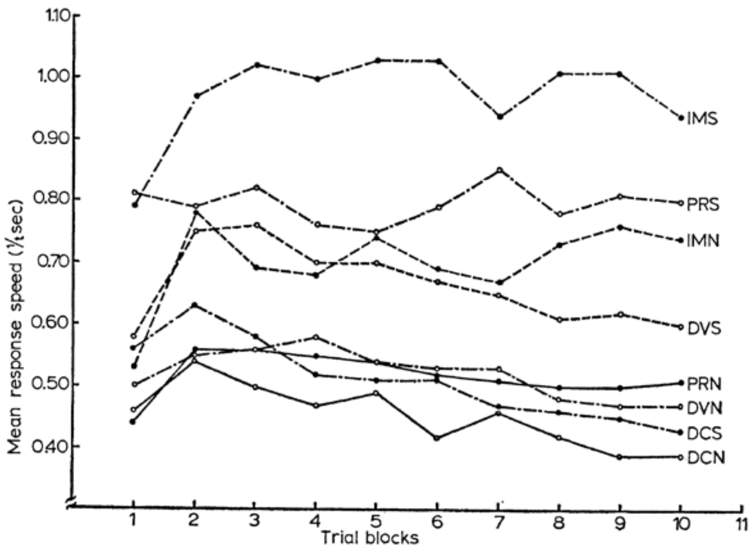


FIG. 1.- Mean response speeds for all the eight subgroups on each of the ten blocks of trials.

A Lindquist Type III (Lindquist, 1953) analysis of variance was con- ducted on response speeds. The main effects for ready signal ($F = 21.72$; df 1, 72) and for reinforcement condition ($F = 14.38$; df 3, 72) were significant beyond the .001 level. As is clear from Figure 2, a group given a ready signal performed faster than a group not given a ready signal. To understand the meaning of the main effect for reinforcement condition, the mean response speeds of the four reinforcement groups were compared with one another through a series of t tests using the mean square among Ss for obtaining the estimate of error variance. Table 1 presents a summary of the results of the t tests, which indicate that group IM performed faster than the other three groups; group PR performed faster than group DC, but not group DV; whereas group DV was faster than group DC. Figure 3 pre- sents the mean response speeds for the four groups on each of the ten blocks of trials.

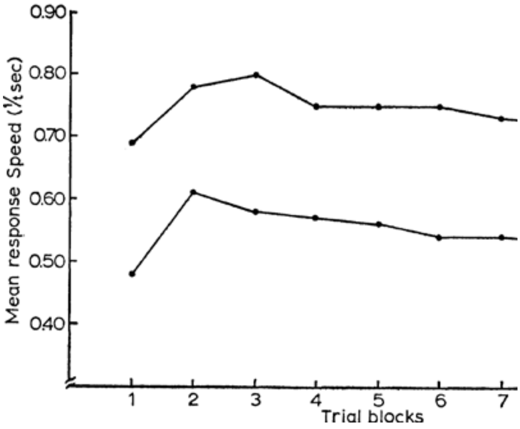


Fig. 2.- Mean response speeds for group S and group N on each of the ten blocks of trials.

