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A Study of Learning in Groups Under Fixed and Variable Ratio Reinforcement Schedules

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A STUDY OF LEARNING IN GROUPS UNDER FIXED AND VARIABLE RATIO REINFORCEMENT SCHEDULES

by

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The thesis is concerned with the effects of interaction of individuals in groups upon learning performance. It also seeks to determine whether the difficulty of the task presented is an important factor in learning. The data are expressed primarily in terms of the number of correct responses in a Humphreys' guessing game situation given by individuals in groups working at two levels of difficulty, that is, under fixed and variable reinforcement schedules.

LIFE

Frederick Ronald Oberman was born in Chicago, Illinois, November 15, 1936.

He was graduated from the Hyde Park High School, Chicago, Illinois, June, 1954. He attended the Massachusetts Institute of Technology from September, 1954 to June, 1956, and was graduated from the University of Chicago, December, 1959, with the degree of Bachelor of Arts. He began his graduate studies at Loyola University in September, 1959, and completed course requirements there in February, 1962. From August, 1961 until the present, the writer has been engaged in the field of engineering psychology at the firms of Airborne Instruments Laboratory, Deer Park, New York, Adler Electronics, New Rochelle, New York, and McDonnell Aircraft Corporation, Saint Louis, Missouri.

The writer has performed research in the areas of sleep conditioning (University of Chicago, 1959) and learning under sleep deprivation (Loyola University, 1960). He is presently conducting studies in the areas of human engineering at McDonnell Aircraft Corporation, Saint Louis, Missouri.

PREFACE

The literature of psychology is replete with studies upon learning and it might be questioned why the writer might not have turned his attention to some of the new frontiers in psychological research. The answer lies in the fact that learning is one of the central problems confronting the investigator working in any behavioral area. Perhaps surprisingly, not only are there enormous gaps in our knowledge of the learning process, but much of what is written may yet have to be modified by more realistic studies.

The present investigation in the restricted time afforded to a master's candidate can be devoted only to a tiny segment of a vast field. The writer has chosen to concern himself with the influence of a group upon the performance of the individual within the group, and also with the question of whether the difficulty of the learning task and the existence of a feedback from the group can significantly affect performance.

Because of a conviction that the specific problems attacked can best be solved by a quantitative approach, the experimental results are presented in a quantitative form and appropriate statistical analysis of the data is performed.

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CHAPTER I

INTRODUCTION

Statements are prevalent in the literature that group pressure can produce modifications and distortion of judgments. Asch (as reported in Newcomb and Hartley: Readings in Social Psychology, 1952) made a comprehensive study of group pressure. Using male college students Asch found that individuals performing within experimental groups that contained individuals previously instructed to respond with wrong and unanimous judgments at specified points during a perceptual matching test varied a great deal in terms of remaining independent from group pressure; that there was significant change toward the majority; but that the shift due to group pressure was only slight, in that individuals tested still responded correctly 68 per cent of the time. Asch further investigated the characteristics of those subjects <u>least</u> and <u>most</u> affected by group pressure. The differences are mainly attributable to personality differences and social factors similar to those of the "inner-directed" and "other-directed" individuals of Riesman, Glazer and Denney (1953). Asch also studied the influence of groups with non-unanimous majorities on individuals and included an analysis of "partnerships". He finally performed an analysis to determine the role and influence of the size of majorities and the particular character of the stimulus situation. Such studies clearly show that feedback from the group influences individual judgments.

Wiest, Porter and Ghiselli (1961) found that in a cognitive-type task, teamwork was on the average less productive than was the sum of individual performances. Team performance was influenced by such factors as the extent to which the members of a team facilitated or interfered with each other and the difference in individual proficiencies among the members of the team.

The writer has undertaken to investigate this problem with the point of view that the difficulty of the learning task presented is an important factor in determining the superiority of individual or group performance.

Historically, the experimentation in the area to be discussed was formalized by Humphreys (1939) in a paper which dealt with a simple two-choice situation. In his experiment a subject was seated before a panel containing two lights. In each trial, the left light was turned on for 0.5 seconds. A few seconds later, in some trials, the right light was flashed for a 0.5 second period whereas in other trials no right light would appear. The subject was asked to guess whether or not the right light would come on. Three schedules were used: (1) continuous reinforcement; (2) partial reinforcement (right light came on during half the trials); and (3) extinction (right light never came on). Humphreys' schedules were 100:0, 50:50, and 0:100. Humphreys' experiment demonstrated a greater resistance to extinction following learning on a 50:50 reinforcement schedule than that obtained on the 100:0 schedule. Humphreys defined the variables he measured in terms of operant terminology. His conditioned stimulus (CS) was the guess itself, and his conditioned response was the verbal response of the subject.

