AMOUNT OF REINFORCEMENT AND CONSUMMATORY TIME IN HUMAN LEARNING

THE EFFECTS OF AMOUNT OF REINFORCEMENT AND CONSUMMATORY TIME ON A LEVER PULLING RESPONSE IN HUMAN SUBJECTS

By

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SCOPE AND CONTENTS:

An experiment was carried out to investigate the effects of magnitude of reward and consummatory time on the choice behaviour of human subjects.

Analysis of the data revealed: (1) choice behaviour was a function of both magnitude of reward and consummatory time; (2) the effects of these two variables differed depending upon the period of training under consideration; (3) short consummatory times resulted in highly variable behaviour.

The results were discussed in relation to theories derived from experiments using infrahuman subjects.

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CHAPTER ONE

INTRODUCTION

Since Pavlov's early writings on "conditioned reflexes" and Thorndike's formulation of the Law of Effect, reinforcement has assumed an increasingly important role in the psychology of conditioning and learning. However, not all psychologists give the same emphasis to the reinforcement principle in their theories. For example, Guthrie (1935) contends that the function of reinforcement in learning is only to prevent already conditioned behaviour from becoming unlearned; he is, therefore, not interested in studying the nature of reinforcement as such. Skinner (1938) is concerned with those aspects of reinforcement that affect the rate of learning and performance, such as schedules of reinforcement. On the other hand, Hull (1943) and his followers believe that reinforcement is one of the central factors in any learning situation, and they claim that its effects must be defined before learning can be fully understood. Because of the importance attached to reinforcement in Hullian theory, a great deal of the present day research on this variable stems from his students.

Spence, an exponent of Hull's theory, and his research assistants at the State University of Iowa have designed and carried out a research program in an attempt to define the functions of such parameters as delay of reinforcement and magnitude of reinforcement in the con-

ditioning of lower animals. The findings of these experiments have furnished the background for a general theory of learning, which Spence has described in his book Behavior Theory and Conditioning (1956). According to Spence's theory, one of the major determinants of behaviour is the size of the reinforcing agent. This conclusion was based on a number of studies which demonstrated that the strength of an instrumental response was a function of the magnitude of reinforcement; that is, the larger the reward the greater the response strength. This finding was in general agreement with the results of earlier experiments concerned with the same problem, (Wolfe and Kaplon, 1941; Crespi, 1942; Zeaman, 1949).

During the course of the investigations at Iowa, it was noted that the findings were complicated by an uncontrolled variable that probably exerted a considerable influence on the results. Magnitude of reinforcement (the variable under study) was always positively correlated with consummatory time; in other words, animals receiving the larger reward invariably spent a longer time in the goal box consuming the entire amount than those animals receiving the smaller reinforcement. Thus, time spent in the goal box might have been the variable determining response strength. Two experiments (Swisher, 1951; Czeh, 1954) were performed in an attempt to isolate the consummatory time variable. The findings from these studies indicated that time spent in the goal box, and not magnitude of reward, was the factor responsible for the differential response strength. For various reasons, Spence believed these latter results were inconclusive. He suggested that the

problem of the relationship between magnitude of reward, consummatory time and response strength would have to be decided by further investigation.

Spence's suggestion prompted the research undertaken and described in this paper.

Previous experimental studies on consummatory time and magnitude of reward have almost exclusively employed infrahuman subjects; consequently, little is known of the effects of these variables on human behaviour. Yet, undoubtedly, these two factors do play an important part in the ordinary life of the individual. For instance, humans often must choose between two similar, but differentially reinforced tasks in which there is only a limited time available to complete the selected task and collect the reward. This research was designed to explore the nature of human behaviour in this type of situation.

More specifically, the present experiment will investigate the relationship between magnitude of reinforcement and consummatory time in a two-choice behaviour situation using human subjects. An attempt will be made to relate the findings to Spence's reinforcement theory, which is outlined in the following historical review.

CHAPTER TWO

HISTORICAL REVIEW

Clark Hull, in his Principles of Behavior (1943), was the first learning theorist to formulate a hypothesis concerning the effects of magnitude of reinforcement on instrumental learning. He wrote:

> "In a learning situation which is optimal in all other aspects, the limit (M) of habit strength ($_SH_R$) attainable with unlimited number of reinforcements is a positive growth function of the magnitude of the agent employed in the reinforcement process." (1943, p. 128).

Hull based this postulate on the results of three early animal studies. The first of these was one conducted by Grindley (1929-30). Grindley used five groups of chicks and trained them under five different reward conditions in a straight runway. The amounts of reinforcement were one, two, four and six grains of boiled rice, with the fifth group receiving no reward. Running the chicks for one trial per day, Grindley measured the time taken for each animal to cover the distance between the starting box and the food box on each trial. He noted that, at the end of training, animals receiving the larger amounts of reward covered the distance in shorter times.

A study by Gantt (1938) on conditioned salivation in dogs was the second study Hull employed as supporting evidence for his hypo-

thesis. Gantt conditioned a number of dogs to four different conditioned stimuli, each stimulus being reinforced by varied amounts of food ranging from one half gram to twelve grams. The four conditioned responses were reinforced in a random order. Utilizing the results of one stable animal who had learned to respond differentially to the four different stimuli, Gantt reported that the average amount of conditioned secretion at the end of training was a direct function of the amount of reinforcement.

The third study cited by Hull as strengthening his belief that the asymptotic level of habit strength was a function of the size of reward was published in 1941 by Wolfe and Kaplon. These authors described the effects of amount of reinforcement and consummatory activity on learning in chicks. In a maze situation, one group of chicks ran to one quarter of a kernel of popcorn, another group to one kernel and a third to one kernel divided into four pieces. Using running speed as the response measure the authors found that animals receiving one kernel ran a great deal faster than those receiving only one quarter kernel; also that the chicks rewarded with one kernel divided into four pieces responded at a faster rate than those running to one whole kernel. Wolfe and Kaplon interpreted this latter finding as an indication that the amount of consummatory activity (i.e. pecking and eating) involved in the greater number of pieces was an additional factor in determining level of performance.

From the data of these experiments Hull made a further assumption concerning the rate of learning. He stated that: "the rate of learning is an increasing monotonic function of the amount of the agent employed at each reinforcement." (1943, p. 127). In other words, the size of the increment of habit strength on each reinforced trial depends on the amount of reinforcement used.

Thus, according to Hull's theory, magnitude of reward affects learning in two ways: (1) it determines the increment of habit strength acquired on each reinforced trial, and (2) it defines the limit to which habit strength can grow.

From these premises Hull derived two hypotheses regarding the effects of suddenly shifting the size of the reward after the asymptotic level of learning had been attained with one reward. First he suggested that a shift to a larger reward would result in a gradual increase in the acquisition of habit strength until a new limit of performance had been reached for the larger reward. Secondly, if the shift was from a relatively large reinforcement to a smaller one, a progressive weakening of habit strength would occur.

These early formulations of Hull's stating relationships between habit strength and magnitude of reward were not totally in accord with the results of other experiments, however.

Prior to the publication of Hull's Principles of Behavior (1943), Crespi (1942) reported on a series of experiments in which he studied the effects of various amounts of reinforcement on the running speed of

white rats. Crespi carried out three different studies. Since he used similar procedures in all three, and combined the findings from each of these in the final analysis of the results, only the general procedure and the combined results will be summarized.

Crespi used a straight runway as apparatus. He divided his experimental animals into five groups, and ran each group to a different amount of food reward varying from one unit (1/50th of a gram) of Purina biscuit to 256 units (over grams). Each of the rewards was made into a single pellet in order to keep the number of reinforcing objects per trial the same for all animals. Each rat was run once a day following 22 hours food deprivation. In an attempt to hold drive constant for all animals, each one was fed individually after his trial an amount of food sufficient to maintain his body weight. Food eaten during the experimental run was included in this daily ration. All the rats were run for a total of 20 trials.

Crespi found that those animals receiving the largest reward ran at an increasingly faster rate than those running to the smaller rewards; animals receiving the smallest reward gave the poorest performance. The regularity of the results was shown in a graphical representation in which the average mean running speed of three of the groups was plotted as a function of the number of trials. Starting at the same level of performance the curves began diverging on the fourth trial and showed increasing differences from the fourth to the fifteenth trial. At this point the curves were widely separated, with that for

the largest reward being highest and the one for the smallest reward being lowest. From the fifteenth to the twentieth trials the curves remained fairly steady, fluctuating only a small amount from the performance level achieved on the fifteenth trial. Crespi interpreted this as representing the asymptote of learning.

The results of this investigation were in general agreement with Hull's hypothesis that magnitude of reinforcement affected both rate of learning and asymptotic level of performance. However, Hull and Crespi differed in their theoretical explanations of this phenomenon. Whereas Hull assumed that reinforcement influenced the habit strength of the instrumental response, Crespi believed that different magnitudes of reward affected an emotional drive within the organism; it was this drive that determined the various levels of performances noted between the groups. This explanation of Crespi's was founded on an observation he made during the course of his studies. He observed that animals trained with very small amounts of reward tended to behave in a manner 'indicative of frustration' (1942, p. 447). After a few training trials these rats were observed jumping, biting, clawing, etc. when they were placed in the starting box. Crespi attributed this behaviour to an emotionally based drive which he called 'eagerness'. He wrote regarding this factor: "with varying incentive amounts, after they have been experienced of course, there arise among the groups of animals varying amounts of anticipatory tension or excitement at the prospect of their acquisition." (1944, p. 352). The degree of eagerness generated

by a particular amount of reinforcement was assumed to be determined by the past experiences of the animal with that amount.

As a test of his emotional drive theory, Crespi carried his experiments one step further. He investigated the effect of shifting the reward values both to a higher amount and to a lower amount. Two groups of rats, trained to asymptotic performance level with one and four units of food reinforcement, were suddenly shifted to sixteen units of food; groups which had received 256 units and 64 units were given sixteen units of food. A control group received sixteen units throughout the experimental session, Crespi reported that within the first three trials post-shift the groups which had been shifted upward in amount of reward had surpassed the performance of the control group; while the groups which had experienced the decrease in reward size fell below the control group on the very first trial after they had received the smaller reinforcement. Crespi designated the first effect an "elation effect" and the second a "depression effect." These two constructs tended to fit in well with his postulated "eagerness" drive. According to Crespi, both the groups shifted to the larger reward and those shifted to the smaller one showed an increase in excitement; but elation resulted in increased goal-directed vigour, while depression culminated in disruption of behaviour with consequent goal-avoidance activity.

