PLACE OF DELAY AND INTERFERENCE IN LONG DELAY LEARNING

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by

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ABSTRACT

Three groups of rats were trained to select the rewarded side of a T-maze with a 1-minute delay of reward. One group spent the delay in the home cage, a second group was delayed in a separate chamber resembling the startbox of the T-maze, and the third group was delayed in the startbox. All rats were rewarded for a correct choice in the startbox of the T-maze. It was found that the group delayed in the home cage learned the discrimination, the group delayed in the startbox did not learn, and the group delayed in the separate chamber were intermediate. The results are explained in terms of Revusky's (1971) concurrent interference theory and in terms of Lett's (in press) memory theory.

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INTRODUCTION

Learning procedures involving temporal delays might be divided into three categories:

1) Delay conditioning. In this type of experiment the delay is between the offset of a prior stimulus and the occurrence of a later stimulus. This procedure, sometimes called trace conditioning, is one in which the CS is terminated prior to the onset of the US.

2) Delayed reaction learning. In this type of experiment the delay is between a stimulus or cue and a response. The cue forms the basis on which the animal's response is made, depending on the particular delayed reaction experiment. If it is a go, no-go experiment the cue indicates whether or not reward will be given for a single response. If it is a go-left, go-right type of experiment the cue will indicate which of a number of possible responses will be rewarded. In both of these cases, cue offset occurs before the animal is given the opportunity to emit a response.

3) Delay of reward learning. In this case an animal makes a response and a delay occurs between this response and the presentation of a reward.

In the past these three categories have been treated as different effects requiring different explanations. That is, the underlying process is usually assumed to be different for each delay procedure. For example, a delay of reward is assumed to affect learning by decreasing the efficacy of reinforcement, while a delay between a stimulus and a response might have its effect due to the fading stimulus trace. The assumption made in this paper is that the process underlying all three instances of delay learning procedures is an association between temporally separated events, whatever the nature of the events in question.

The traditional view has been that learning cannot occur unless the events to be associated are temporally contiguous. The results of studies that have apparently shown instances of delay learning have usually been explained in terms of mediating events that (Perkins, 1947; Grice, 1948; Spence, 1947, 1956) form an associative chain (Hull, 1952) bridging the temporal gap between two events. For example, suppose an animal is presented with A; after a delay, D is presented and the animal is expected to make an association between the two. This can be achieved by the animal forming a chain of associations from A to B, B to C and C with D. Hence there is no direct association between A and D. Each link in the chain is assumed to be temporally contiguous with the preceding and the following events so there is no direct learning over delays; thus apparent delay learning is really a sequence of temporally contiguous associations.

A second mediational explanation is that involving stimulus traces. After a stimulus A is terminated, the trace of A persists for some time and gradually fades away. As in the associative chain hypothesis this view also assumes that the "real" association is between events that are temporally contiguous; that is, the remains of the trace of stimulus A is present when the delayed event D occurs and thus A becomes associated with D. If event A is a flash of light, the stimulus trace hypothesis assumes that the light is biologically present as an afterimage when event D occurs. Therefore, there is no association over a delay but the stimulus trace of A is associated with D as they are both present concurrently.

Traditionally delay of reward learning has been explained in terms of the secondary reinforcement hypothesis (Hull, 1943; Spence, 1947). This hypothesis says that "stimulus cues which have been closely and consistently associated with a reinforcing state of affairs themselves acquire reinforcing properties". In other words, features of the training apparatus were associated with the primary reinforcer, thus eliminating any delay factors, as these features were present throughout the delay period. Therefore the secondary reinforcement hypothesis assumes no delay of reward learning, but rather immediate secondary reinforcement which provides temporal contiguity between the response and the reward.

Revusky (1971) has made explicit a variant of the secondary reinforcement hypothesis which may apply to delay learning in general. He points out that secondary reinforcement need only occur during two portions of the delay period, i.e., immediately following the response in order to reinforce the response and it must precede the primary reinforcer if it is to retain its reinforcing power. Suppose A is followed by a light, B, and B precedes a primary reinforcer, D. If A and D are separated by a 60-second delay it is presumed that the light, B, can potentiate the association between A and D. Bixenstine (1956) has provided evidence which supports this analysis. Bixenstine trained groups of rats to associate a discriminative stimulus with delayed punishment of eating. For all groups of rats, a blinking light as they approached the food trough indicated that eating would be punished with shock after a delay. For the experimental group only, shock was preceded for 3 seconds by this blinking light. All experimental groups learned to suppress eating in the presence of the blinking light, even though the light was not present during most of the delay period.