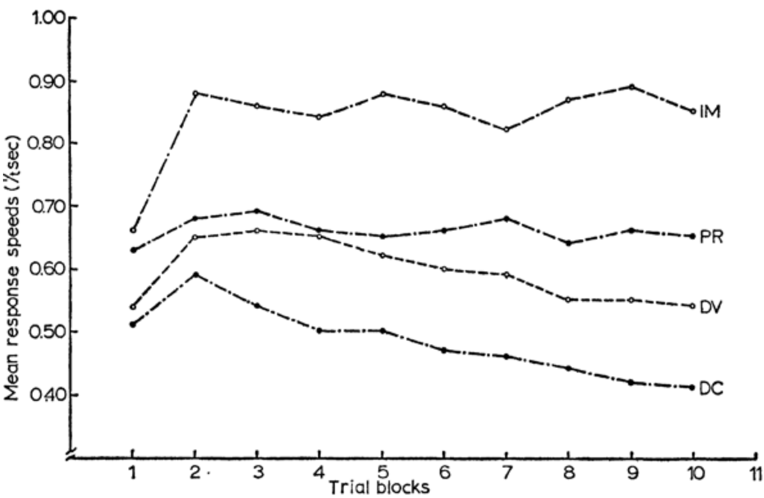
TABLE 1

RESULTS OF *t* TESTS COMPARING THE MEANS OF GROUPS IM, PR, DV , AND DC WITH ONE ANOTHER

Group	IM	PR	DV	DC
IM....	...	3.35**	4.46***	6.69***
PR....	...	...	1.12	3.35**
DV....	...	...	...	2.23*
DC....	...	...	...	...
* p <.05..	** < 01.	*** p <.001		

For within-Ss, there were significant effects for trial blocks ($F = 4.99$; df 9, 648; $p < .001$) and reinforcement × trial-blocks interaction ($F = 3.25$; df 21, 648; $p < .005$). The most significant factor contributing to the reinforcement condition × trial-blocks interaction seems to be the fact that the speeds of the two delay groups (DV and DC) increase in the beginning and then show a continuous gradual decrease, whereas groups IM and PR, after an initial increase in the speed, do not show a gradual decrease; rather, they stay more or less at the asymptote (see fig. 3).

To learn more about the reinforcement condition × trial-blocks inter-



Fm. 3.-Mean response speeds for the four reinforcement groups on each of the ten blocks of trials.

action, t tests were performed to compare the mean speeds of different groups at different blocks of trials. For an estimate of error variance, a com- promise error term was used that was constructed from the between- and within-Ss error terms (Winer, 1962). The appropriate critical values of t were obtained in a manner suggested by Cochran and Cox (1957) . As a result of these t tests, it was found that after the first trial block, group IM performed faster than all the other three groups. On the first trial block, its speed was faster than only group DC. As shown in Figure 3, the difference in the speeds of groups PR and DV kept on increasing, but at no point did it become statistically significant. Group PR started performing faster than group DC after the second block of trials. The difference in the speeds of groups DV and DC was significant only on the fourth block.

The interaction between ready signal and trial blocks was not signifi- cant, nor was the interaction between trial blocks, reinforcement condition, and ready signal.

A closer inspection of the data for groups PR and DV revealed that the effect of immediate reward, delayed reward, and nonreward manifested itself on the trials immediately following the particular reward condition. The data for these groups were analyzed in the following manner. For each in- dividual in group PR, two scores (FN and FR) were obtained. The FN and FR scores represented the mean response speed on the trials following the nonrewarded trials, and the mean response speed on the trials following the rewarded trials, respectively. The same procedure was followed for the individuals in group DV. Also, FD and FI scores were obtained which represented the mean response speed on the trials following the delayed reward and immediate reward, respectively. Since fhst and last trials were dis- carded, each of these scores was based on 19 trials. Two correlated t tests compared the FN scores with the FR scores, and the FD scores with the FI scores, yielding the t values of 2.94 $(df\ 19, p < .01)$ and 3.25 $(df\ 19,\ p <$

.01), respectively. These t values indicated significantly slower response speeds on the trials following the nonrewarded trials as compared with the speeds on the trials following the rewarded trials, and significantly slower speeds on the trials following delayed reward as compared with the speeds on the trials following immediate reward.

The difference between the FN and FD scores was not significant ($t = 0.50$, df 38), nor was the difference between the FR and the FI scores significant ($t = 0.73$, df 38).

DISCUSSION

The main findings of this study may be summarized as follows: (a) the group given a ready signal performed faster than a group not given a ready signal; (b) the ready signal did not enter into any significant interaction with reinforcement condition; (c) there were significant effects for reinforcement condition, and reinforcement condition × trial-blocks interaction; (d) for the partial reinforcement and the varied delay groups, the mean speed on the trials following the immediately rewarded trials was faster than the mean speed on the trials following the nonrewarded trials or the trials with delayed reward, depending upon the reinforcement condition.

