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Discrimination of delays of reinforcement in aversive conditioning.

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DISCRIMINATION OF DELAYS OF REINFORCEMENT IN AVERSIVE CONDITIONING

by

ELLIS M. HONIG

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Abstract

This study was designed to determine if rats are able to discriminate among different delays of shock termination, and if so in what way do rats discriminate among these delays of negative reinforcement? The hypothesis that rats do prefer the shorter delay of negative reinforcement was supported. It was also found that rats made their discrimination on the basis of a combination of the relative differences between delays and the absolute lengths of delays of negative reinforcement. A delay of reinforcement gradient was obtained.

Acknowledgments

The writer wishes to express his grateful appreciation to Dr. A. A. Smith under whose direction this study was carried out. He is also indebted to Dr. T. Hirota and Dr. W. Bringmann for their suggestions.

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Table of Contents

List of Tables

Table Page

List of Figures

Chapter I

Introduction

A survey of the literature in areas closely related to the present investigation showed that there exists an abundance of studies into the effects on learning of the delays of positive reinforcement, discrimination of delays of positive reinforcement, and the delay of negative reinforcement. An as yet uninvestigated area of research which seems to follow logically from the three just mentioned is that of the discrimination of delays of negative reinforcement. It is with this fourth area that the present investigation is concerned.

Before proceeding any further it is necessary to clarify a point, this point being the operational definitions of and distinctions among negative reinforcement, positive reinforcement, and punishment. A reinforcer is defined by its effects. Any stimulus is a reinforcer if it increases the probability of occurrence of a response (Skinner, 1953). The word <u>reinforce</u> connotes that a response is strengthened, while the word <u>negative</u> seems to add the implication that the response is somehow weakened at the same time. The use of the term negative reinforcer clearly raises some semantic problems, but these can easily be straightened out if one keeps in mind an operational definition. A negative reinforcer is a stimulus which when removed from a situation strengthens the probability of an operant response. Loud noise, extreme heat, and electric shock are classified as negative reinforcers according to this operational definition. This is the paradigm for simple escape training. Negative reinforcement involves the use of a stimulus event which has aversive properties, a stimulus which the organism will ordinarily avoid if it can (Deese and Hulse, 1967).

If the appearance of a stimulus as a consequence of a response results in an increased probability that the response will recur in the future, then the stimulus is called a positive reinforcer. Food and water are positive reinforcing stimuli according to this operational definition (Reynolds, 1968).

Punishment is something other than negative reinforcement as previously defined. While a reinforcer is defined by its effects, this is not true for punishment (Hilgard and Bower, 1966). A punishment situation is the opposite of a reinforcement situation. There are two cases. The first is the presentation of a negative reinforcer as defined earlier, and the second is the removal of a positive reinforcer after the occurrence of a response. Since aversive stimuli like electric shock can be used operationally to produce two very different effects, namely reinforcement and punishment, it is necessary to be explicit about the experimental operations that will lead to one effect as opposed to the other. Noxious stimulation can be used to reinforce a response when it is supplied independently of anything that the animal is doing, and when the occurrence of a response removes or turns off the noxious stimulation. On the other hand, noxious stimulation can be used to punish a response when the occurrence of the response produces or turns on the noxious stimulation. This procedure then consists of making the occurrence of some aversive stimulus contingent upon the occurrence of some specified response.

Operationally defined, delay of reinforcement refers to the length of time that elapses between the operant response and the reinforcing stimulus. In general, empirical evidence from studies of delay of positive reinforcement suggests that responses temporally near to reward are learned more quickly than responses more remote from reward. Perin (1943) trained rats in a modified Skinner box using delays of 0, 2, 5, 10, 20, and 30 seconds for food reward. His results showed that rats working under short delays learned the problem at a much faster rate than rats working under longer delays. Seward and Weldon (1953), also using rats in a Skinner box with 2.5 and 10 seconds of delay of food reinforcement following a bar press, found longer latencies for the 10 second delay group than for the 2.5 second delay group. They also found that it took longer for the 10 second delay group to reach an asymptote of responding than it did for the 2.5 second delay group. Wolfe (1934) using rats in a T-maze found that delays as short as 5 seconds interfered with learning, and increased delays of reinforcement produced progressive decreases in the efficiency with which the task was learned. Harker (1956) using rats in a Skinner box with 1 and 10 second delays of reinforcement found that latencies were longer for the 10 second delay group than for the 1 second delay group. In general then, it has been shown that response strength typically declines as a monotonic function of the delay of reinforcement following the occurrence of a response (Perin, 1943).

An organism is said to discriminate between two stimuli when it behaves differently in the presence of each one of them. Studies investigating discrimination learning with two reinforced stimuli have been done in which two stimuli are both associated with a positive reward, but a less effective reward is used for the "incorrect" stimulus (Kimble, 1961). Logan (1952) trained rats in a position discrimination in a two-bar Skinner box with 1 second and 5 second delays of food reinforcement following the two responses. Rats responded faster to the short delay bar and selected it in preference to the long delay bar. Terrell (1964) using children in size and form discrimination tasks with immediate and 7 second delayed reinforcement found that latencies were shorter when reinforcement was immediate than under a delayed condition. Ss also acquired the discrimination more quickly under the immediate reward condition. Myers (1958), working with pigeons in a key-pecking situation, built up a colour discrimination based on different delays of reinforcement. He found that the rate of pecking was higher at the colour disc associated with a shorter delay of reinforcement. Chung and Herrnstein (1967), also using pigeons in a key-pecking situation, built up a discrimination based on different delays of food reward. He found shorter latencies and higher rates of pecking at the key associated with the shorter delay of reinforcement.