Types of Long Delay Learning

It is improbable that associative chains or lingering stimulus traces could account for associations being formed with delays of over a few minutes. Thus, recent studies which show direct learning over delays of an hour and longer in the absence of mediating events suggest that delay learning cannot always be explained in such terms. These recent studies involve learned flavour aversions, intertrial discrimination learning and home cage delay learning. Each type of study will be described below.

Learned Flavour Aversion

Studies have shown that if animals consume sublethal doses of a poisonous substance they will form an aversion to that or similar tasting substances. The procedure for these experiments was developed by Garcia, Kimeldorf and Koelling (1955). They allowed rats to drink saccharin-flavoured water for a period of six hours while simultaneously exposing them to continuous X-irradiation. They found that the rats formed an aversion to the saccharin. In this case there was no delay between the consumption of the saccharin and the exposure to X-irradiation.

This technique has also been used to demonstrate long delay flavour aversion learning. Smith and Roll (1967) exposed rats to X-irradiation 0, 0.5, 1, 2, 3, 6, 12, and 24 hours after consumption of saccharin. They were able to obtain a strong aversion to saccharin with delays up to six hours. Revusky (1968) allowed rats to drink sucrose solution and later exposed them to 50 R of X-irradiation. An aversion to sucrose was shown with delays of up to 4 hours between the ingestion of sucrose and exposure to the toxic agent. Aversions have also been obtained over long delays with other toxic agents, e.g., lithium chloride and hypertonic saline (Revusky & Garcia, 1970).

Intertrial Discrimination Learning

With this procedure the animal is exposed to the discriminative cue towards the end of one trial but is not given the opportunity to respond until the following trial. In order to make a correct response the animal must make use of this discriminative cue which was present on the preceding trial but is not present during the current trial. In other words, the delay period, the time between the discriminative cue and the animal's receiving the opportunity to respond, is also an intertrial interval (ITI).

One demonstration of this effect involves alternate reward in a runway. Learning has been shown to occur in this type of situation with delays of up to 24 hours (Capaldi & Spivey, 1964). Tyler, Wortz and Bitterman (1953) were the first to show that the reward outcome on one trial can become the discriminative cue for whether or not reward would be available on the next trial. They rewarded rats on odd trials in a runway and not on even trials. The result of this procedure is that for any trial the only valid discriminative cue is the outcome of the preceding trial, i.e., whether it had resulted in reward (S+) or nonreward (S-). They found that the rats ran faster on rewarded trials than nonrewarded trials, indicating that the rats had learned an association between the preceding goal outcome and the present one. More recently this phenomenon has been studied extensively by Capaldi (1967, 1971).

An experiment by Pschirrer (1972) demonstrated that intertrial discrimination learning can occur in situations other than alternating reward patterns. Pschirrer was able to show that the type of reward, not just reward or nonreward, can function as a discriminative cue. He administered a regular sequence of reward of chow pellets, milk, and nonreward. Thus a milk reward indicated nonreward. Pschirrer found that the rats ran faster on both types of rewarded trials than on nonrewarded trials. The minimum intertrial interval was 15 minutes. Thus the properties of the rewards themselves, not merely their presence or absence, functioned as the discriminative cue for the following trial. Pschirrer was able to extend his findings so that the type of reward, either chow pellets or milk, became a cue for a left or right response on the next trial. In this case the intertrial interval was 3 minutes.

Revusky (1974) extended the generality of these findings by using external cues as discriminative stimuli in an intertrial discrimination experiment. A trial in the runway was rewarded if the preceding trial terminated in a small white goal box, but was not rewarded if it had terminated in a large black goal box. The rats learned the black-white discrimination with a minimum intertrial interval of 4 minutes.