The finding of faster response speeds for group S than for group N may be readily accounted for. During the intertrial interval following a response, Ss frequently engaged in behavior (e.g., looking at the toy, talking to E) in- compatible with a prompt starting response. Consequently, it is quite possible that the appropriate instrumental response is interfered with when a trial is initiated after a given intertrial interval without any warning to S of the coming event. On the other hand, when Ss are given a ready signal, the effect of such a response set is probably to reduce competing responses.

The absence of a significant interaction effect for ready signal and reinforcement condition indicated that the lack of a ready signal had the same effect, whichever reinforcement condition was used. One could expect that **a** signal to mark the beginning of a new trial would be more important for the nonrewarded Ss than for those getting delayed reward, especially since many of the Ss in both groups engaged in behavior presumably incompatible with a prompt starting response (e.g., telling *E* that no marble has ar- rived). In the case of those on a delayed reward schedule, such behavior is probably terminated when the marble finally arrives. Since no marble arrives in the case of a nonrewarded trial, this behavior may continue and interfere with beginning of the next trial. Although there was no significant interaction, Figure 3 does suggest that the absence of a signal has a stronger inhibitory effect in the case of partial reinforcement than delayed reinforce- ment.

Ryan (1963), using a ready signal, was able to obtain faster starting speeds under partial than under continuous reinforcement. The present study, on the other hand, has failed to support this finding. Attention should be drawn, however, to the fact that the age of Ss and the type of apparatus or task were not precisely the same in these studies.

The finding of a faster response speed for group IM than for group PR is in agreement with Ryan and Cantor's (1962) results. These results are explainable in nonassociative and/or associative terms. Both Amsel (1958; 1962) and Spence (1960) regard frustration as an aversive motivational condition having stimulus properties that elicit avoidance behavior. After an expectancy for reward is built up, nonreward would be frustrating. Following Amsel's and Spence's formulation, it would be expected that, at least initially, the response speed of group PR would be adversely affected by the frustration-produced competing responses. It is also possible that, following nonrewarded trial, *Ss* in group PR made responses (e.g., turning, etc.) which presumably were conditioned to the apparatus cues and the general experimental situation, and interfered with the appropriate response. Since starting speed is very susceptible to the effect of competing responses (Spence, 1956), the motivationally and/or associatively produced competing responses may well have caused a decrement in the performance of group PR.

The faster response speed of group IM than group DV is consistent with Estes' (I 963) finding, while the finding of faster response speed for group IM than group DC agrees with the results obtained by Rieber (1961) and Sheikh (1966). In the case of constant delay (group DC), the associative factor is probably the most important one. If there is any frustration involved, it is likely to disappear after the first few trials. If the expectancy for reward is built up very quickly in children (Ryan & Cantor, 1962), it seems reasonable to assume that after getting a few delayed rewards, expectancy for delayed reward would also be built up very quickly. Of course, once such an expectancy was developed, delay would no longer be frustrating. In the case of varied delay (group DV), both associative and nonassociative factors would presumably be operating, since the immediately rewarded trials would lead the child to expect immediate reward, and thus the subsequent delay would be frustrating.

Groups PR and DV performed faster than group DC, whereas there was no difference in the speeds of groups PR and DV. It is possible that the conditioning of the competing responses to the apparatus cues goes on more strongly in the case of group DC than it does in the case of groups PR and DV. If so, these extraneous responses get reinforced on every trial with group DC, on 50 per cent of the trials with group DV, and not at all with group PR. According to this analysis, group DC should be the slowest, and group DV should be slower than group PR. Figure 3 shows that the difierence in the speeds of groups PR and **DV** kept on increasing after the fourth block of trials and might have reached a significant level if the trials had been continued. **At** the same time, it should be noted that, with training, the performance of group DV became more and more similar to that of group DC, and that the speeds of the two groups were not significantly different from each other after the fourth block of trials-a factor which may have contributed to the reinforcement condition × trial-blocks interaction.