Crespi's results were at variance with Hull's predictions concerning performance following shifts in quantity of reinforcement

In keeping with his habit strength theory, Hull suggested that a sudden shift to a larger reward would result in a gradual increase in rate of responding until the limit of performance for the new reinforcement had been attained. Conversely, an abrupt decrease in reward size would cause a progressively slower rate of responding until the lower asymptotic level had been reached. While Hull's theory correctly predicted the direction of change, it could not account for the suddenness with which the changes occurred. On the other hand, the emotional drive construct introduced by Crespi into his theory allowed him to predict an abrupt change in performance following a shift in the size of the reward. This factor received additional support from a study by Zeaman (1949).

Zeaman trained groups of rats to traverse an elevated runway to different amounts of food reinforcement of from .05 to 2.40 grams. He used response latency as his measure of performance. After all the groups had attained a stable asymptote he reversed the reward for the two groups receiving the largest and smallest amounts, and ran all groups for an additional eight trials. Zeaman reported that performance was a function of the size of the reinforcement, and a shift in reward at the asymptote of learning resulted in an abrupt reversal in response latency. In agreement with Crespi he concluded that some factor other than habit strength must be operating to determine level of performance.

In view of the findings submitted by these two experimenters and Crespi's interpretation of his data, Hull (1951) introduced a new intervening variable into his postulate system, which he designated by

the symbol 'K'. He defined 'K' as an incentive motivational factor, and assumed it to be completely independent of habit strength ($_{S}H_{R}$). Habit strength was now determined solely by the number of previously reinforced trials (N), while the incentive motivational factor was a function of the reinforcement variable. According to Hull's new formulation, these two factors combined multiplicatively to determine response strength or reaction potential (E), i.e. $E = f(H \times D \times K)$. It remained for Hull's students to test the implications of this new equation (Spence, 1956).

These investigators followed the same general procedure that Crespi had utilized in his studies. Groups of rats were trained to traverse a straight runway to different amounts of food reward. Each reinforcement was made up into a single pellet. The animals were given one trial a day, and were always run under twenty-two hours' food deprivation. The response measure employed in most of the studies was the reciprocal of the running time, including starting time. One notable departure from Crespi's method was that of continuing training for forty-eight trials with one quantity of reward before switching to a larger or smaller reinforcement. It will be recalled that Crespi (1942) and Zeaman (1949) ran their subjects for only twenty trials.

The results of these studies confirmed Hull's predictions and Crespi's and Zeaman's findings, i.e. rate of learning and asymptote of performance were found to be functions of the magnitude of the reinforcing agent. However, one finding that differed from those reported by Crespi and Zeaman concerned performance following a shift to a

larger reward. It was now found that an abrupt increase in reward after the limit of performance had been reached did not result in a so-called "elation effect." Rather there was an immediate rise in response rate only to the level of the control group which had always been trained with the larger reinforcement. Crespi and Zeaman had reported that a sudden increase in reward magnitude resulted in an immediate performance in excess of that attained by a group of subjects which had been trained throughout the experimental sequence with the large reward. Spence suggested that the reason for the "elation effect" exhibited in the Crespi and Zeaman studies was that the shift in reward size occurred prior to the attainment of the true asymptote of learning and the observed "elation effect" was the result of increased training following the shift in reward magnitude. In the Iowa studies increments in performance were observed until the fortieth training trial; when the magnitude of reward shift took place at the forty-eighth trial the performance curves of the group shifted to the larger reward did not exceed those of the groups trained with that reward.

However, all the experimenters reported finding a "depression effect" when the shift was from a large to a small reward; in other words performances dropped below the level attained throughout for animals trained on the small reward. One of Spence's students, Swisher (1951), noted that the "depression effect" observed in his rats appeared to be of a transitory nature. That is, following the shift to a smaller reward there was an abrupt decrement in performance to a level

below that of a control group;[1] but on the subsequent ten trials performance of the shifted group increased, and it appeared that, with further training, the response rate of the shifted group would have reached the same level as that of the control group. To account for this phenomenon Swisher suggested a state of frustration developed in the animals shifted to the smaller reward because of failure to obtain the expected reinforcement. The amount of frustration was dependent upon the expectation level of the animal, this latter being related to the amount of previous experience with the larger reward. As a result of this frustration, the animal engaged in a number of incompatible activities which tended to interfere with his performance. Following repeated experience with the new reward these irrelevant responses were gradually extinguished, frustration slowly dissipated and performance returned to its normal pattern. This explanation of Swisher's was similar to Crespi's "eagerness" theory and Hull's "incentive motivation factor" in that all three believed that an underlying emotionally based drive was responsible for the observed behaviour.[2]

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1. Swisher's control group was trained throughout the experiment with the smaller reward.

2. It is of interest to note that three later experiments, which studied the effects of shifting the magnitude of reward, failed to find either an "elation" or a "depression" effect. Pereboom (1957) and Metzger, Cotton and Lewis (1957) used different numbers of food pellets as reinforcement, while Collier and Marx (1959) utilized different concentrations of sucrose solution. All three studies reported no evidence of abrupt changes in performance following shifts in the quantities of reward.

This motivational formulation of the effect of reinforcement on performance was adopted by Spence in his book, Behavior Theory and Conditioning (1956). Accepting Hull's (1951) basic proposal that reaction potential ($_{S}E_{R}$) was determined by habit strength ($_{S}H_{R}$) and the incentive motivational factor (K), Spence outlined a system that was somewhat analogous to a two-factor learning theory. Like Hull, he believed that the habit strength of the instrumental response was only dependent upon the number of trials; while the value of the incentive motivational factor was determined by the classically conditioned goal response. Through reinforcement the goal response (R_g) became conditioned to stimulus cues (s_g) in the goal box and to cues immediately preceding the goal area. Stimulus cues (s_g) in the response chain further back also became conditioned to part of the goal response (r_g), even in the absence of the reward. In this way the fractional goal response (r_g) was assumed to move back to the beginning of the instrumental chain, and r_g-s_g was identified with the incentive motivational "K"; thus, the value of "K" was determined by the experimental variables which acted on the vigour or intensity of the r_g-s_g mechanism. Spence specified two of these variables: first, the number of classical conditioning trials, that is, the number of times the subject entered the goal box and responded to the goal object; second, the amount of reinforcement. He also suggested there were probably a number of unknown variables which affected the vigour of "K", but these had not yet been identified.

One of these unknown factors became apparent while Spence's students at Iowa were studying the effects of the magnitude of reward

variable. These experimenters noted that subjects running to the larger reward were spending more time in the goal box consuming the reward than were those receiving smaller rewards. It was suggested that time spent in the goal box might be a confounding variable in the magnitude of reward studies, and that some attempt should be made to isolate the effects of consummatory time.

Swisher (1951) undertook such a study using an instrumental learning situation. He varied the amount of reinforcement while keeping the time allowed in the goal box constant. One group of rats was rewarded with a pellet of food weighing 2.5 grams, and a second group received a pellet weighing 0.05 gram. The subjects in the large reward group remained in the apparatus thirty seconds before being removed to their carrying case, where they consumed the remainder of the pellet; animals receiving the smaller reward were allowed thirty seconds in the goal box, that is, sufficient time to consume the whole pellet. Using latency of response as a measure, Swisher found that there was no difference in the level of performance between the two groups. He concluded that variations in magnitude of reward do not affect response strength in an instrumental learning situation when consummatory time is held constant.

Czeh (1954) utilized a somewhat different technique to study the effects of consummatory time and magnitude of reward on response strength. He trained groups of rats to traverse a straight runway, employing both starting time and running time as dependent variables. Conditions were varied for three groups of rats: group I animals received a large pellet

of food and were allowed four minutes in the goal box to consume it; group 2 animals received a similar amount of food, but were removed from the apparatus after thirty seconds and were allowed to finish eating the remainder of the food in the carrying case; group 3 animals received a small pellet of food and were allowed thirty seconds in the goal box to consume it. With this arrangement, groups 1 and 2 received the same magnitude of reward but were allowed different amounts of time in the goal box, while for groups 2 and 3 consummatory time was similar with magnitude of reward differing. Czeh reported that, after 51 training trials, group 1 showed a marked superiority in starting time over the other two groups, while the performance of groups 2 and 3 was approximately the same. These findings complement those of Swisher in demonstrating that time spent consuming food in the goal box, and not magnitude of reward, is responsible in determining speed of response evocation.[1]

Czeh also investigated the effects of shifting the magnitude of reward and the consummatory time variables. Half the subjects in group 2 were changed to four minutes consummatory time while still receiving the same large reward; the other half of this group were shifted to the small reward with consummatory time remaining at thirty

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1. Czeh found there was no difference between the groups when running time was employed as the response measure. This is at variance with the findings of a number of investigators cited earlier (Grindley, 1929-30, Wolfe and Kaplon, 1941 and Crespi, 1942). In attempting to explain these diverse results, Czeh suggested: "It is possible that the running measure is not a sensitive indicator of the strength of E and that differences appeared only because of the inclusion of the response evocation measure." (1954, p. 24).

seconds. The latter group performed at the same level following the change of reward as they had previously. The group switched to the longer consummatory time while still receiving the large reward showed marked variability in behaviour, which resulted in a lower performance level than that of the control group which had been trained throughout with the large reward and long consummatory time. However, Czeh reported that the difference between these two groups was not found to be significant, and concluded that time spent in the goal box should be considered the major determinant of performance level.

At the same time Czeh offered an explanation for the variability in behaviour observed in those animals shifted to the longer consummatory time. During preliminary training a number of the rats in group 2 had merely picked up their pellets of food in the goal box, and then waited thirty seconds until they were placed in the carrying case before consuming them. Some of these animals behaved in the same manner following the shift in consummatory time, that is, they held the pellets in their mouths in the goal box and four minutes later, after being removed to the carrying cases, they ate them. Because of the delay in consummatory activity on the part of some of the subjects, the overall response rate of this group was somewhat slower than that of the control group. Czeh contended that, on the whole, these results supported his hypothesis that consummatory time, and not magnitude of reward, was the effective variable in determining response strength.