Home Cage Delay of Reward

Until recently it was considered proven that learning cannot occur unless reward, either primary or secondary, immediately followed the response (Grice, 1948; Perkins, 1947). Lett (1973), however, hypothesized that the same processes underlie intertrial discrimination learning and delayed reward learning; thus, if intertrial discrimination learning can occur over long delays, then it must be possible to obtain delayed reward learning over long delays. She further reasoned that the only difference between the delay of reward experiments (Grice, 1948; Perkins, 1947), which failed to yield long delay learning, and the intertrial discrimination experiments, which yield learning over delays of many minutes and perhaps hours, is the place in which the animal spends the delay. In the delayed reward experiments by Grice and Perkins, the delay is spent in a delay chamber that is part of the training apparatus while in the intertrial discrimination experiments, the delay is spent outside of the training situation in a holding cage or the home cage. Thus, it might be that spending the delay outside the training situation was critical in facilitating intertrial discrimination learning over long delays. If removing the animal from the experimental apparatus facilitated intertrial discrimination learning, then the same procedure might also facilitate delayed reward learning. This assumption formed the basis of a series of studies carried out by Lett in which the subjects spent the delay period in the home cage. In these studies the rats were trained in a position discrimination in a T-maze. After the rat made its choice response, it was immediately removed. Whether the response was correct or incorrect the rat spent the delay in the home cage. After the delay the rat was returned to the startbox of the T-maze where it received feedback for the choice response. Using this basic procedure, Lett was able to demonstrate learning with delays of 1-8 minutes (Lett, 1973) and a delay as long as 1 hour (Lett, 1975).

Concurrent Interference Theory

The results obtained in flavour aversion learning, intertrial discrimination learning, and home cage delay learning clearly show that learning with long delays is possible. These results cannot be readily explained in terms of traditional learning theory which assumes that temporal contiguity, either direct or mediated, is necessary for learning to occur. How then are we to account for these results?

Revusky (1971, 1977) conjectured that animals cannot learn in traditional long delay learning situations because experimenters expect the animal to solve an insoluble problem. In a typical delay learning experiment, in which the animal has to associate between A and B in order to behave appropriately, the experimenter treats the situation as though these are the only two events in the experimental environment. In fact, this is entirely incorrect. Once an animal is removed from its home cage and placed in an experimental apparatus it is subjected to a whole new range of experiences, in what Revusky, quoting William James, calls "a buzzing, booming confusion of sense impressions". In such a confusion of events why should the animal associate between two events separated by a delay rather than between events that occur close together in time? This analysis formed the basis of

Revusky's (1971) theory of concurrent interference.

Stated simply, this theory says that as the time interval between event A and event B increases, there is also an increase in the number of intervening events. If this is so, then the probability of intervening events becoming associated with A or B also increases. Concurrent interference theory assumes that associations of A with later occurring intervening events and/or associations of B with previously occurring intervening events interfere with the A-B association. Therefore, long delay learning is facilitated by reduction of the number of intervening events that have high associative strength relative to the A and B events to be associated over the delay. According to this approach, delay learning of an A-B association is facilitated by factors which prevent A and B from becoming associated with intervening events. These factors are principles of selective association called relevance principles, which will be described below.

Stimulus Relevance

The principle of stimulus relevance assumes that external events, such as visual and auditory stimuli, are more likely to become associated with a consequence, such as footshock, that is perceived as emanating from the external environment, than with an internal consequence, such as gastrointestinal sickness. Conversely, internal events are more likely to become associated with other internal events; for example, an ingested flavour is more likely to be associated with sickness than with footshock.

Garcia and Koelling (1966) provided strong evidence for stimulus relevance. They had rats consume saccharin-flavoured water in the presence of a flash of light and a clicking noise produced by the drinkometer. Drinking this bright, noisy, sweet water was followed by exposure to X-irradiation for some rats and by footshock for other rats. Subsequently, the rats were tested with saccharin-flavoured water or bright, noisy water. If the consequence of ingestion had been illness, the rats avoided the saccharin solution but not the bright, noisy water, indicating that the flavour stimulus rather than the audiovisual stimulus was more readily associated with illness. If the consequence had been footshock, the rats avoided the bright, noisy water, not the saccharin solution, indicating that the audiovisual stimulus rather than the flavour stimulus was more readily associated with footshock. Garcia, McGowan, Ervin and Koelling (1968) have extended these findings by demonstrating that stimuli produced by motor responses give results similar to audiovisual stimuli. Such findings strongly support the conclusion that external stimuli are more likely to become associated with external, rather than internal, consequences while internal stimuli are more readily associated with internal, rather than external, consequences. On the basis of concurrent interference theory, the stimulus relevance principle permits the selective association of a long delayed sickness with a flavour not only because it insures that flavour and sickness are highly associable or relevant to each other but also because it insures that flavour and sickness are not highly associable to the intervening delay events. It is tacitly assumed that most uncontrolled delay events are external so that associations between flavour and sickness are subject to less interference than most associations between external events.