If one accepts a drive reduction, or more specifically a drive stimulus reduction, theory of reinforcement and regards escape from a noxious stimulus to be the critical negative reinforcing event, then the appropriate experiment to use in the study of delay of reinforcement in aversive conditioning is one in which shock termination follows the response to be learned by varying periods of time. A discussion of drive stimulus reduction as the critical mechanism of reward must begin with a definition of drives. Drives are conceived of abstractly as intervening variables tied to operations such as food deprivation, or to the administration of a painful stimulus such as electric shock. It is assumed that a particular need state has associated with it a characteristic pattern of drive stimuli. In the case of hunger, for example, the drive stimuli produced by food deprivation can be reduced by food almost immediately while the actual need reduction takes much longer. It is the ability of food pellets to quickly reduce the intensity of drive stimuli that gives them the power to act as reinforcers.

A broad experimental program cast in drive reduction terms has been conceived by Miller (1959). For Miller, a drive can be produced by any stimulus if it is made strong enough to "impel action." Thus, strong electric shock can function as a drive stimulus. Miller states that a reinforcing state of affairs is simply that which produces a rapid reduction in the intensity of a drive stimulus. In the situation of escape from an electrically charged grid, the reduction in pain (the consequence of stimulation) is theoretically the basis for reinforcement (Hilgard and Bower, 1966). It is the drive stimulus reduction theory of reinforcement that is used in the present study.

There have been several studies using a delayed negative reinforcement (delayed escape) design. Bell, Noah, and Davis (1965) using rats in a shuttle box situation found that running speeds were slower with longer delays of shock termination. They used delays of 0, 1.25, 2.5, and 5 seconds. These data demonstrate an empirical gradient effect of delay of shock termination on escape learning that is similar to those under conditions of food reward (Wolfe, 1934). Keller (1966) using rats in a Skinner type situation with 1, 2, 5, and 10 second delays of escape from intense light found that response latencies were longer for the longer delays of negative reinforcement than they were for the shorter ones. Fowler and Trapold (1962) using rats in a straight alley with 0, 1, 2, 4, 8, and 16 second delays of shock termination found that running speeds were slower with the longer delays of negative reinforcement. Woods and Feldman (1966) using rats in a water tank escape situation with 0, 3, and 10 second delays found that response speed was faster for shorter delays of reinforcement.

In studying instrumental avoidance conditioning with delay of reinforcement, the time at which the warning signal terminates after the response is manipulated. Kamin (1957), using rats in a shuttle box situation, reasoned that the warning signal, through its association with punishment (shock onset), becomes a noxious stimulus itself. Thus the termination of the stimulus should be reinforcing and postponing the time at which it terminates should be the same as delaying any other reinforcement. Kamin used a buzzer as the conditioned stimulus. The offset of the buzzer followed the correct response by 0, 2.5, 5, or 10 seconds. It was found that learning was much better when the response terminated the buzzer immediately than it was under any of the other delayed conditions. Kamin obtained a delay of reinforcement gradient that is quite similar to those obtained by other investigators using positive reinforcement (Spence, 1956). Kamin thus shows that a delayed conditioned negative reinforcer bears the same functional relationship to behaviour as does the delay of a positive reinforcer or a primary negative reinforcer.

An analogue of the present investigation involves the research into why animals in a maze learn to take the shorter path to the goal rather than the longer one, and how they do this. In the maze learning situation errors, such as entries into blind alleys, are actually reinforced, but a correct run through the maze results in reward sooner. This notion is akin to the situation investigated by Logan (1952) in which the two lever pressing responses were reinforced, but one yielded reinforcement sooner than the other. According to the goal gradient principle, the responses in a maze situation that are involved in a correct run should therefore be learned better (Kimble, 1961). Yoshioka (1929) tested this assumption. Rats in his study ran a maze in which there were two alternative paths to food reinforcement. In one maze the longer path was always 211 inches from start to goal. For another maze of the same pattern, the longer path was twice as long, or 422 inches. In either maze the other path could be shortened to any desired length. Yoshioka used ratios of long to short paths of 1.07, 1.14, 1.23, 1.33, and 1.44 in each of these two mazes. He found that (1) rats learned to take the shorter path, (2) the rats took more trials to learn the short path when the ratios were small than when they were large, and (3) equal ratios were equally difficult to learn in the long and in the short mazes. Yoshioka then proposed that it was the relative response strength produced by differing delays of reinforcement that determined the ease or difficulty of acquiring the short path habit, and that the ease of learning to take the short path is independent of the lengths of the paths. According to this hypothesis, learning to take the short path would be just as easy in a very small maze as in a very large one, as long as the ratios of long to short paths were equal.