Experiments similar to those of Humphreys were performed by Grant et. al. (1950; 1951). They used various partial reinforcement schedules, such as

0:100, 25:75, 50:50, 75:25, 100:0. These investigators also studied the effect of varying the inter-trial interval from five to twenty seconds, but found no significant differences in learning performance.

Jarvik (1951) reported an experiment in which subjects predicted on each trial whether the experimenter was going to say the work "check" or "plus." Partial reinforcement schedules of 60:40, 67:33, and 75:25 were used in that study. Jarvik employed the 67:33 "below threshold" concept developed by Brunswick (1939) in the analysis of his own empirical data. Brunswick's statement was that below a 67 per cent reinforcement schedule, learning did not occur. Jarvik had earlier used various partial reinforcement schedules in studying the behavioral choice of rats in a T-maze with food as a stimulus.

Hake and Hyman (1953) described an experiment in which subjects predicted whether a horizontal or vertical row of lights would appear. These investigators used schedules of 50:50 and 75:25 and introduced probabilistic dependencies into the scheduling sequences. They found (1) that the probability of a guess that either a horizontal or vertical row of lights would appear approached the same level as the respective reinforcement schedules (50:50 and 75:25) over a period of trials; (2) that performance (the guess) on any trial was directly dependent upon the previous one or two guesses and upon the success or failure obtained on these previous guesses; and (3) that subjects were able to attain highly accurate scores for short sequences of the schedule presentation.

Hays and Bush (1954) developed a model for group learning where the group was repeatedly faced with a choice between two alternatives. These writers produced two alternatives of this one model based upon different assumptions

concerning the influence of the individual members upon the group.

Bush and Mosteller (1955) suggested stochastic models to account for individual learning behavior. They attempted to show that making a specific guess on a particular trial is dependent upon previous events. The first model that they developed was called the "group actor model." By using this, it was possible to calculate the expected probability of choice at each trial with the group considered as a whole. The second, or "voting model," did the same thing, but it made allowances for majority rule within small groups of three subjects.

Hays (as reported by Coleman, 1960) extended the experiments (above) of Bush and Mosteller by (1) restricting the interaction among subjects to seeing the choice made by other subjects, (2) having each subject make choices, and (3) rewarding the subjects at the end of each trial. One difficulty with the data obtained by Hays is that they are not applicable to a simple mathematical model.

Taub and Myers (1961) found that the quantitative reward value affected the performance of the subjects in a two-light guessing game. The observed response frequencies were a function both of the frequency of reward and the relative amount of reward.

Edwards (1961) investigated a probability learning situation in a great number of trials and found that the subjects responded to changes in the relative frequency of an event by similar changes in their predictions of that event. This phenomenon is called "probability following." Edwards also found that most predicting is based upon the information conveyed to the subject by the immediately preceding trial.

Brackbill, Kappy and Starr (1962) observed that the amount of the reward

effectively changed the rate of learning and the amount of correct predictions in a learning situation.

An analysis of the historical attempts to solve the problem indicates a need for testing at more than one level of difficulty. The concept of what is a specific level of difficulty is, itself, somewhat difficult to define. The two Skinnerian schedules used in the present study have already been stated in the literature to involve two distinct levels of difficulty in terms of the rate of response, extinction time and other behavioral parameters (Skinner, 1938; Ferster and Skinner, 1957).

CHAPTER II

MATERIALS AND METHODS

A. The Selection of Variables to be Analyzed

In order to analyze differential performance, three experimental groups of subjects (with 48 individuals per group) were tested under each of two conditions. One condition was a fixed ratio reinforcement schedule and the other was a variable ratio reinforcement schedule.

In Group 1, the subject took two distinct tests, each of which contained 100 items. One test involved a fixed ratio (75:25) reinforcement schedule in which the same CS was always given on the first, third and fourth trials and a different CS was given on the second trial. The second test involved a variable ratio (75:25) reinforcement schedule in which the ratio of presentation (75:25) of each CS was kept the same, but the order of presentation was selected from a table of random numbers (Lindquist, 1953). These same two tests were used in Groups 2 and 3 (below).