Situational Relevance

In extending his theory to explain discrimination learning over long intertrial intervals, Revusky (1971) proposed another principle of selective association which he called situational relevance. This principle, modelled after stimulus relevance, proposed that animals are more likely to make an association between two events that occur in the same situation than between two events that occur in different situations. This implies that all events occurring in an experimental apparatus are situationally relevant to each other; therefore, if the delay period between the cue and the opportunity to respond occurs in the training situation, any number of associations between the cue and some delay events or between delay events and the response are possible. However, if the animal is removed from the apparatus during the delay period, the delay events will not be readily associated with the cue or the response, while the cue and the response will be readily associated with each other. That is, removal of the animal from the experimental situation reduces the probability of concurrent interference thereby facilitating the delayed association between cue and response.

The findings of long delay learning in the T-maze achieved by Lett (1973, 1974, 1975) were based upon the situational relevance hypothesis. Presumably the delay events, since they occurred outside the apparatus (i.e., the home cage), were not associable with events occurring within the apparatus. Thus, the response and the reward, both of which occurred in the experimental apparatus, were subject to minimal concurrent interference. This enabled the animal to learn an association between the choice response and the delayed goal outcome.

Although the occurrence of long delay learning provided strong indirect evidence for the situational relevance hypothesis, Lett attempted to test the hypothesis more directly. According to the situational relevance principle, delay events that occurred in the apparatus should have high associative strength with either the response or the reward. If this is so, then having the animal spend part of the delay in the choice alley of the apparatus should result in concurrent interference. Further, it could be reasoned that the longer the animal remained in the choice alley the greater the impairment in learning.

Lett (1975) devised an experiment to test this hypothesis. Three groups of rats were delayed for 0, 15 or

60 seconds in the choice alley of a T-maze. The remainder of a 120-second delay period was spent in the home cage. It was found that the performance of the rats was impaired as a function of the length of time they were confined in the choice alley. That is, rats confined for 0 seconds performed at a higher level than rats confined for 15 seconds and these rats performed better than the rats confined for 60 seconds in the choice alley.

Lett (1975) varied the amount of concurrent interference by varying the length of time spent in the end box after the choice response. An alternative way to vary concurrent interference might be to vary similarity between the place of delay and the training apparatus. If the principle of situational relevance is correct, learning should be impaired as a function of similarity between the place of delay and the training apparatus. For example, if the place of delay is exactly like some part of the training apparatus then the associative strength of delay events will be high relative to training events and should result in little learning of the discrimination. If the place of delay is less similar, then we should expect some learning but less than when the animal is delayed in a place entirely different from the apparatus, such as the home cage.

The present experiment was designed to test the hypothesis that long delay learning would be affected by the degree of similarity between the place of delay and the T-maze. Animals were trained to select the left or the right side of a T-maze with a 1-minute delay of reward. One group was delayed in the home cage, one group in the startbox and one group in a separate chamber similar in appearance to the startbox.

METHOD

Subjects

The subjects were 36 male Wistar rats, and were approximately 90 days old at the start of the experiment. All subjects were reduced to 80% of their free feeding weight prior to training and subsequently maintained with 12g of rat chow per day. They were housed in individual polypropylene cages. Water was available at all times.

T-maze

The T-maze consisted of a startbox and two choice alleys. The startbox, measuring 32.5 cm x 20.0 cm x 17.5 cm, was constructed of plywood with a hinged plexiglass lid and wire cloth floor. All walls were painted grey. Transparent one-way plexiglass doors were located on either side of the startbox to allow access to the choice alleys. A third one-way plexiglass door was located at the end of the startbox farthest from the other two doors. This was the entry door through which subjects were placed into the startbox. Each choice alley, measuring 33.0 cm x 12.7 cm x 17.5 cm, was of plywood construction with hinged plexiglass lid and wire cloth floor. One alley was painted white and the other was painted black.

Delay Chamber

A separate delay chamber was utilized for the Other-Box Delay Group (see below). This chamber, measuring 35.0 cm x 27.5 cm x 17.5 cm, was constructed of plywood with a hinged plexiglass lid and wire cloth floor. The four sides were painted grey.