Swisher's and Czeh's conclusions concerning the importance of the consummatory time variable in magnitude of reward studies induced

Spence (1956) to consider this factor in relation to his incentive motivational theory. In discussing the role of these two variables within his theory, Spence suggested that the size of the reinforcement should influence the vigour of r_g, while time spent in the goal box should effect the amount of conditioning of r_g per trial. Thus, a longer consummatory time would result in more conditioning of the cues in the goal box to r_g on each trial. Spence also assumed that the intensity of r_g was a function of the number of conditioning trials in the goal box. Therefore, the growth of habit strength of all conditioned r_gs, regardless of differential consummatory times, should reach the same asymptotic level after a long period of training.

In order to test this hypothesis, Spence outlined a study using rats in a T maze with a large reward in one arm of the maze and a small reward in the other. When the animals chose the side containing the large reward they would be allowed sufficient time in the goal box to consume the entire amount; when the small reward side was chosen, the animals would be left in the goal box just long enough to consume that reward. The number of entries to the two alleys could be equated by using a method of free and forced trials, which, according to Spence, would keep the habit strengths of the two responses equal. Spence hypothesized that the animals would tend to choose the alley leading to the larger reward and longer time in the beginning, but this response bias would gradually disappear until eventually the animals would be running to each of the alleys fifty per cent of the

time.[1] If this prediction were tested and found to be correct, consummatory time would have to be considered one of the major variables in determining reaction potential. However, the behaviour of the group of animals in Czeh's experiment (1954) which waited to consume its food in the carrying case caused Spence to question the validity of the results of this study. He, therefore, proposed this new experimental procedure for testing the consummatory time hypothesis. But, so far as this writer is aware, the experiment has never been performed.

In summary, then, the main question posed by the studies reviewed in this section is whether magnitude of reinforcement or consummatory time is the variable affecting response strength. The earlier investigations indicated that magnitude of reward determined level of response; but these studies failed to control for time spent in the goal box. Two later studies (Swisher, 1951 and Czeh, 1954) intimated that consummatory time was the sole determinant of response evocation. This unresolved problem prompted the research presented in this thesis.

Specifically the present experiment was designed to study the

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1. A study by Festinger (1943) reported results unfavourable to Spence's hypothesis. Using a maze with two alleys, rats were given the choice of running to one goal box where they had one minute to consume all the food they were able, or to the other one where they were allowed ten seconds' eating time. The animals were run four trials a day for twenty-four days, using forced trials on the first three days and free trials on the fourth day. This procedure was continued throughout training. The results indicated that rats chose the side on which they could eat for one minute one hundred per cent of the time. However, Festinger failed to keep the trials to the two sides equal on free choice days and for this reason Spence felt Festinger's results could not be accepted as evidence against the hypothesis.

effect of consummatory time on human behaviour in a simple two-response selective learning situation, involving two different amounts of reward and with habit strength of the two responses held constant.

Because the problem underlying this research was derived from animal investigations, the experimental procedures were designed to parallel as closely as possible those used in infrahuman studies. A human operant conditioning apparatus developed by Lindsley (1956) offered a two-choice instrumental response situation similar in some respects to the T maze. In a T maze the animal learns to discriminate between two alleys one of which leads to a larger reward than the other; in Lindsley's apparatus, the subject learns which one of two available levers must be pulled to obtain the larger reinforcement. The two types of apparatus also permit using techniques of forced and free-choice trials. In the maze one of the two alleys is blocked off to force the animal to run to a specific side; in the operant conditioning apparatus stimulus lights are situated over the levers and an illuminated light signifies which lever the subject is to pull on that trial. On a free-choice trial in the T maze both alleys are open; in the operant conditioning apparatus both lights are illuminated on a free trial. The response measure in both experimental situations is the percentage of times the subject chooses a particular one of the two responses on free-choice trials.

Animal investigators have, to a large extent, solved the problem of motivation and reinforcement by employing deprivation schedules and food reward. These two factors continue to plague the students of

human behaviour. Jenkins (1933) found that the proper use of instructions tended to increase the motivational level of humans. With the purpose of stimulating interest in the present investigation, the subjects were informed that the experiment was being developed for use by the Armed Forces for the selection of personnel. There is no method of measuring the effect this information has on performance.

The second problem, that of finding an appropriate reinforcement agent for human subjects, presents additional difficulty. Different types of rewards have been employed by previous experimenters, including words of praise (Hurlock, 1924), words of agreement (Verplank, 1955) and monetary incentive (Lindsley, 1956). Lindsley and his co-workers (1956) undertook a systematic study of the effectiveness of a number of reinforcing agents using schizophrenic patients and hospital personnel as subjects. They measured the rates of pulling a hand lever for such rewards as cigarettes, candy, money, nude pictures of the opposite sex and feeding a hungry animal. With normal subjects (hospital personnel) they found the only reliable reinforcing agent was the monetary reward.

Lindsley's findings led the present experimenter to carry out a pilot study with McMaster University students, using money as reinforcement. Surprisingly, this investigation indicated that money was not an effective reinforcing agent for this population. Some of the subjects showed obvious embarrassment at receiving payment, while others emphatically refused to accept their earnings. Whether this finding was due to the rather large quantities of small value coins received or

not is difficult to ascertain. Other experimenters, notably Lewis (1952), do not seem to have encountered this same difficulty.

The choice of reinforcing agent in the present study was influenced by psychologists (e.g. Lewis and Duncan, 1957) who reported the effectiveness of tokens as rewards. The reinforcing value of tokens, or poker chips, undoubtedly stems from past experience with games of chance or skill in which the acquisition of large numbers of these agents generally denoted "winning." A preliminary study using poker chips as reward indicated their efficacy as reinforcements in the performance of McMaster University students. In the present experiment two levels of poker chips were used as rewards: four poker chips making up the large reinforcement, with one being used for the small reward.

The term "consummatory time" when used in animal studies generally refers to the amount of time the animal takes to consume the food reward in the goal box. In the Swisher (1951) and Czeh (1954) experiments reviewed earlier this time factor was varied; that is some of the animals were given enough time to eat their pellet in the goal box, while others were removed to carrying cages before they could finish consuming their whole reward. In the present instance, consummatory time is the amount of time available for the subject to make the goal response; in other words, the time allowed the subject to lift the poker chips, one at a time, from a receptacle and place them in containers provided. Two levels of consummatory time are employed

as variables with the long time being just sufficient to remove all of the large reward (four chips) and the short time only enough to collect the small reward (one chip).

In the present thesis subjects are assigned to one of four groups, the groups differing in the amount of consummatory time available to make one of the two differentially rewarded responses. Each group is treated like one of the others in the amount of time allowed to obtain the large reward, but unlike it in time available to make the small reward response. Again, each group is treated similarly to another group in consummatory time given to obtain the small reward, but differs from the group in amount of time allowed to acquire the large reward. This design permits a comparison of selective behaviour between two rewarded responses, which differ in the time available to complete the response.

In summary, the following issues in human choice behaviour will be investigated in this research:

1. Consummatory time as a factor in determining level of performance.

2. Magnitude of reward as a determinant of response strength, independent of the consummatory time variable.

3. Both consummatory time and magnitude of reward operating to determine performance.

CHAPTER THREE

METHOD

Subjects and Apparatus:

The subjects used in this experiment were 80 male and female students enrolled in the Introductory Psychology course at McMaster University. Each subject was randomly assigned to one of four experimental groups.

The apparatus was designed by O. R. Lindsley (1956) at the Behavior Research Laboratory of the Metropolitan State Hospital, Waltham, Massachusetts and is shown in Figure 1.

Insert Figure 1 about here

A 2' x 2' panel (A) is mounted at a 60° angle against a wall. Two handles (B and C) project from the right and left hand sides of the panel. The handles can be pulled out approximately 4"; when released they are returned to the starting position by compression springs. On either side of the panel and directly above the two handles are two lights (D and E), which act as stimuli. A receptacle (F), into which the reinforcements drop, is set into the centre of the apparatus between the two handles. A light goes on behind the receptacle whenever a reinforcement is delivered.

The electrically operated recording equipment and reinforcement dispenser are in an adjoining room.