More recent evidence (Anderson, 1933; Grice, 1942) in this area suggests that Yoshioka's specific interpretation is incorrect and that the ratios and the absolute lengths of the paths combine to determine the number of trials required to learn to take the shorter path. Also contrary to the results of Yoshioka (1929), Anderson (1933), using rats in a runway and measuring running speed, found that learning was better with equal long to short ratios when the absolute time delays were shorter. Grice (1942), using rats in a maze learning situation, obtained results in agreement with those of Anderson (1933), but in addition he also found slower learning as the ratio of long to short paths decreased, as did Yoshioka (1929). These conclusions support Hull's (1932) goal gradient hypothesis which briefly states that learning varies directly with the immediacy with which reward follows the response to be learned. It is the conclusions drawn from these conflicting results which are being investigated in the present study.

The questions being investigated in the present study are two-fold. First, an attempt is being made to find out if rats are able to discriminate among delays of negative reinforcement in the same way as they are able to discriminate among delays of positive reinforcement (Logan, 1952). According to the results of the studies by Bell, Noah, and Davis (1965), Keller (1966), Fowler and Trapold (1962), and Woods and Feldman (1966), all of which showed that the delay of negative reinforcement has essentially the same effect on learning as does the delay of positive reinforcement, it is expected that rats are able to discriminate among different delays of negative reinforcement. The second major question being investigated is the way in which rats discriminate among different delays of negative reinforcement. According to the results of the study by Yoshioka (1929), rats discriminate among relative differences between delays of reinforcement, while Grice (1942) and Anderson (1933) suggest that it is both relative differences and absolute lengths of delays that combine to affect discrimination in this situation. It is hoped that the present investigation, by virtue of its experimental design, either supports the finding that equal ratios of long to short delays of reinforcement are equally easy to discriminate regardless of the absolute lengths of the delays (Yoshioka, 1929), or the finding that even when ratios of delay are equal, subjects discriminate better with shorter absolute time delays than with longer absolute time delays (Grice, 1942; Anderson, 1933).

Basically, the present study is one of discrimination among delays of negative reinforcement in a two-bar Skinner box situation, the reinforcement being in this case shock termination after varying periods of time following the bar press. In this situation two visual stimulus cue lights differing in intensity are each associated with negative reinforcement, but one is always associated with a more effective reinforcement (shorter delay) than the other. The former is then designated as the "correct" stimulus. The present study attempts to show that rats are able to discriminate among different delays of negative reinforcement (shock termination) when these delays are always paired with a particular intensity cue light above one of the bars. Munn (1950) states that there seems to be no inherent significant brightness or position preference (left or right) in the rat. In order to try to eliminate the effects of any possible position or brightness preferences, the position of the correct stimulus light is varied in a randomly balanced fashion. The short and long delay conditions are also randomly balanced with respect to the two discriminative stimuli.

It is hypothesized that rats do prefer the correct stimulus light with its associated shorter delay of reinforcement, and that they press the bar beneath it based upon the differential effects of that response on terminating electric shock.

In the controversy over colour vision in the rat, most research seems to indicate that rats are unable to discriminate between light of differing wavelengths, but that they are able to make discriminations on the basis of relative differences in the brightness (intensity) of light (Coleman and Hamilton, 1933; Watson and Watson, 1913). According to Munn (1950), brightness discrimination is elementary in the rat.

According to specifications obtained from Lehigh Valley Electronics the intensities of the two visual stimulus cue lights used in the present investigation have a subjective relative brightness ratio equal to 4.37 (bright/dim). This ratio is more than adequate to enable rats to differentiate between brightnesses of light (Lashley, 1930).

Chapter II

Method

Subjects Fifty-four naive male Long-Evans Hooded rats served as subjects for this experiment. The Ss were approximately 90-100 days old at the beginning of pre-training.

Apparatus The apparatus used in this study consisted of a Lehigh Valley #1316 test cage mounted in a #1417C sound-insulated cubicle. Front, top, and back panels of the test cage were ¼" plexiglass. The intelligence panel and side panel were stainless steel as were the electric shock grid bars. Sheets of 1/32" stainless steel were also mounted on the insides of the front, top, and back plexiglass panels. These sheets were electrified in the same manner as the shock grid to prevent S from escaping shock by any means other than a bar press.

There were two interchangeable intelligence panels for the test cage. One, having a single centrally located lever 1-3/16" above the grid floor with a single cue light above it which is 2-¼" from the grid floor, is used for pre-training procedures. The other intelligence panel, for use in the test situation, consisted of two levers 6-3/4" apart and 1-3/16" above the grid floor. Each lever had above it a stimulus light (LVE #1348QL) which is mounted behind a translucent panel. This light may be programmed to illuminate three different intensities of light, and was mounted 2-½" from the grid floor. The dimensions of the animal working space were 7-½" high by 12" wide by 8" deep.

Delay intervals and intertrial intervals were programmed by five LVE #1309 recycling timers. The shock system consisted of an LVE #1531 constant current shocker which maintains a constant DC current output over a wide range of animal resistances, and incorporates an LVE #1311SS shock scrambler. When the scrambler output is applied to a test cage each floor grid and the walls are placed at a high potential to every other grid. The shock scrambler operates in such a way as to supply six shock pulses per second to a subject on any two grids. Current in milliamps is adjustable within a range of .02 to 10 ma. DC. Shock presentation is automatically programmed.