Procedure

All subjects were handled for 10 minutes a day for three weeks prior to the start of the experiment. No pre-training in the apparatus was given.

The 36 rats were divided into three groups of 12 each. The groups, designated in accordance with the place where the delay period would be spent, are as follows:

> Group HCD, which spent the delay in the home cage,
>
> Group SBD, which spent the delay in the startbox, and
>
> Group OBD, which spent the delay in the other box that resembled the startbox.

Half of the rats in each group were trained to select the left choice alley and half were trained to select the right choice alley. A training trial began with a subject being placed through the entry door into the startbox. A response was considered to have been made when the rat moved through a one-way door into a choice alley far enough to allow the door to close behind it. Whether the response was correct or incorrect, the rat was removed from the choice alley immediately after the response and confined in the appropriate place of delay for 60 seconds. If the response was correct the subject was returned to the startbox after the delay period and given approximately 3 ml of surcose solution (25% w/v) in a small dish. If the response was incorrect the rat was returned to the startbox and confined for 60 seconds but no reinforcement was given. In both cases the rats were returned to the home cage immediately after this period. The subjects were fed their daily ration of 12g rat chow 30 minutes after being returned to the home cage. Each subject received one trial per day for 60 days.

Data Analysis

If a subject failed to make a response after 600 seconds had elapsed, it was guided into the choice alley opposite to the one chosen on the last trial. After the first two blocks of trials no more than two guided responses occurred in any block. The rat was then treated as if the response had been made voluntarily. Responses of this type were given a score of 0.5, correct responses were given a score of 1.0 and incorrect responses were given a score of 0.0. The percentage of correct responses during each block of 10 trials was calculated for each rat and provided the input for a two-factor analysis of variance with repeated measures (Winer, 1962) in which one factor was place of delay and the other was a block of 10 trials.

RESULTS

The results are shown in Fig. 1 in terms of the percentage of correct responses during each block of 10 trials for each group. Inspection of Fig. 1 suggested that the groups differed in their patterns of performance over blocks; this difference was confirmed by the presence of a significant interaction between groups and blocks in the analysis of variance summarized in Table 1. A test of the simple blocks effect indicated that Group HCD, which spent the delay in the home cage, showed a significant improvement in performance over blocks ($\underline{F}(5,165) = 5.25$, $\underline{p} < .01$). In Group OBD which spent the delay in the separate chamber similar to the startbox, a test of the blocks effect yielded a marginally significant outcome ($\underline{F}(5,165) = 2.11$, $\underline{p} < .05$ one-tailed). Group SBD, which spent the delay in the startbox, did not show any improvement in performance over blocks ($\underline{F}(5,165) = 1.04$, $.25 < \underline{p} < .50$).

It had been predicted that Group HCD would show more learning than Group OBD and that Group SBD would learn little, if at all. The results of Groups HCD and SBD are clearly consistent with these predictions, but the results of Group OBD are difficult to interpret due to the early increase in