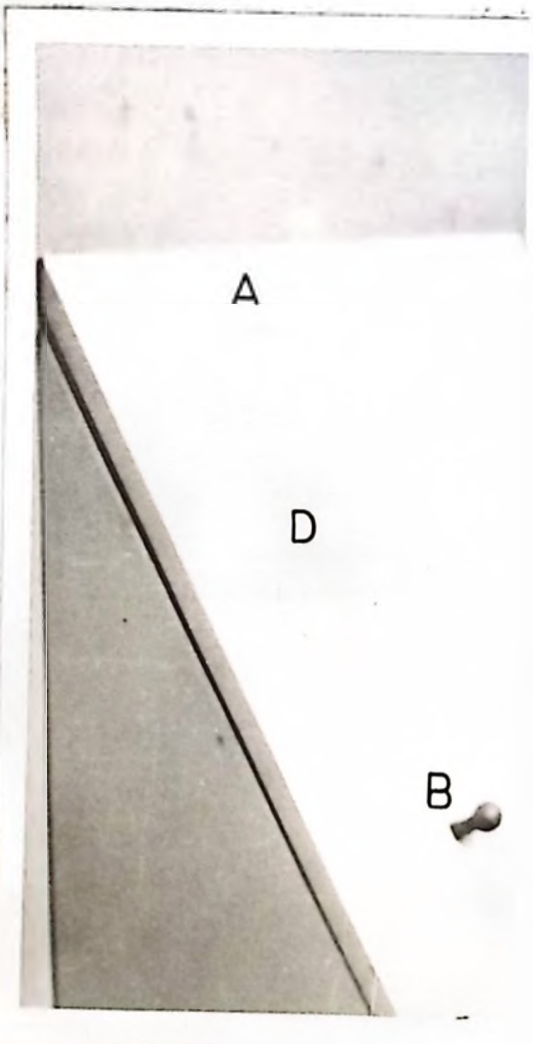
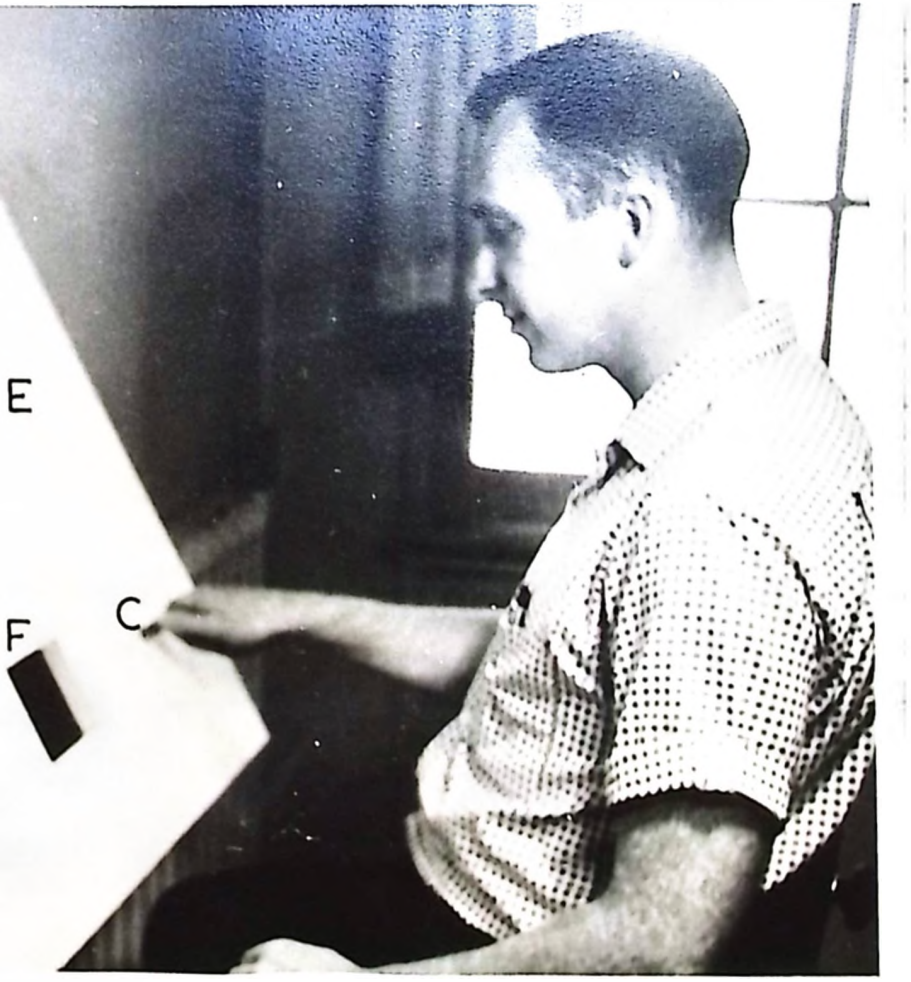


Figure 1



: Front View of Apparatus

The control and recording equipment consist of standard Grason-Stadler operant conditioning units with automatic programming procedures and counters for responses.

The reinforcement dispenser is similar to a vending machine. Following the pull of one of the handles a reinforcement is delivered down an aluminum chute into the illuminated receptacle in the experimental room.

A hand operated switch in the recording room activates the two 100 watt bulbs (stimulus lights), which are situated above the handles on the instrument panel.

Procedure:

Each subject was run individually. After entering the experimental room he was seated comfortably before the instrument panel and given the following instructions:

"This experiment is being developed for use by the Armed Forces for purposes of selecting personnel.

As soon as you see one of these two lights come on (indicating the two lights) I would like you to pull the lever situated directly under the light - pull this lever with your left hand and the other one with your right hand (here the experimenter demonstrated how the levers could be pulled). When you have pulled the lever, poker chips will fall into this opening. As soon as you see the poker chips, I would like you to pick them up one at a time - remember to remove only one chip at a time - and put them into one of these containers. (The experimenter pointed out two boxes on either side of the panel). At the end of the

experiment there should be approximately an equal number of chips in each box.[1] At the same time you must always be watching for these lights to come on; even if you have not removed all the chips you must stop removing them and pull one of the levers as soon as you see the light come on. From time to time both lights will come on; then you may pull whichever lever you wish. Please remember just to pull one lever. Are there any questions?"

If there were any questions, pertinent parts of the instructions were re-read to the subject.

The experimenter then left the room and went into the recording room where he started the timing apparatus.

Experimental Design:

The design was a choice behaviour situation, using two different amounts of reinforcement. For any one subject the reward was four poker chips from one lever, but only one chip from the alternate lever. The four experimental groups were treated similarly in this respect.

In the present study consummatory time consisted of picking up the poker chips (one at a time) from the receptacle and depositing them in the boxes provided. Time allowed to make the consummatory response at the two levels of reinforcement was varied for the four groups according

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1. This was specified so that the subject would use both hands when removing the chips, thus preventing him from keeping either one or the other hand on the levers between trials. The amount of consummatory time allowed in the experimental design was sufficient only if the subject used both hands in removing the poker chips.

to the following design:

Group	Time for Small Reward (1 chip)	Time for Large Reward (4 chips)
A	3 seconds	10 seconds
B	10 seconds	10 seconds
C	3 seconds	3 seconds
D	10 seconds	3 seconds

With this arrangement the following conditions obtained: 1. Groups A and B were similar in that they had sufficient time to complete the consummatory response if the large reward lever was chosen; 2. Groups C and D were not given sufficient time to complete the goal response if they chose the large reward side; 3. Groups A and C were allowed enough time to obtain their reward if they selected the small reward bar; 4. Groups B and D had more than enough time when the small reward side was chosen.

It should be noted that the rewards accumulated in the delivery receptacle when the subjects did not have enough time to remove them to the boxes provided. Thus, Groups C and D differed in that subjects in the latter group were able to remove their accumulated reward in the ten seconds allowed for the small reward side.

Each subject was given a total of 157 trials. Each trial was automatically timed from the moment the subject pulled the lever until the onset of the stimulus light, which always signified the start of a new trial. The time allowed the subject to complete the trial was either three seconds or ten seconds, according to the group and to the

lever pulled. In other words a subject in Group A would have three seconds to pick up the poker chip if he chose the lever delivering the small reward, and ten seconds if he pulled the alternate lever.

Of the 157 training trials given each subject, 107 were forced and fifty were free trials. Forced trials consisted of the presentation of only one stimulus light, and the subject was forced to pull the lever under that light. Both lights were illuminated in the free trial situation, with the subject being allowed to pull whichever lever he preferred. Forced trials were employed to keep habit strength to each of the levers equal for each of the fifty free trials.

The order of presentation of the sequence of free and forced trials was identical for all subjects. The first four trials were forced, two to the right hand lever and two to the left. The fifth trial was a free one. The next three trials were forced, one being to the side the subject selected on trial five with the other two forced trials being to the opposite side. The ninth trial was a free trial. Following the first free trial, equalization of the number of occurrences of the two responses was continued throughout the sequence of trials by administering the trials in blocks of 2, 4, and 6, the last numbered of these being free trials. The last response, that is the 157th trial, for all subjects was a free one.

The 157 experimental trials were carried out in a continuous sequence for each subject. A switching device, operated by the experimenter, started the timer and illuminated one or both stimulus lights according to the pre-arranged schedule. The subject responded by pulling

one of the levers which operated the vending machine and released the reinforcement into the receptacle in the centre of the experimental panel. According to instructions the subject then removed the chips one at a time, alternating hands, to the two boxes situated on either side of the apparatus. When the designated consummatory time had elapsed, the stimulus light or lights automatically came on indicating the start of a new trial.

The amount of time required per trial for each of the reinforcement values was determined from the results of a pilot study.[1] With the small reward it was found that the total trial, including lever-pulling and consummatory response, could be easily completed within three seconds; it took ten seconds to complete the trial when the reinforcement was four chips.

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1. The amounts of time for the two rewards specified in the experimental design are for the whole trial, and not just the consummatory response. The assumption is made that the time taken to make the lever-pulling response is equivalent for all subjects.

CHAPTER FOUR

RESULTS

The response measure used in this research was the number of times the subject chose the lever which delivered the large reward on the fifty free trials. The percentage of responses was computed in ten blocks of five trials for each of the four experimental groups. These data can be found in the Appendix.

Performance curves for each of the four groups are presented in Figure 2, where percentage of pulls to the large reward side are

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Insert Figure 2 about here

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plotted as a function of blocks of five free trials. A preliminary examination of the curves reveals three noteworthy aspects: (1) The first block of five free trials indicates a differential preference between the groups for the two bars.[1] During the early trials Groups A and C tend to pull the large reward lever more frequently, while Groups B and D show a preference for the small reward side. Groups A and C are treated alike in that they have a short time to remove the small reward, but differently in that Group A has a long time for the large reward and Group C a short time for that reward. Groups B and D

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1. Prior to the first free trial all subjects had four forced trials two to each side.