Preliminary testing for threshold of overt responses to electric shock, as well as data from Campbell and Teghtsoonian (1958) indicated that with the constant current shocker employed here, animals manifested an observable reaction at approximately .04 ma. Based on the pilot investigation the most appropriate shock level to use in the present study was found to be approximately .06 ma. as recorded by the dial on the shock source with S on the grid floor of the test cage.

The randomly balanced sequential presentation of the two different intensity cue lights above the left and right levers was controlled by an LVE #1656 Stepper. The sequence used was dim, bright, dim, dim, bright, dim, bright, bright, dim, bright. This sequence was repeated ten times in each 100 trials.

Experimental Design The 54 Ss used in this investigation were randomly assigned to nine groups of six Ss each. All Ss underwent the same pre-training procedure to be described shortly. The design was a 3 x 3 factorial design consisting of three "shorter delays of negative reinforcement" and three "ratios of long/short delays of negative reinforcement." The three ratios of long/short delays of negative reinforcement were 3:2, 2:1, and 5:2. The three shorter delays of negative reinforcement were 1.0, 1.5, and 2.0 seconds. The entire factorial design is presented in Table 1. A note of explanation is in order as to why the delay intervals presented in the table were used. In discrimination of delay situations such as the present investigation it has been found (Munn, 1950) that a five second delay of reinforcement is the maximum delay that can be used in order for learning to occur. Munn (1950) also states that the smallest difference detectable in delay intervals in 0.5 seconds.

Preliminary Procedures The Ss that were used in this study were received at approximately 80 days of age. Upon arrival the Ss were placed on an ad libitum feeding and watering schedule for four days and then placed on a deprivation schedule for seven days. During deprivation the Ss received approximately 15 grams of Purina lab chow at 24-hour intervals, with water available at all times. This deprivation schedule was designed to reduce the Ss to 80% of their ad lib weight, and the 15 grams diet was continued as a maintenance diet throughout the entire training schedule. At the end of the stated seven day deprivation period the Ss began the pre-training phase of the study.

Table 1

Factorial Design of Experiment

Shorter Delay (Seconds)	Long Delay/Short Delay Ratio		
	3:2	2:1	5:2
1.0	1.5 vs. 1.0	2.0 vs. 1.0	2.5 vs. 1.0
1.5	2.25 vs. 1.5	3.0 vs. 1.5	3.75 vs. 1.5
2.0	3.0 vs. 2.0	4.0 vs. 2.0	5.0 vs. 2.0

Pre-training Procedures All Ss underwent the pre-training conditions appropriate to the training condition to which they were randomly assigned. Initially all Ss were trained to press the lever in the Skinner box having an intelligence panel with the lever centrally located and a single cue light above the lever. Each lever press was reinforced with one 45 mg. P. J. Noyes Formula A rat food pellet. Each S was allowed to make 200 reinforced bar press responses. When this training was completed the Ss were randomly assigned to groups and continued pre-training as follows. Using the same intelligence panel as described above, except for the intensity of the cue light, each S was given 100 delayed escape trials each to the dimmer cue light and to the brighter cue light. The delays associated with each brightness light were the same as those used in the discrimination training for a particular group of Ss (see Table 1). This procedure insured that within each group of Ss all Ss had equal experience with each brightness separately. Responses to both brightnesses were equated, that is, an equal number of responses (100) was made to the brighter and dimmer cue lights. The short and long delay conditions were randomly balanced with respect to the two discriminative stimuli. That is, one-half of the Ss had the brighter stimulus light associated with the shorter delay of shock termination, while the other half of the Ss had the dimmer stimulus light associated with the shorter delay of shock termination.

Training Procedures Training consisted of 100 simultaneous discrimination trials per day for all Ss using the following procedure. For the discrimination training trials the original intelligence panel was replaced by one having two levers with an illuminated disc above each. After a 15 second intertrial interval both the brighter and the dimmer stimulus came on simultaneously. Two seconds later the electric shock was initiated and remained on until a bar was pressed by S. The bar press turned off the lights and shock together after the delay period expired. If the bar under the "correct" stimulus light was pressed, then the shorter delay schedule was begun. If the bar under the "incorrect" stimulus light was pressed, then the long delay schedule was begun. The position (left vs. right) of the stimulus lights was varied from trial to trial according to a randomly balanced presentation schedule so as to diminish the effects of any position preference on the part of S.

Subjects were run to 600 trials. Previous studies in this general area of research have indicated that 600 trials are sufficient for the solution of the simple brightness discrimination problem (Munn, 1950). Pilot work using the present apparatus had demonstrated the ability of Ss to discriminate within 600 trials.)

Measures The number of bar presses at the left hand bar, the number of bar presses at the right hand bar, the number of initial bar presses to the shorter delay bar, and the number of initial bar presses to the longer delay bar were recorded for each S for each day's performance (100 trials). Initial bar presses were defined as which bar S pressed first at the beginning of each trial. Bar presses to the left and right stimulus, regardless of brightness, were recorded in order to observe if there was any indication of a position preference in any subject. The actual measure of the degree of discrimination being made by Ss was determined by examining the percentage of initial bar press responses made to the shorter delay light and bar combination. These percentage preferences were recorded for each block of approximately 25 trials for each 100 trials during the discrimination training procedure. Data were collected in this way so that possible in-session changes in performance could be analyzed.