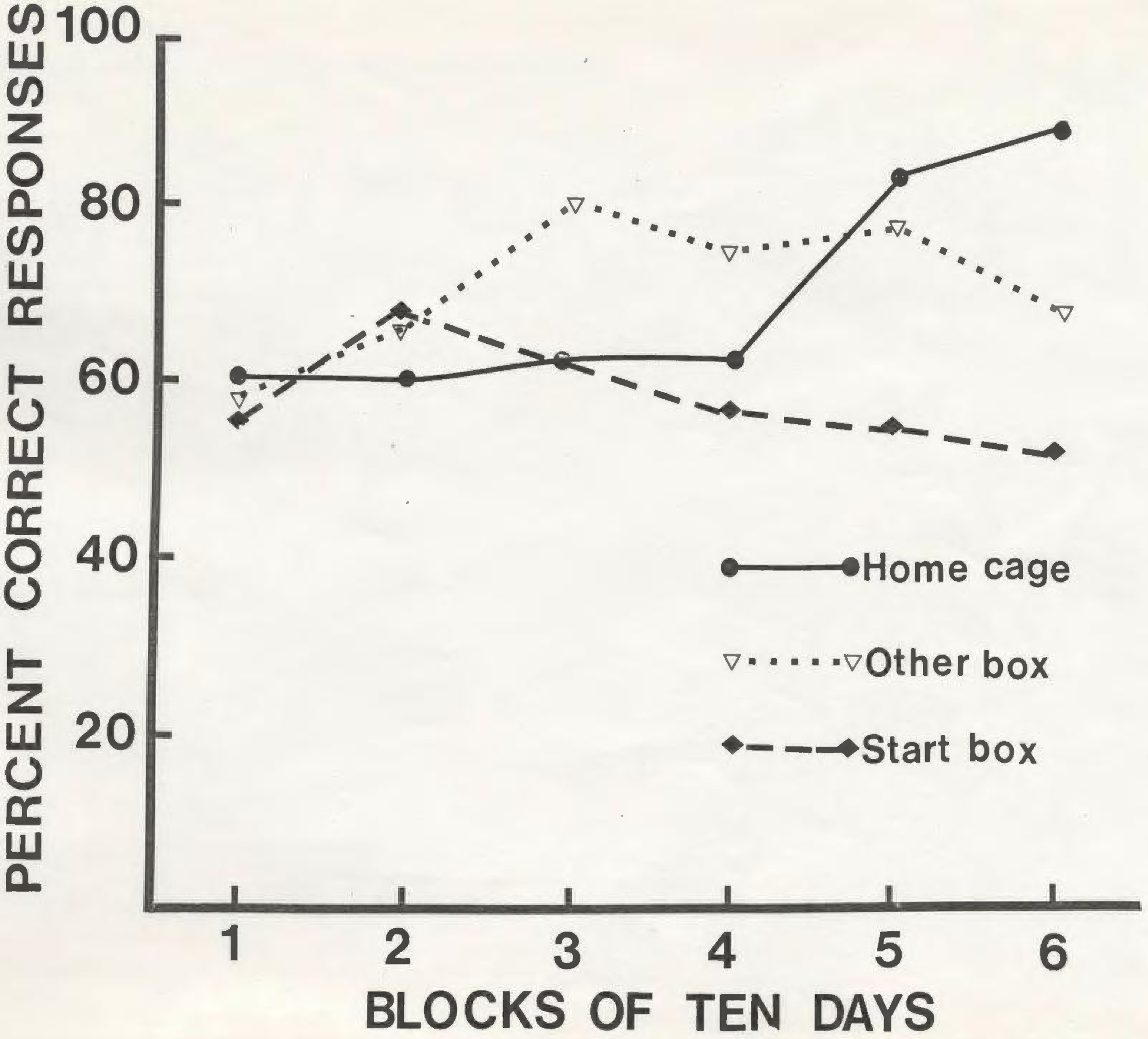

FIG. 1. Percentage of Correct Responses in Block of 10 Delays for Rats Delayed in the Home Cage, the Separate Delay Box, or the Startbox of the T-maze.

TABLE 1

Summary of Analysis of Variance

Source of Variation	df	MS	F
Between Subjects			
A (place of delay)	2	34.81	--
Ss within groups	33	47.18	--
Within Subjects			
B (blocks)	5	8.97	2.33*
AB	10	11.71	3.04**
B x Ss within groups	165	3.85	--

*$p < .05$
**$p < .01$

correct responses shown by this group during blocks 3 and 4. Although there was no significant difference between groups during the first two blocks combined, the Newman-Keuls test indicated that Group OBD made significantly more correct responses that did Groups HCD and SBD during blocks 3 and 4 combined ($p < .01$). This finding suggests that Group OBD started to learn before the other two groups, but it may be due to a sampling error since Group OBD did not continue to show an increase in correct responses during blocks 5 and 6. During the last two blocks combined, Group HCD made significantly more correct responses than Group OBD ($p < .01$), which in turn made significantly more responses than Group SBD ($p < .01$). This last result is consistent with the situational relevance hypothesis.