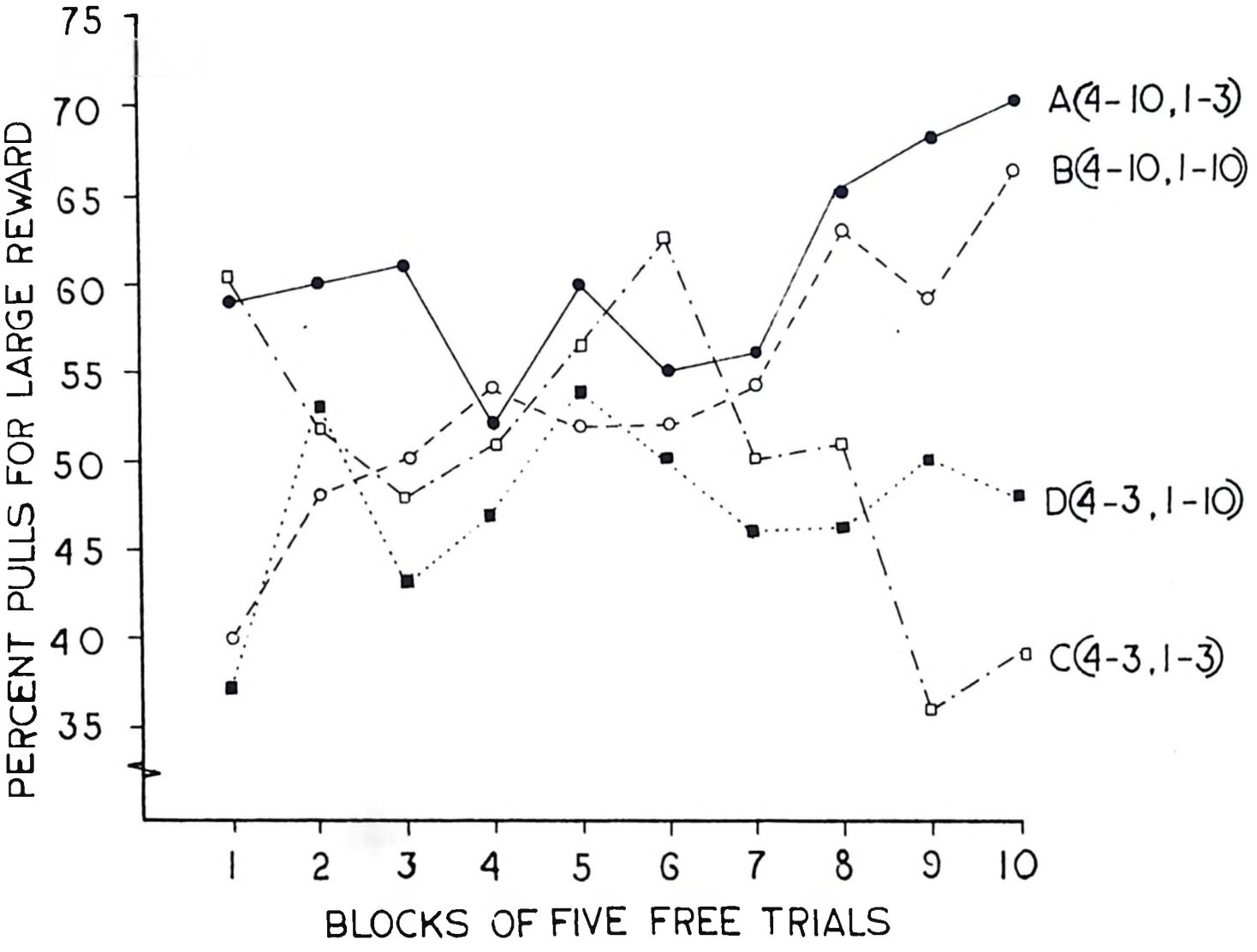

Figure 2: Percentage of pulls to the large reward side as a function of blocks of five free trials.

both have a long consummatory time for the small reward, with Group B having a long time for the large reward and Group D having a short time for the large reward. Thus, it would seem that time on the small reward side affects behaviour early in training.

(2) From the second to the seventh block of trials, all four groups show considerable variability in performance, but they all behave similarly in that they tend to select the two levers equally often.

(3) On the last three blocks of trials the groups show an increasing divergence in preference of one lever over the other. Groups A and B, who have a long time to remove the large reward, show an increasing preference for that side; Group C, with a short time for both rewards, tends to choose the small reward lever more frequently; Group D appears to be selecting the two sides equally often.

A consideration of the overall trend of training indicates that some factor is operating to influence behaviour early in the experiment, but that the effect of this variable disappears during the intermediate stages. Late in training another factor is apparently acting on the selective behaviour of the four groups.

To investigate the nature of these differences, the data were submitted to an overall analysis of variance (Lindquist, Type III, mixed design, 1953). The summary of this analysis is shown in Table I.

Insert Table I about here

The results indicate that the only significant effect when the complete training sequence is considered is the interaction between trials and

TABLE I

Analysis of Variance of Overall Pulls to the Large Reward Side

Source	df	MS	F
Time on large reward side (TL)	1	33.21	NS
Time on small reward side (TS)	1	12.75	NS
TL x TS	1	1.54	NS
Between subjects (Error)	76	19.67	
Trials (T)	9	1.29	NS
T x TL	9	4.30	3.28*
T x TS	9	2.28	1.74
T x TL x TS	9	1.35	NS
Within subjects (Error)	684	1.31	
Total	720		

* $p < .001$

consummatory time on the large reward side ($F = 3.28$, 9 and 684 df, $p < .001$). In other words, the determining factor in the overall differential behaviour is the amount of consummatory time allowed to complete the response to the large reward side. Thus, the performance of the two groups having a long time to complete the consummatory response to the large reward side (i.e. Groups A and B) differs significantly from the two groups which are allowed only a short time to make the goal response (Groups B and D).

In order to get a better indication of the effect of consummatory time on the large reward side for the overall performance of the subjects, the scores obtained for Groups A and B (long time) were combined, as were the scores for Groups C and D (short time). The results of these combined scores are presented graphically in Figure 3. The percentage of pulls to the large reward side of the combined groups is

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Insert Figure 3 about here

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plotted as a function of ten blocks of five free trials. It is evident from an examination of these curves that the differences in performance between these combined groups is mainly due to the selection of responses on the last three blocks of free trials. At this stage of training the two curves show an increasing divergence, attaining maximum separation on the tenth block of free trials.

A 2 x 2 analysis of variance was carried out on the last block of five free trials to determine if the response level of Groups A and B was significantly different from that of Groups C and D. A summary

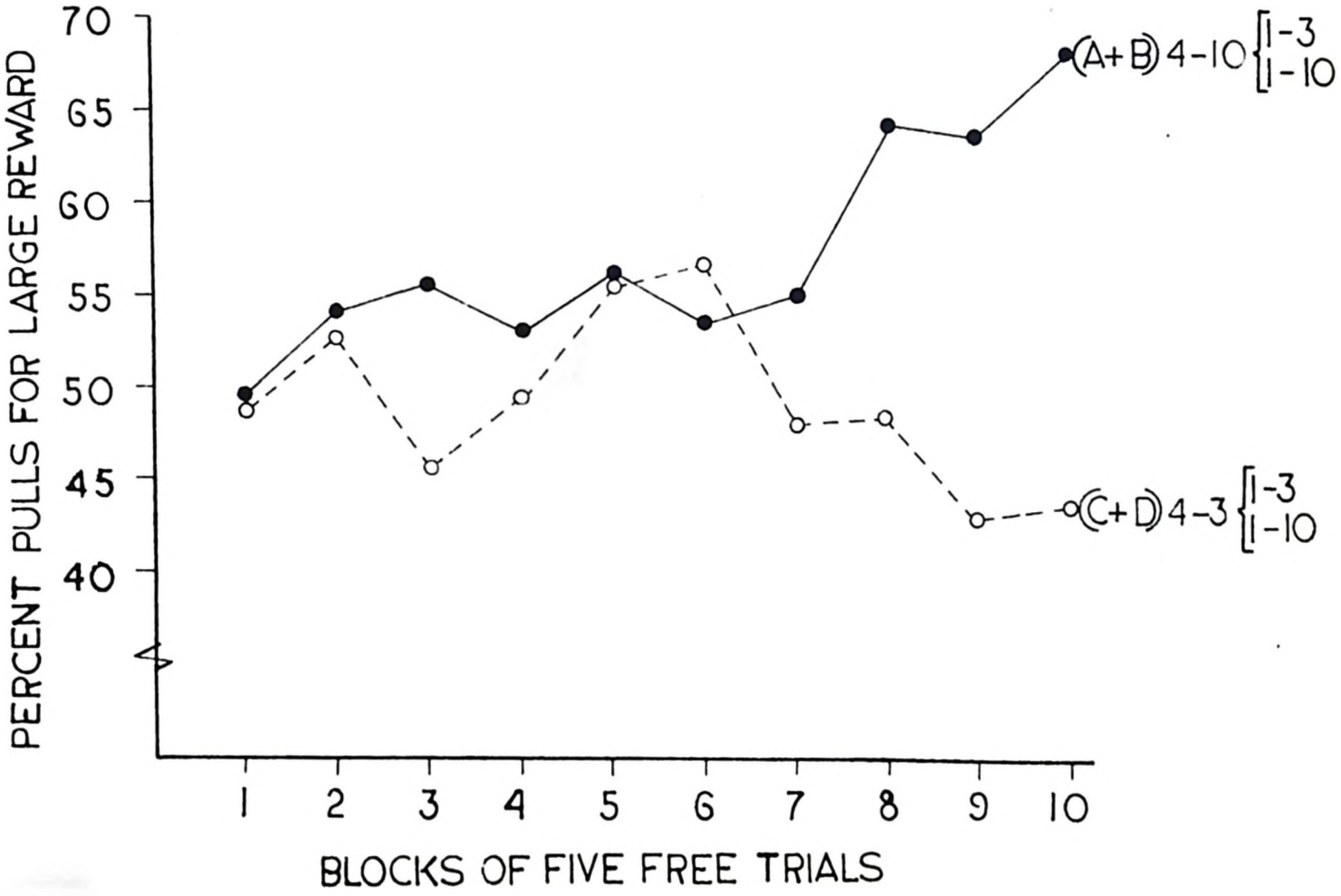

Figure 3: Percentage of pulls to the large reward side as a function of blocks of five free trials for combined scores of Groups A and B, and Groups C and D.

of the results of this test is shown in Table II. As expected, this

Insert Table II about here

difference is significant ($F = 8.88$, 1 and 76 df, $p < .005$). This finding implies that, after considerable experience with the experimental conditions, those subjects having sufficient time to complete the goal response to the large reward side perform differently than those not permitted enough time to complete that response.

At the end of training, the two groups (A and B) who have a long time to collect the large reward prefer that side, while the other two groups (C and D) who only have a short time to obtain the large reward choose the small reward side increasingly often. Thus, time spent on the large reward side is the effective variable at the end of the experiment.

A further look at the results of the overall analysis of variance in Table I shows that the interaction of trials and time spent on the small reward side falls just short of significance ($F = 1.74$). Inspection of Figure 1 reveals a variation in the curves on the very first block of trials, and it appears likely that the 'time spent on the small reward side' variable may be responsible for the differences noted. To obtain a clearer picture of this variability, the combined scores of the two groups having a short time for the small reward (A and C), and the two (B and D) having a long time to obtain the small reward are presented graphically in Figure 4. It is obvious that the only difference between these two curves is on the very first block of

TABLE II

Analysis of Variance of Pulls to Large Reward Side on the Last Five Free Trials

Source	df	MS	F
Time on large reward side (TL)	1	30.02	8.88*
Time on small reward side (TS)	1	.32	NS
TL x TS	1	2.10	NS
Error	76	3.38	
Total	79		

* $p < .005$

free trials.