Chapter III

Results

The percentages of the initial short delay bar press responses for each experimental condition for each of the six training days were examined and no trends in behaviour were noticeable, therefore the mean percentages of the initial short delay bar press responses for each experimental condition over all 600 trials were calculated and are shown in Table 2. The significance of the obtained differences among percentage preference for the shorter delay was assessed by analysis of variance as summarized in Table 3.

The results indicated that there was a significantly greater preference for the shorter delay as the size of the delay ratio increased ($F = 3.51$, $df = 2, 45$, $p < .05$). The analysis also pointed out that there was a significantly greater preference for the shorter delay as the absolute size of the shorter delay of each pair decreased ($F = 6.96$, $df = 2, 45$, $p < .01$). There was no significant interaction. These results support the hypothesis that rats do prefer the "correct" stimulus light with its associated shorter delay of negative reinforcement.

Figures 1 and 2 respectively graphically illustrate the findings that across all absolute sizes of delays the percentage preference for the shorter delay increased as the size of the delay ratio increased, and that across all delay ratios the percentage preference for the shorter delay decreased as the size of the shorter delay increased.

Table 2

Mean Percentage of Initial Short Delay Bar Presses

Shorter Delay (Seconds)	Long Delay/Short Delay Ratio		
	3:2	2:1	5:2
1.0	52.95	57.09	58.67
1.5	52.73	54.77	57.06
2.0	52.30	52.78	55.10

Table 3

Analysis of Percentage Preference for Short Delay

Source	SS	df	MS	F
Delay Ratio (A)	72.72	2	36.36	3.51*
Short Delay (B)	144.35	2	72.18	6.96**
A x B	43.67	4	10.92	1.05
Error	466.57	45	10.37	
Total	727.31	53		