Since different types of reward conditions for groups PR and DV might result in different aftereffects, the data for group PR were analyzed in terms of FN and FR scores; and for group DV, in terms of FD and FI scores. Significant differences between FN and FR scores, as well as between FD and FI scores, pointed to the possibility that delay of reward and nonreward affected response speed through a nonassociative mechanism. For varied delay, similar findings were reported by Rieber (1964) and Rieber and John- son (1964) with children, and by Cogan and Capaldi (1961) with rats. However, for partial reinforcement, the results of the present study are in conflict with Rieber and Johnson's (1964) and Cogan and Capaldi's (1961).

On the whole, the present study has indicated that partial reinforcement and varied or constant delay of reinforcement may not be regarded as equivalent conditions. Thus Amsel's (1958; 1962) theory would seem to re- quire modification in order to be extended to situations involving delay of reward. It would, however, be premature to suggest the directions that modifications of Amsel's theory should take until the relevant variables have been studied in much greater detail.

REFERENCES

Amsel, A. The role of frustrative nonreward in continuous reward situations.*Psychological Bulletin,* 1958, **55,** 102-119.

Amsel, **A.** Frustrative nonreward in partial reinforcement and discrimination learning: some recent history and a theoretical extension. *Psychological Review,* 1962, **69,** 306-328.

Cochran, W. G., & Cox, G. **M.** *Experimental designs.* New York: Wiley, 1957. Cogan, **D.,** & Capaldi, E. **J.** Relative effects of delayed reinforcement and partial reinforcement on acquisition and extinction. *Psychological Reports,* 1961, **9,** 7-13.

Estes, R. E. The effect of constant and varied delay of reward on the speed of an instrumental response in children. Unpublished doctoral dissertation, State University of

Iowa, 1963.
Lindquist, E. F. *Design and analysis of experiments in psychology and education.* Boston: Houghton MifHin, 1953.
Penney, R. K. The effects of nonreinforcement on response strength as a faction of number of previous reinforcements. *Canadian Journal of Psychology,* 1960, **14,** 206-215.
Rieber, M. The effect of CS presence during delay of reward on the speed of an instrumental response. *Journal of experimental Psychology,* 1961, **61,** 290-294.
Rieber, M. Delay of reward and discrimination learning in children. *Child Development,* 1964, **35,** 559-568.
Rieber, M., & Johnson B. M. The relative effects of alternating delayed reinforcement and alternating nonreinforcement on response speed of children. *Journal of experimental child Psychology,* 1964, **1,** 174-181.
Ryan, T. J. The effects of nonreinforcement and incentive value on response speed. Unpublished doctoral dissertation, State University of Iowa, 1963.
Ryan, T. J., & Cantor, **C. N.** Response speed in children as a function of reinforcement schedule. *Child Development,* 1962, **33,** 871-878.
Sheikh, **A. A.** Children's response speed as a function of delay of reward, distance of delay from the goal and incentive value. Paper presented at the annual convention of Southern Society for Philosophy and Psychology, New Orleans, April 8, 1966.
Spence, **K.** W. *Behavior theory and conditioning.* New Haven, Conn.: Yale University Press, 1956.
Spence, **K.** W. *Behavior theory and learning.* Englewood Cliffs, N. J.: Prentice- Hall, 1960.
Winer, B. J. *Statistical principles in experimental design.* McGraw-Hill, 1962.

This paper is a part of the dissertation submitted to the Department of Psychology at the University of Western Ontario in partial fulfilment of the requirements for the degree of Doctor of Philosophy. The writer wishes to express his sincere appreciation to Thomas Ryan for his advice and assistance throughout the course of the investigation. Thanks are also due to Mrs. G. H. Turner and other teachers of Church of the Redeemer Nursery School for their kind coopera- tion. Author's address: Department of Psychology, Marquette University, Mil- waukee, Wisconsin.