Insert Figure 4 about here

To determine if there was a significant difference between the combined groups at the beginning of training, a 2 x 2 analysis of variance was performed on the first five free trials. The results of the analysis are shown in Table III. An inspection of this table in-

Insert Table III about here

dicates that the one significant source of variability is the two different consummatory times spent on the small reward side ($F = 9.76$, 1 and 76 df, $p < .005$). That is, the two groups who have only a short time on the small reward side (A and C) behave differently at the beginning of the experiment than the two (B and D) which have a relatively long time to obtain the small reward.

This effect is shown more clearly in Figure 5, where the perfor-

Insert Figure 5 about here

mance curves of the four groups on the first five free trials are plotted.[1] The extreme variability in choice-behaviour displayed early in the experiment is interesting. Group C, with only a short time to complete the consummatory response to either the large reward or the small reward side, shows an increasingly decided preference for the large reward

1. It should be recalled that all subjects had two forced trials to each side before the first free trial.

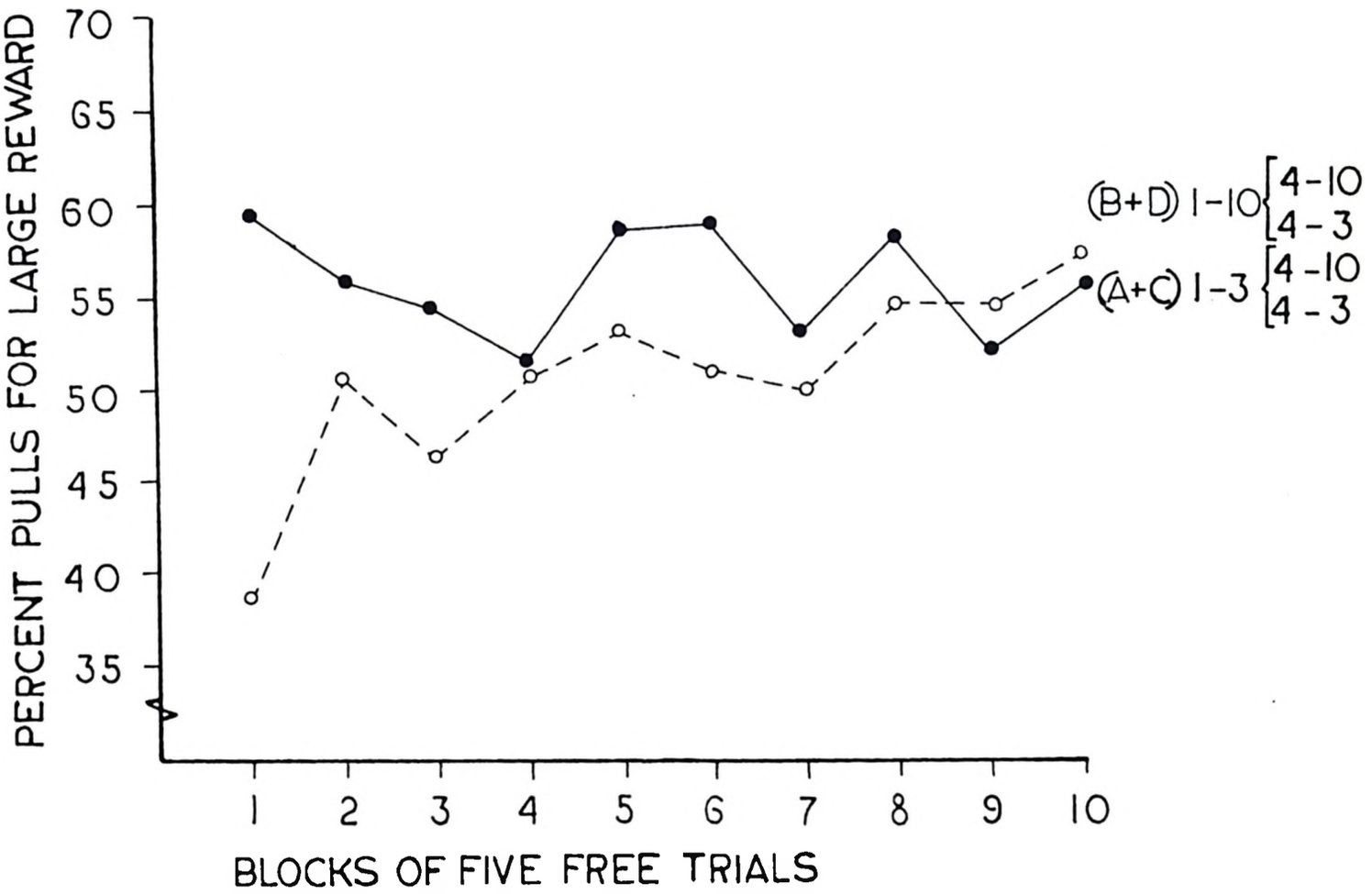

Figure 4: Percentage of pulls to the large reward side as a function of blocks of five free trials for combined scores of Groups A and C, and Groups B and D.

TABLE III

Analysis of Variance of Pulls to the Large Side on the First Five Free Trials

Source	df	MS	F
Time on large reward side (TL)	1	.05	NS
Time on small reward side (TS)	1	22.05	9.76*
TL x TS	1	.20	NS
Error	76	2.26	
Total	79		

* $p < .005$

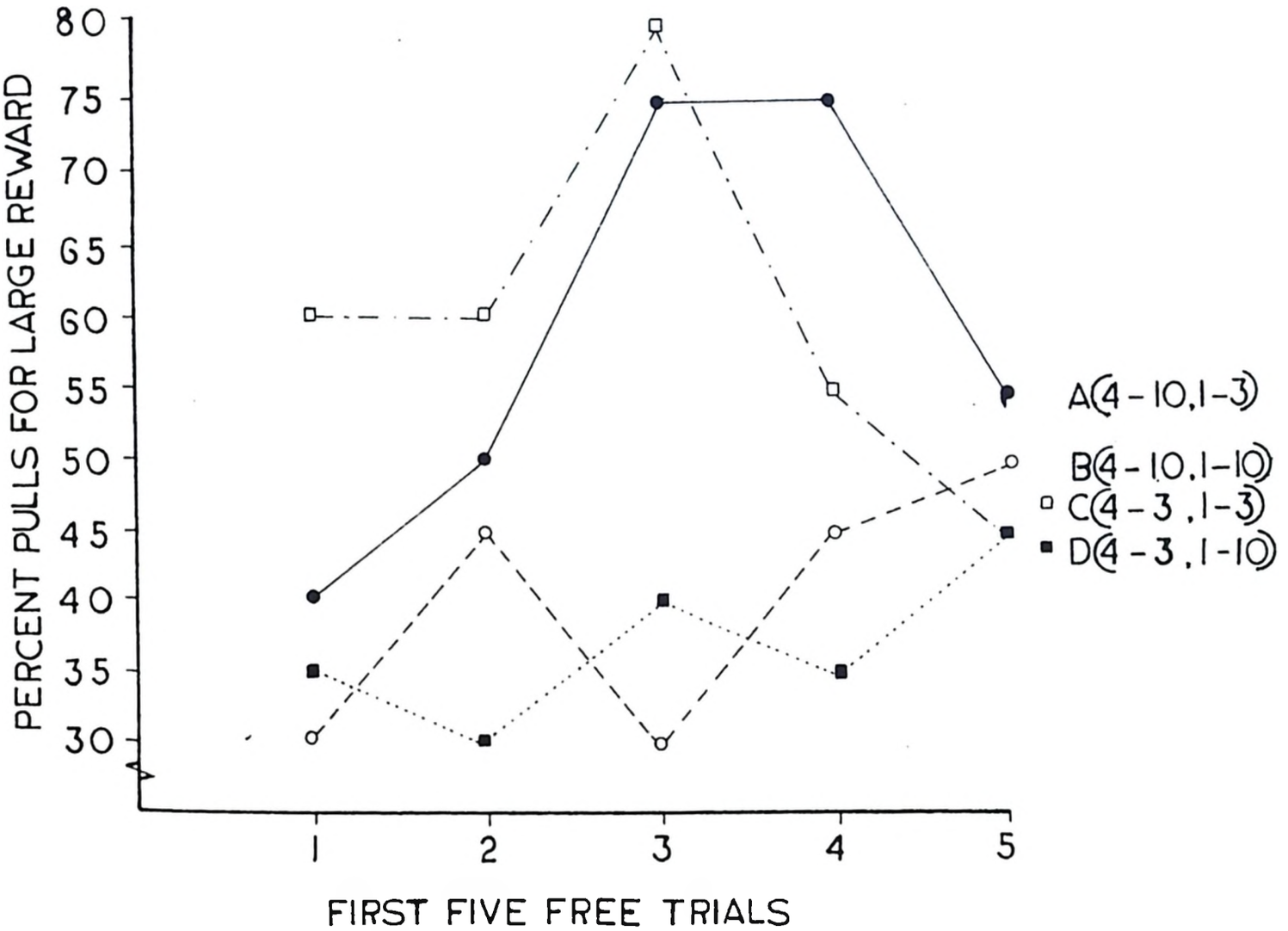

Figure 5: Percentage of pulls to the large reward side as a function of the first five free trials

early in training. This preference reaches a peak on the third free trial and then rapidly declines on trials four and five, where a preference for the small reward side prevails. Group A, with a long time for the large reward and short time for the small reward, chooses the smaller reward side on the first free trial but then abruptly shifts to the large reward side and continues to show a preference for that side. Group B (long time, large reward; long time, small reward) and Group D (short time, large reward; long time, small reward) prefer the small reward side on the first four free trials. Figure 5 also reveals another interesting feature; that is the tendency of all four groups of subjects to pull the two bars equally often on the fifth free trial. Figure 2 shows that this indecision in preference for one response over the other for all groups continues until the seventh block of trials.

In summary, the results of this experiment indicate that different factors affect the selective performance of human subjects at varying stages of training. Early in the experiment, consummatory time available to make the small reward response determines behaviour; while at the end of training, time allowed for the large reward is the factor influencing performance. During the intermediate stages, responses fluctuate about the fifty per cent level with the four groups showing little preference for one reward over the other.