* $p < .05$

** $p < .01$

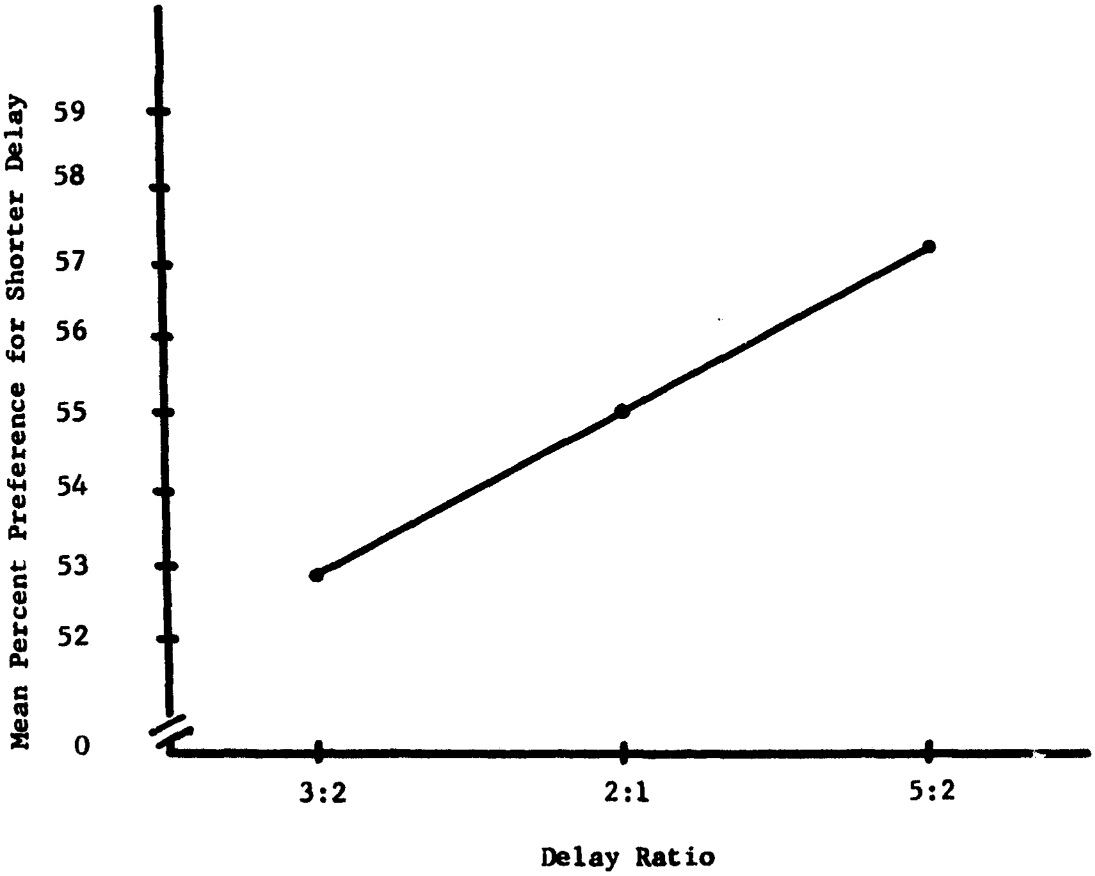


Fig. 1. Effect of delay ratio on preference for shorter delay

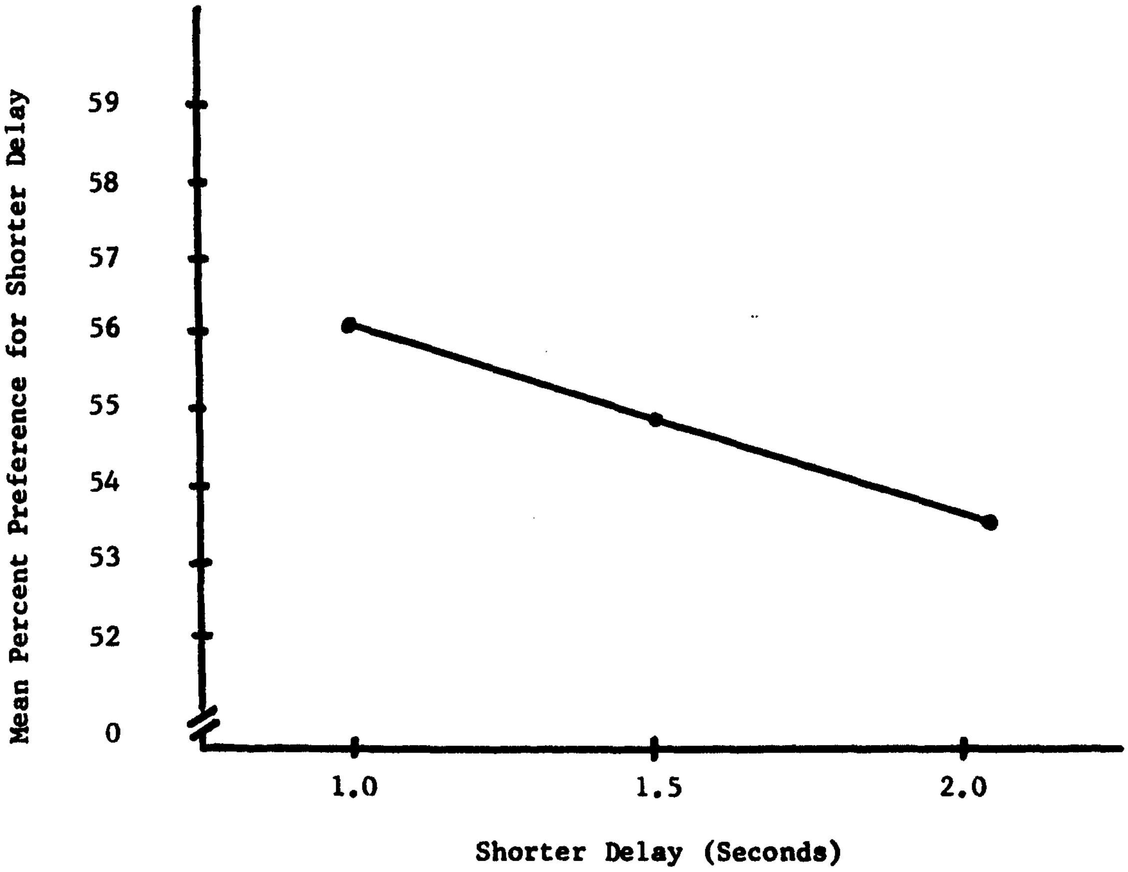


Fig. 2. Delay length and preference for shorter delay

From Table 2 it can be seen that within each of the shorter delay conditions (1.0, 1.5, and 2.0 seconds), the percentage preference for the shorter delay increased regularly as the size of the delay ratio increased, and that within each of the three delay ratio conditions (3:2, 2:1, and 5:2), the percentage preference for the shorter delay decreased regularly as the size of the shorter delay increased.

Chapter IV

Discussion

The results of the present investigation indicated that rats are, in fact, able to discriminate among delays of negative reinforcement just as they are able to discriminate among delays of positive reinforcement (Logan, 1952). The present data support the findings of Bell, Noah, and Davis (1965), Keller (1966), Fowler and Trapold (1962), and Woods and Feldman (1966) that a delayed negative reinforcer bears the same functional relationship to behaviour as does the delay of a positive reinforcer.

The present data also indicated that the way in which rats discriminate among different delays of negative reinforcement is dependent upon the combination of both the relative differences between delays and the absolute lengths of the delays. These findings are in agreement with those of Grice (1942) and Anderson (1933) that within each delay ratio condition, the smaller the absolute length of the delay interval, the greater is the preference for the shorter delay.

The present results can be explained in terms of Hull's (1932) goal gradient hypothesis "...that the goal reaction gets conditioned the most strongly to the stimuli preceding it, and the other reactions of the behaviour sequence get conditioned to their stimuli progressively weaker as they are more remote (in time or space) from the goal reaction." Thus, in the context of the present investigation, those subjects experiencing longer absolute delays of negative reinforcement, regardless of their delay ratio condition, are temporally farther removed from the goal (shock termination) than those subjects experiencing shorter absolute delays of negative reinforcement. These results do not support the findings of Yoshioka (1929) that equal ratios of delay of reinforcement are equally difficult to discriminate regardless of the absolute sizes of the delays of reinforcement.