Each individual in Group 1 took the tests above as part of a large group. Each individual could ascertain the correctness of the score achieved by him alone on each item of the test being given while the test was proceeding.

In Group 2, each subject took the same two tests, but as a member of a small group under circumstances where he was apprised of the immediate past

achievements of the other members of the group, as well as his own achievement, for each item of the test, as the test was going on.

In Group 3, each subject took the two tests also as a member of a small group. He was informed of the correctness of the score achieved only by himself on each item of the test, while the test was in progress. He was not apprised, however, of the corresponding achievement of any other member of the group, for each item.

Data were analyzed to determine whether the scores on each test did or did not vary significantly among subject Groups 1, 2, and 3. For each test, the results were also analyzed within each Group. This was to test the view that the two schedules employed involved two distinct levels of difficulty.

To guard against any type of transfer effect, which could produce positive or negative increments of learning, one series of subjects was given the variable ratio schedule first and the fixed ratio schedule next, whereas the second series of subjects was given the tests in reverse order.

B. The Selection of Subjects

A total of 144 subjects, all males, were selected for this study from a junior class level undergraduate population, at Southern Illinois University in Carbondale and at a branch of the University of Missouri in Saint Louis. They were divided as follows: each Group of 48 students contained two equal Subgroups. Each Subgroup of Groups 2 and 3 was further subdivided to eight small groups, each having three members. The first Subgroup was always initially given the fixed ratio schedule. The second Subgroup was always initially given the variable ratio schedule.

The following general instructions were given to every subject in all three Groups: "I am going to conduct an experimental study on learning and would like you to participate as subjects. I have a deck of cards arranged so that certain cards will bear an 'X' on them whereas others will be blank. I would like you to guess prior to presentation which kind of card will appear." (At this point the subjects were shown the two kinds of stimulus cards.)

The following specific instructions were given, in addition, to the groups specified below:

Group 2. "After I say the word 'ready,' you will have three seconds to prepare to make a guess. After I say the word 'guess,' I want you to signify your guess to the others by raising your right hand if you believe an X will appear. Following another three-second interval, I will say the word 'check.' At this point I want you to record your guess by placing an X on the paper only if you believe that a card bearing an X will appear. Otherwise you are to leave the paper blank. Your guess must be recorded next to the number of the corresponding trial. Following a third three second interval the stimulus card will be shown to you. The entire procedure just outlined will be repeated for each trial." (At this point the experimenter demonstrated the procedure with sample cards.)

Groups 1 and 3. The same instructions as those to group 2 were given, but the second sentence above was altered as follows: "After I say the word 'guess,' I want you to consider what guess you will make." In order to eliminate feedback, no guess was signified to the others.

C. The Selection of Test Materials

The material consisted of two paper and pencil variations of Humphreys' guessing game. Fixed ratio and variable ratio forms with a 75:25 reinforcement schedule were used. On each of the two tests used, there were 100 trials. In the fixed ratio test, the X appeared as illustrated in Table 1A, for all subjects in all groups. In the variable ratio test, the X appeared as illustrated in Table 1B for all subjects in all groups.

One hundred 3" x 5" cards were used by the examiner to elicit the response of each subject for each test. The card which was presented 75 per cent of the time was blank whereas that presented 25 per cent of the time contained an X. The same 75:25 ratio applied to all three subject groups.

Each subject recorded his guess on two data sheets which had four columns numbered from one to twenty-five; each subject used a pencil to indicate his guess. The experimenter timed all phases of each test with a stopwatch.

D. Statistical Analysis of the Data

Total correct responses (TCR) were obtained for each subject on both tests used. The TCR represents the total number of correct responses for each subject, i.e. the total number of correct blank and correct X responses recorded. Graphs and tables illustrating the TCR responses are presented in a modified form elsewhere in this thesis. The effect of sequence presentation of the fixed or variable ratio schedule was tested using the Link and Wallace range test and the results are presented in tabular format. Results from t tests between TCR scores of subjects in each Group run under fixed ratio schedules versus TCR scores of subjects in each corresponding Group run under variable ratio schedules are also presented in tabular format. Results from a

t test run on TCR scores achieved by all subjects regardless of Group under each condition are also shown. Results from t tests between Groups are also presented.

CHAPTER III

RESULTS AND DATA ANALYSIS

The sequence of presentation of the fixed or variable ratio schedules had no significant effect upon performance in any of the three groups. The data are presented in Table 2.