CHAPTER FIVE

DISCUSSION

Spence, in his book Behavior Theory and Conditioning (1956), offered an explanation of complex learning, in which he specified three conditions to be met in experiments on selective learning. The first condition was that the discriminanda and stimulus lights on the apparatus must be effective from the beginning of training. This was fulfilled in the present experimental situation in that the two discriminanda were pointed out to all subjects during the instruction period, and each subject had two forced trials with each discriminandum and stimulus light before his first free trial. The second condition was that the stimulus lights should be presented simultaneously. Since both stimulus lights and both discriminanda were available to the subjects on all free trials, this condition was also met satisfactorily.[1]

The third condition stipulated by Spence was that of controlling for initial preference of one response over the other. In the study under consideration here, this factor was not specifically controlled; however, subjects were randomly assigned to groups such that the large reward appeared on the right hand side for 50% of each group, and on

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1. The operant conditioning apparatus employed in this experiment is similar in many respects to the double-bar Skinner box which Spence utilized in animal studies.

the left for the other 50%. It was assumed that this would adequately balance natural preferences of one hand over the other. With only four of the eighty subjects consistently pulling one lever (one in each of Groups A and B, two in Group D), it is apparent that the overall results were influenced to a minimal extent by this factor.

Since the present experimental design satisfies the requirements for selective learning outlined by Spence, the results will be discussed in relation to that portion of his theory concerned with the effects of magnitude of reward and consummatory time.

According to Spence's theory, response strength is directly determined by reaction potential (E), which in turn is a multiplicative function of habit strength (H) and the incentive motivational factor (K). He also assumes that in a two-choice experiment habit strength (H) of the two responses can be kept equal by using forced trials; that is, by forcing the subjects to go to each side an equal number of times throughout the experiment. Thus, in a choice-behaviour situation, with equal trials to each side, differences in performance between the groups can be related to differences in the variables affecting the incentive motivational factor. These variables include the number of trials in the goal box, any variation in the property of the goal object and a number of unknown factors which determine the vigour of the consummatory response.

In the present research, the number of trials to each side was equalized throughout the experiment for all subjects, and the number of conditioning trials in the goal box was the same for all sub-

jects.[1] Consequently, it follows that any differences in performance level between the groups may be ascribed to (a) variations in the goal objects (magnitude of reward), (b) time allowed to remove the goal object (consummatory time) or (c) a combination of these.

If magnitude of reward alone is important, then all subjects should indicate an increasing preference for the large reward side. The performances of Groups A and B in the present situation confirm this prediction, and are in line with the results of early animal studies (Wolfe and Kaplon, 1941; Crespi, 1942, etc.). However, two of the present groups, C and D, fail to conform to this principle, and it is suggested that differences in consummatory time may be the reason.

It will be recalled that this was the contention of Swisher (1951) and Czeh (1954), who felt that consummatory time was the determinant of performance regardless of the magnitude of reward involved. If this is indeed the case, then the side with the longer consummatory time should be preferred; that is, Group A should prefer the large reward side, Group D the small reward side, while Groups B and C should not indicate a decided preference for either reinforcement. The subjects of Group A are the only ones who behave in a manner predicted by this hypothesis. It is clear that consummatory time alone cannot account for the results.

However, in keeping with his theory, Spence (1956) offered a different prediction concerning performance and the consummatory time

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1. This can be assumed to be true only if the removal of the four chips from the goal box is considered to be a single trial.

variable. He postulated that, in a two-choice situation where consummatory time on the two sides is different, a subject would at first favour the large reward side, but eventually this preference would disappear and the subject would choose both sides equally often because of equalized habit strength for the two rewards. Spence made this prediction with the reservation that time spent in the goal box should be just sufficient to complete the consummatory act for that reward. In the present experimental design, Group A is the only one to meet this requirement. The subjects in this group tend to contradict Spence's prediction in that they choose the small reward at the very beginning, and then select the larger reward increasingly often throughout the remainder of the experiment.

Since the performances of the four groups of subjects in this study are not consistent with either a simple magnitude of reward hypothesis or with the consummatory time predictions, it is highly probable that these two factors are operating in a more complex fashion to determine behaviour. Since choice of reward is the same for all four groups, that is, large or small, it is possible to make a comparison between the performances of the groups with regard to time allowed to obtain the two different reinforcements. In other words, the behaviour of the groups having a long time for the larger reward can be compared with those having only a short time to obtain that reward; while the responses of the groups having a long time for the small reinforcement are comparable with those having only a short time.

That these two variables interact to influence choice behaviour

in normal human adults is indicated by the overall findings of this experiment. The results reveal that the response level of the two groups, A and B, which have a long time on the large reward side is significantly different than that of Groups C and D, where only a short time was allowed for the large reinforcement. That is, Groups A and B show an increasing preference for the large reward while Groups C and D tend to favour the small reward.

An examination of the data relating to time on the small reward side discloses that most of its effect occurs on the first block of five free trials. At this time, Groups A and D, with only a short time on the small reward side, select the large reward more frequently; Groups B and D, given a long time to complete the response to the small reward side, choose that side a greater percentage of the time. The implication of this finding appears to be that all subjects prefer a long time to complete their responses at the beginning of the experiment; however, those subjects (Group C) who do not have a long consummatory time for either reward choose the large reward in preference to the small one.

One interesting aspect is the differential performances of the four groups when the first block of trials is broken down into the original five free trials. On the first free trial (after four forced trials) the members of Groups A, B, and D, with sufficient time to remove all the chips, choose the small reward side; while the members of Group C, unable to remove all the large reward, select that side 60% of the time. On the next three free trials Groups A and C show a prefer-

ence for the large reward, while Groups B and D continue to prefer the small reward. On the fifth free trial both sides are chosen approximately an equal number of times by all four groups. This variability in performance early in training may be due to exploratory behaviour occasioned by an inadequate knowledge of the conditions involved. As training progresses the time and reinforcement elements become more apparent; by the fifth trial all groups are behaving in a similar manner in that they are selecting both sides approximately 50% of the time.

The type of behaviour observed on the fifth free trial is carried through until the seventh block of trials, that is, none of the groups show a decided preference for one reward over the other for this period. It appears that neither of the independent variables (time spent on the large reward side or time spent on the small reward side) is exerting an overwhelming influence, but rather that equality of habit strength is the determining factor.

On the last three blocks of free trials, the groups again begin to respond differentially; Groups A and B show a significantly greater preference for the large reward side, while Groups C and D tend to prefer the smaller reward. The statistical analysis ascribes this behaviour to time spent on the large reward side. This implies that if consummatory time is sufficient to complete the goal response for the large reward, that side will be chosen; but if there is not enough time to carry through the consummatory response for the large reward, the small reward side will be the preferred one. Thus, consummatory time and magnitude of reward together determine reaction potential as they did at

the beginning of the experiment, but at this stage it is in the opposite manner.

From the overall analysis it can be concluded that the combination of these two variables does influence the selective performance of human subjects, but that this effect varies at different phases of training. In the beginning, the amount of time allowed to complete the consummatory response to the small reward side is important; during the intermediate stages neither variable is dominant; in the latter phase of training, time spent on the large reward side is the determining variable.

A closer inspection of the performances of each of the four groups reveals some interesting additional information. Groups A and B conform to the pattern of behaviour predicted by previous experimenters who have studied the magnitude of reward variable, in that both groups indicate a gradually increasing preference for the larger reward. The curves plotted in Figure 2 indicate that these groups have not attained asymptotic performance at the end of the experiment. If training had been continued it is conceivable that the subjects in these two groups might have chosen the larger reward 100% of the time. Such a finding would be in line with Festinger's experiment (1943), in which animal subjects came to prefer the side containing the large reward on all trials.

While the performances of Groups A and B agree with expectations derived from previous studies, those of Groups C and D do not follow any suggested pattern of behaviour. Instead of selecting one

side or the other more frequently, Group D tends to fluctuate about the 50% level for most of the experiment. One interpretation of this finding may be that equalized habit strength for the two responses is the determining factor; but this is considered unlikely in view of the performances of the other three groups where the condition of equal habit strength is the same. A better interpretation might be that activity following both responses has an equivalent reward value. In other words, when the large reinforcement is chosen there is only time to remove part of that reward, but the remainder can be perceived in the receptacle; if the small reward is chosen on the subsequent trial there is sufficient time to remove that reward plus the remainder of the previous reinforcement. This is similar to Spence's delay of reinforcement condition. Thus, these two factors, large reward - short time and small reward - long time, seem to exert an equal influence on performance.

The members of Group D could acquire all the reinforcement by pulling first one lever and then the other, but the subjects in Group C were never given sufficient time to remove the entire reward. The behaviour of this latter group is noticeably different from that of the other three. It resembles in some respects the performance of the group of animal subjects in Czeh's experiment (1954) given a large reward with insufficient time to consume it. Czeh reported that this group reacted in an extremely variable and unpredictable manner, and suggested that this was caused by a "state of frustration" brought on by being interrupted during the course of eating. The data for Group C in the present

study is also highly variable. The first five free trials (Figure 5) show this group choosing the large reward side with increasing frequency on the first three trials, but on the fourth and fifth trials selecting the small reward more often. From the third to the sixth block of trials Group C once again indicates an increasing preference for the large reward, followed by a rapid switching to the small reward side. This behaviour could be attributed to a "state of frustration" similar to Brown and Farber's (1951) treatment of this phenomenon, which they call "a hypothetical state or condition of the organism" (p. 480) resulting from interference with an ongoing response. According to these authors, this interruption in behaviour may be followed by a variety of acts such as attempts to escape, more persistent approaches, etc. In the present instance, it would appear that Group C is attempting to reach the goal, or complete the consummatory response, by reacting more vigorously on the first three trials; this behaviour then subsides for a short time. On the third block of free trials the motivational state begins building up once again and reaches a peak at the sixth block of free trials. The inability to overcome the obstacle once again results in withdrawal to the small reward side.

It is conceivable that an experiment could be conducted, using the same conditions as were applied in this study, to test the hypothesis that interference with the goal response will lead to more vigorous behaviour. The human operant conditioning apparatus makes it possible to test the strength of pull on the levers. If frustration - defined as a motivational state brought on by the inability to complete the consum-

matory response - is operating, presumably those subjects who are interfered with while making the goal response will show a stronger pulling action during such a motivational state.