The conclusions drawn by Grice (1942) and Yoshioka (1929) that the larger the ratios of delay of reinforcement, the easier will be the discrimination between them are clearly supported by the data in the present investigation. These data indicated that within each of the absolute time delay conditions (1.0, 1.5, and 2.0 seconds), there was a greater preference for the shorter delay as the size of the delay ratio increased.

This finding can be explained by understanding that within any given absolute size of delay of reinforcement, as the ratio of delays increases, the absolute difference between the long and short delays to be discriminated must, of necessity, also increase. All other things being equal, the greater the difference between any two stimuli, the easier it is to discriminate between them. This rather obvious statement is supported by Pavlov's (1927) research in the area of experimental neuroses in dogs. Pavlov found that as the ratio of differences between two stimuli decreased, thus making the absolute differences between them smaller too, the ability to discriminate between them became progressively impaired. It must be noted here that the "neurotic" behaviour exhibited by Pavlov's animals due to an increasingly difficult discrimination, and the "neurotic" behaviour observed by Cook (1939) in white rats in a similar discrimination situation was not apparent in the present investigation. This was probably due to the fact that, since Munn (1950) stated that the smallest detectable difference in delay intervals is 0.5 seconds, no difference of less than 0.5 seconds was used in the present study. Thus since there was no difference between delays of negative reinforcement which should not have been discriminated by the rats, the "neurotic" behaviour found in earlier studies was not expected in the present investigation.

Chapter V

Summary

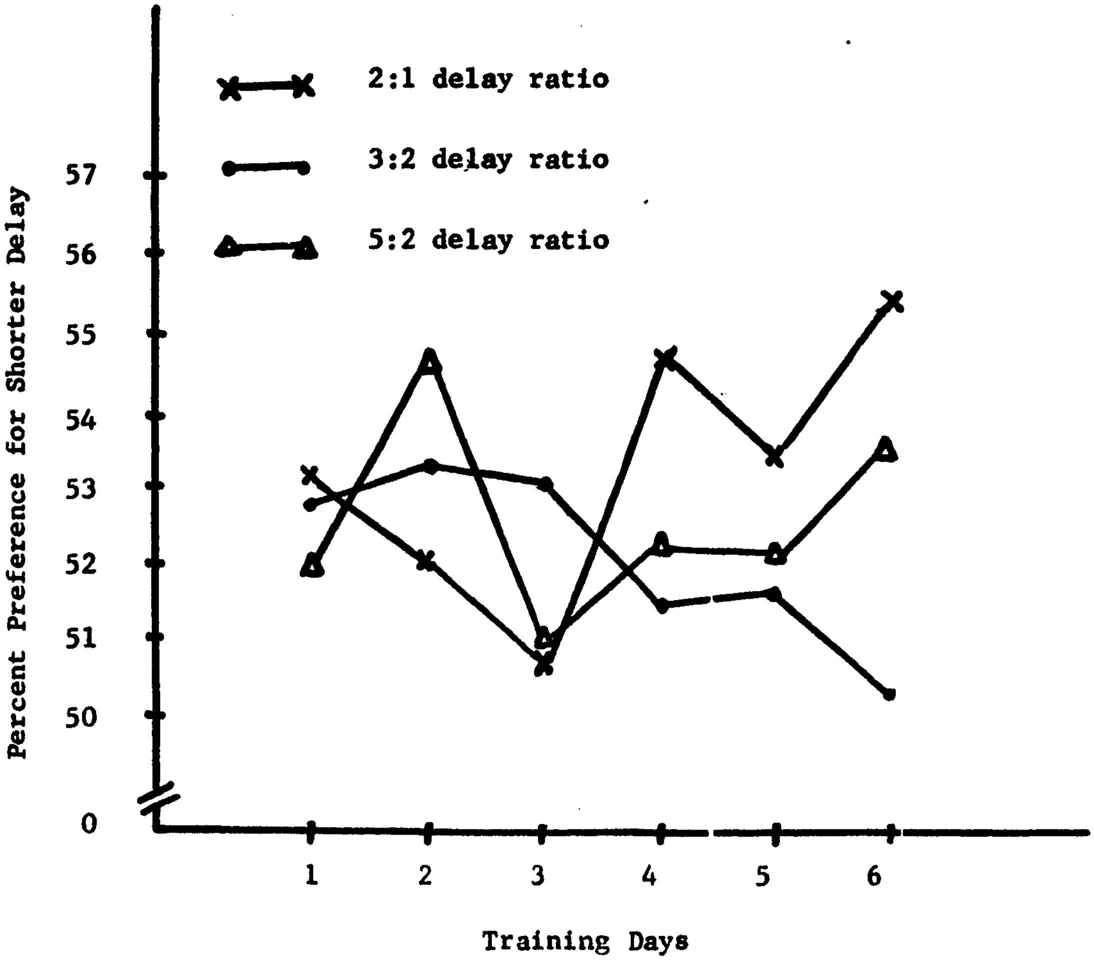
Fifty-four male hooded rats were randomly assigned to the nine experimental conditions in a 3 x 3 factorial design having three ratios of delay of shock termination (3:2, 2:1, and 5:2), and three shorter delay intervals (1.0, 1.5, and 2.0 seconds). The percentage preference for the shorter delay was noted for each S for each discrimination pair by recording which bar each rat pressed first at the beginning of each trial. It was predicted according to the goal gradient hypothesis that rats would prefer the shorter delay interval. The results supported the prediction. Results also showed that rats discriminate between delays of negative reinforcement on the basis of both relative differences and absolute lengths of delay intervals. All differences in the analysis of variance were statistically significant beyond the .05 level. The conclusions reached in the present study were that the preference for the shorter delay increased as the size of the delay ratio increased, and that the preference for the shorter delay decreased as the absolute size of the shorter delay increased.