DISCUSSION

The rats in Group HCD clearly learned the discrimination, those in Group SBD did not, and the rats in Group OBD were probably somewhere in between. These results are consistent with concurrent interference theory. According to this theory, the animals in Group HCD were able to learn the discrimination with a 1-minute delay of reward because the events that occurred in the home cage during the delay had little associative strength relative to the events in the T-maze. Group SBD as expected, on the basis of concurrent interference theory, did not exhibit any learning whatsoever. For this group of rats the response, the reward and the delay events occurred in the same situation, therefore concurrent interference was expected to be maximal in this situation. The performance of Group OBD was expected to be intermediate because the separate delay chamber was designed to be similar to the startbox of the T-maze. If so, the events occurring during the delay in this box should have had some associative strength relative to events occurring in the training apparatus and should, therefore, have produced some concurrent interference. In retrospect, however, the assumption of some fixed degree of similarity between T-maze and the separate delay chamber may have been premature. It seems possible that the rat initially perceived the separate delay chamber as distinct from the T-maze but with increasing experience came to connect them together because the training procedure involved a reliable, temporally related sequence of events; placement in the T-maze, followed by placement in the separate delay chamber, and then back to the startbox. This would imply that concurrent interference may have been minimal during the early part of training and increased during the latter part of training; if so, this would account for the initial high rate of increase in correct responses of Group OBD and its subsequent decline in learning rate during the latter half of training. Although the results of Group OBD cannot be unambiguously explained, they should not be construed as contradictory to the situational relevance hypothesis.

The present results can also be discussed in terms of a memory theory of long delay learning recently proposed by Lett (in press). Briefly the theory is as follows: Lett makes a distinction between two kinds of memories, active or inactive. An inactive memory involves events which have been experienced previously, it is only potentially available for use in associative processes or to influence future behavior. Before it can be used, an inactive memory first has to be returned to the active state. An active memory is an inactive memory that has been reactivated, or it is the initial input into memory at the time the organism experiences some event. Reactivation occurs when the animal is exposed to the events or the environment present when the memory was formed initially.

Lett argues that this reactivation of memory can account for long delay learning in the T-maze. Suppose a rat is trained in a position discrimination using the home cage delay procedure. The trial begins with the rat being placed in the startbox of the T-maze. When the rat eventually enters a choice alley, memory of the choice response and the context in which the response occurred is formed. Then the rat is immediately removed from the choice alley and placed in the home cage to spend the delay period. At this point, the memory of the choice response becomes inactive because few of the events on which the memory is based are present.

When the delay period is over, the rat is returned to the startbox of the T-maze. This reactivates the memory of the choice response because the startbox stimuli were present when the choice response memory was formed. If the rat had chosen the correct choice alley, the rat is now rewarded. Then the two reference events, choice response and the receipt of reward, are in active memory at the same time. Therefore, the two are likely to become associated. The rat is removed from the T-maze and the memory of the situation and the association between response and reward becomes inactive shortly thereafter.

The consequence of making an incorrect choice response can be similarly explained. When the rat enters the incorrect choice alley, a memory of choice response is formed. During the delay in the home cage, the memory of the response would become inactive. Returning the rat to the startbox would reactivate the memory of the response; however, as there is no reward for an incorrect choice response, the association formed is between response and nonreward. As training progresses, reactivation of the memories of the association between each choice response and its goal outcome has an effect upon the rat's behavior. This is demonstrated by an increase in the tendency to select the rewarded, i.e., correct choice alley.

The results of the present experiment can be made explicable in terms of Lett's memory theory. However, the explanation hinges on the assumption that the memory of the choice response becomes inactive during the delay regardless of where the animal spends the delay. Lett's theory is not clear on whether an active memory becomes inactive when an animal remains in the same or similar situation. The theory is more clear in its assumption that active memories become inactive when the animal is removed from the stimulus context in which the memory is formed. If it is assumed that the memory of the choice response remains active during a delay period spent in the training situation or a similar situation, then reactivation of memory would not be a major factor in explaining the results of Groups OBD and SBD.

Under the assumption that the memory of the choice response soon becomes inactive regardless of where the delay is spent, the results of the present experiment can be explained as follows. Group HCD came to perform better than the other two groups because the training situation and the delay situation (i.e., the home cage) differed most for this group. Thus memory of training events rather than delay events was reactivated when a rat was returned to the start-box to receive feedback for the choice response. Such a condition would favor the learning of an association between choice response and goal outcome.

In contrast, the separation of training situation and place of delay was less distinctive in Group OBD and least distinct in Group SBD. The less distinct this separation, the more likely that memory of the more recent delay events rather than memory of the more remote training events will be reactivated. This argument implies that learning should be impaired in both Groups OBD and SBD and that the degree of impairment should be greater for Group SBD.

Although the present experiment was designed to test the concurrent interference theory and yields results consistent with this approach, it does not exclude the memory theory. The results of the present experiment appear to be explicable in terms of either theory. At this point, it might seem appropriate to attempt a selection between the two theories or an integration of them. Unfortunately, the present experiment does not provide, nor was it designed to provide, the necessary information for performing this task.

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