At this point certain assumptions concerning the term 'reinforcement' as used in this and Czeh's experiments need to be clarified. Czeh suggested that the group of animals, forced to complete their consummatory response in the carrying cases, were rewarded the same amount as the group allowed time to finish eating in the goal box. Similarly, it is assumed in the present experiment that reward is held constant for the four groups of subjects. The findings of both studies lend some doubts to these assumptions. Czeh pointed out in his discussion the extreme variability of behaviour of rats interrupted in the middle of eating. A large number of the animals refused to eat in the goal box at all, merely picking up the pellet of food and waiting until they were in the carrying case before consuming it. This is equivalent to delay-of-reward. In addition these consummatory responses were conditioned to different stimuli than were those of the animals completely rewarded in the goal box. Because of this it seems difficult to believe that both groups of animals were equally reinforced.

In the present research the question may be asked: what is the reward? If it is merely perceiving the reinforcement in the receptacle, then it can be said that all four groups receive the same reward. However, if the overt act of picking up and depositing the chips in the boxes is the reward, then its value for the four groups is different. Findings of the present experiment indicate that the consummatory ac-

tivity of removing the chips is the most important part of the reinforcement. In this connection it will be recalled that Wolfe and Kaplon (1941) found that animals responded at a faster rate for one pellet of food divided into four pieces than for the same amount in one whole piece, and suggested that amount of consummatory activity was the determinant of performance level. From these considerations it appears doubtful if reinforcement was the same for the three groups in Czeh's experiment or for the four groups in the research under discussion. Future study will require a better understanding of the components involved in consummatory activity, with some attempt made to control these factors. The effect of amount of reinforcement on each component of the consummatory act could then be examined separately to decide which portion is the most rewarding.

A study to determine if the amount of consummatory activity is the rewarding element in magnitude of reinforcement studies is possible using human adult subjects and the operant conditioning apparatus. The choice of equivalent rewards, that is, one nickel and five pennies, could be offered on all free trials. The amount of consummatory time allowed for both rewards would be just sufficient to remove all five pennies. Maintaining equal habit strength to the two sides, it could be argued that amount of consummatory activity is the determinant of behaviour if the subjects indicated a definite preference for the side which permitted them to pick up the five pennies on the free trials.

Finally, the following conclusions may be drawn concerning the choice behaviour of human adult subjects from the findings of this re-

search:

1. The effect of the magnitude of reward varies with the available consummatory time. When the time is sufficient to complete the consummatory act, there is a direct relationship between behaviour and the size of the reinforcement. However, when there is not enough consummatory time available, magnitude of reward has a differential influence on performance.

2. Study of a combination of the two variables, time allowed for the large reward compared to time available for the small reward, reveals that the effects vary with the portion of the training sequence being measured; in the beginning, time spent on the small reward side affects performance; no dominant effect is apparent during the intermediate trials; while late in training, time allowed for the large reward is the determinant of behaviour.

3. Interference with an ongoing goal response leads to increased variability in behaviour with sudden preferences being shown for one reward, and just as abrupt reversals for the opposite one.

CHAPTER SIX

SUMMARY

This research was designed to investigate the effects of magnitude of reward and consummatory time on the choice behaviour of normal human adults. An operant conditioning apparatus with two levers delivered two different amounts of reward, four chips or one chip, depending on the lever pulled. The rewards were the same for all subjects.

The subjects, eighty university students, were randomly assigned to one of four experimental groups. The groups, differing in time allowed to complete the consummatory response, were arranged in the following manner: Group A: long time-large reward versus short time-small reward; Group B: long time-large reward versus long time-small reward; Group C: short time-large reward versus short time-small reward; Group D: short time-large reward versus long time-small reward. The long consummatory time was ten seconds, the short time three seconds.

The response measure employed was the number of pulls to the large reward side on all free trials.

The results indicated that there was no simple relationship between magnitude of reinforcement and response evocation when consummatory time was varied. Provided there was sufficient time to complete the consummatory activity, there was an increasing preference for the larger

reward, but with insufficient consummatory time the behaviour was extremely variable. Further, the findings revealed that the effect of time available on the large reward side differed from the effect of time available on the small reward side during the course of the experiment. At the beginning of training, time available on the small reward side was effective, while at the end of training time available on the large reward side was the determinant of performance level. It appeared that initially a longer time was preferred to make the response, but in the group where only a short time was available, the larger reward was chosen. At the end of training, the larger reward was the preferred one provided there was enough time to complete the consummatory act.

It was suggested that the behaviour of the subjects who were never allowed to complete the consummatory response was indicative of some emotional state.

This research emphasizes the plausibility and the difficulty of experimenting with human subjects and relating their behaviour to contemporary learning theories, which have been derived from animal experimentation.

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APPENDIX

NUMBER OF PULLS TO THE LARGE REWARD SIDE

GROUP A (4-10, 1-3)

Subject	Blocks of Five Free Trials										
	1	2	3	4	5	6	7	8	9	10	Total
1	0	4	3	4	3	4	4	5	4	4	35
2	5	2	4	3	2	4	4	4	4	5	37
3	4	1	0	0	0	0	0	4	5	5	19
4	3	3	2	1	2	1	2	3	3	3	23
5	2	1	2	3	0	4	1	3	2	3	21
6	2	2	4	0	4	4	4	3	4	5	32
7	2	1	0	0	0	0	0	0	0	1	4
8	3	5	3	0	5	2	2	4	1	2	27
9	4	5	5	5	5	5	5	5	5	5	49
10	4	2	5	4	3	1	1	5	2	3	30
11	1	3	4	2	2	2	1	1	3	1	20
12	3	1	4	2	3	2	3	1	3	4	26
13	3	5	5	5	5	5	5	5	5	5	48
14	2	2	3	4	3	3	5	2	2	2	28
15	3	4	3	3	4	3	4	3	5	5	37
16	2	3	2	4	5	4	4	3	5	5	37
17	5	5	5	5	5	5	5	5	5	5	50
18	2	5	2	2	4	2	1	4	4	3	29
19	5	5	5	5	5	4	5	5	5	0	44
20	4	1	0	0	0	0	0	0	1	4	10
Total	59	60	61	52	60	55	56	65	68	70	606

NUMBER OF PULLS TO THE LARGE REWARD SIDE

GROUP B (4-10, 1-10)

Subject	Blocks of Five Free Trials										
	1	2	3	4	5	6	7	8	9	10	Total
1	2	1	0	0	0	0	0	0	0	0	3
2	3	2	1	1	1	0	1	0	1	3	13
3	4	4	5	5	5	5	5	5	3	5	46
4	2	0	0	0	0	0	1	1	0	0	4
5	5	5	5	5	4	5	4	5	5	5	48
6	2	5	5	4	5	5	5	5	5	4	45
7	1	2	5	5	5	5	5	5	5	5	43
8	3	0	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	0	0	0	0
10	1	3	4	5	4	3	4	5	5	4	38
11	3	3	1	4	1	1	1	2	3	2	21
12	0	1	3	4	4	5	4	5	4	5	35
13	0	4	1	3	1	1	0	4	2	2	18
14	0	1	1	1	2	3	2	2	2	4	18
15	2	3	2	1	2	3	2	3	2	3	23
16	2	1	3	3	5	2	2	5	5	5	33
17	2	4	5	5	5	4	5	5	5	5	45
18	4	4	4	3	3	3	5	5	4	5	40
19	4	5	4	5	5	5	5	5	5	5	48
20	0	0	1	0	0	2	3	1	3	4	14
Total	40	48	50	54	52	52	54	63	59	66	538

NUMBER OF PULLS TO THE LARGE REWARD SIDE

GROUP C (4-3, 1-3)

Subject	Blocks of Five Free Trials										
	1	2	3	4	5	6	7	8	9	10	Total
1	1	4	3	4	4	2	2	3	1	3	27
2	1	3	2	3	5	5	2	4	2	3	30
3	4	4	4	2	2	4	0	2	1	0	23
4	3	3	1	1	4	5	2	2	0	2	23
5	3	1	4	2	3	5	4	3	4	3	32
6	5	0	1	1	2	1	1	1	2	1	15
7	2	1	0	2	1	2	2	2	0	1	13
8	4	2	2	4	4	3	2	4	3	4	32
9	1	2	1	1	1	1	2	2	2	0	13
10	3	2	2	2	1	1	2	1	0	1	15
11	2	0	0	0	0	0	0	0	0	0	2
12	4	5	5	4	5	5	5	4	5	5	47
13	3	5	5	5	5	5	5	5	3	4	45
14	1	3	3	3	2	5	2	2	1	0	22
15	5	5	4	5	4	5	5	5	4	5	47
16	3	1	0	0	0	0	0	0	0	0	4
17	5	4	4	3	3	4	4	4	5	1	37
18	5	2	0	3	2	3	2	3	1	2	23
19	2	1	4	2	4	4	4	1	0	0	22
20	3	4	3	4	5	3	4	3	2	4	35
Total	60	52	48	51	57	63	50	51	36	39	507

NUMBER OF PULLS TO THE LARGE REWARD SIDE

GROUP D (4-3, 1-10)

Subject	Blocks of Five Free Trials										
	1	2	3	4	5	6	7	8	9	10	Total
1	1	4	3	3	5	4	4	2	5	5	36
2	2	5	3	4	5	5	3	4	5	5	41
3	3	2	1	2	2	3	1	1	2	0	17
4	5	5	5	3	2	3	1	3	2	1	30
5	5	4	4	3	4	0	0	5	1	1	27
6	2	1	3	4	3	4	2	2	2	3	26
7	0	3	1	4	4	4	2	4	4	4	30
8	0	1	2	0	1	4	2	1	2	3	16
9	3	5	5	5	5	5	4	5	5	5	47
10	3	3	2	1	1	1	1	1	1	3	17
11	2	3	2	4	4	5	5	5	5	5	40
12	0	4	4	3	1	1	4	2	1	4	24
13	1	3	1	4	3	2	2	0	1	0	17
14	0	0	0	0	0	0	0	0	0	0	0
15	1	3	2	3	5	5	5	2	4	4	34
16	0	0	0	0	0	0	0	0	0	0	0
17	2	2	0	0	3	2	4	5	5	2	25
18	4	1	2	1	2	0	2	3	1	0	16
19	3	3	2	3	3	2	4	1	4	3	28
20	0	1	1	0	1	0	0	0	0	0	3
Total	37	53	43	47	54	50	46	46	50	48	474