Appendix A

Percentage of Initial Short Delay Bar Presses for Individual Subjects

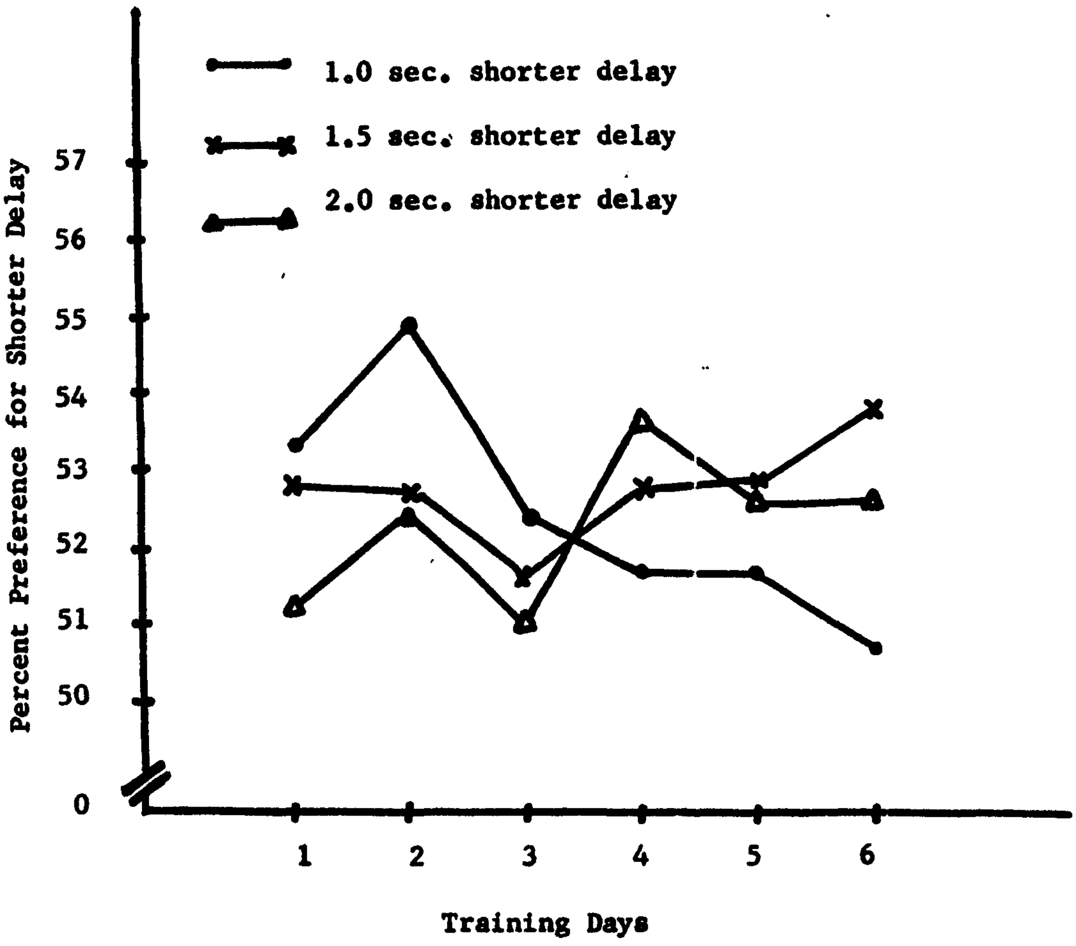
Shorter Delay (Seconds)	Long Delay/Short Delay Ratio						Mean Percent Preference
	3:2		2:1		5:2		
1.0	54.75	54.58	58.88	58.92	58.46	62.25	56.23
	52.46	50.63	57.04	55.58	54.17	58.50	
	53.67	51.58	55.63	56.50	60.33	58.29	
1.5	44.25	52.04	55.13	54.13	59.35	47.25	54.85
	53.88	56.29	58.92	53.42	57.90	56.75	
	53.17	56.75	55.29	51.75	61.00	60.10	
2.0	48.60	58.70	52.32	54.35	55.65	53.55	53.39
	47.25	51.35	51.57	53.45	56.55	56.95	
	58.40	49.50	51.56	53.41	52.70	55.20	
Mean Percent Preference	52.66		54.87		56.94		54.83

Appendix B



Effect of delay ratio on preference for shorter delay over days

Appendix C



Effect of delay length on preference for shorter delay over days

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