In terms of the total correct responses, Groups 1, 2 and 3 performed significantly better on the fixed ratio schedule than on the variable ratio schedule. The data are presented in Table 3. A criterion level, α, of 0.01 was chosen as a threshold of significance for the data analyzed between conditions and an α, of 0.05 was chosen as a significance threshold between Groups. The computed probability value, p, was then compared with α in evaluating significance (Lindquist, 1953; Dixon and Massey, 1957).

Under the fixed ratio schedule, Group 1 had the highest mean of total correct responses, Group 2 ranked second and Group 3 third. The data are presented in Table 4.

Under the variable ratio schedule, Group 1 had the highest mean of total correct responses, Group 2 ranked second and Group 3 third. The difference between these means was not significant. The data are presented in Table 5.

The ratio of correct responses for both stimulus characters, i.e. blank and X responses, is important. Under the fixed ratio schedule, the correct

response ratio should approach 100:0, corresponding to the ideal guessing solution of 75:25, whereas under the variable ratio schedule it should approach 75:25, because this corresponds to the best statistical guessing solution available, 100:0. In Figure 1, the percentage of correct responses is plotted against the trials for each group. Figure 1 applies to the fixed ratio schedule. Figure 2 is similar except that it applies to the variable ratio schedule. The graphic results for the fixed ratio schedule showed that a positive increment occurred in the percentage of correct responses in Groups 1, 2 and 3.

The graphic results for the variable ratio schedule showed that (1) no large positive increment actually occurred in any of the three groups; and (2) a divergence in guessing was more apparent between Groups 1 and 3 than between any of the other groups.

A comparison made among all groups under both fixed and variable ratio schedules showed that Groups 1, 2 and 3 under the fixed schedule had the only significant positive increase in performance with successive trials. The data are presented in Table 3.

TABLE I

TRIAL NUMBERS ON WHICH X WAS PRESENTED

TABLE IA	TABLE IB
FIXED RATIO	VARIABLE RATIO
2, 6, 10, 14, 18	3, 7, 9, 12, 19
22, 26, 30, 34, 38	24, 25, 31, 37, 41
42, 46, 50, 54, 58	43, 46, 49, 55, 56
62, 66, 70, 74, 78	59, 69, 70, 75, 82
82, 86, 90, 94, 98	85, 86, 90, 98, 99

TABLE II

EFFECT OF SEQUENCES OF PRESENTATION OF FIXED AND VARIABLE RATIO SCHEDULES UPON REINFORCEMENT USING THE LINK AND WALLACE RANGE TEST FOR TESTING FOR A SIGNIFICANT DIFFERENCE BETWEEN MEANS

		Fixed Ratio				Variable Ratio			
Group	Subgroup	M	$\lvert M_A-M_B \rvert$	Range	5% Limit[c]	M	$\lvert M_A-M_B \rvert$	Range	5% Limit[c]
1	A[a]	86.75	0.71	50	6.37	67.08	2.58	19	3.98
	B[b]	87.46		36		64.50		34	
2	A	84.58	1.16	44	6.08	65.42	2.71	28	4.73
	B	83.42		37		62.71		35	
3	A	80.67	4.41	31	5.40	63.83	0.95	21	4.28
	B	85.08		41		62.88		36	

[a]Subgroup A was always given the fixed ratio schedule first.

[b]Subgroup B was always given the variable ratio schedule first.

[c]The 5% limit, (value at which $\lvert M_A-M_B \rvert$ is significant at $P = 0.05$), is:

$$\frac{\text{critical factor (1.80) X sum of subgroup ranges}}{\text{number of subjects per subgroup}}$$

TABLE III

COMPARISON OF PERFORMANCE UNDER FIXED AND VARIABLE RATIO SCHEDULES USING THE t FOR TESTING FOR A SIGNIFICANT DIFFERENCE BETWEEN CORRELATED PAIRS OF MEANS

Group	Means		s_D[a]	t	P value
	Fixed Ratio	Variable Ratio			
1	87.11	65.79	11.88	12.47	<0.01
2	84.02	64.06	13.53	10.23	<0.01
3	82.88	63.36	10.16	13.28	<0.01
All Groups	84.67	64.40	11.85	20.47	<0.01

[a] s_D is $\sqrt{\frac{\sum(D-M_D)^2}{N-1}}$

TABLE IV

COMPARISON OF PERFORMANCE OF THE THREE GROUPS UNDER THE FIXED RATIO SCHEDULE USING THE t FOR TESTING FOR A SIGNIFICANT DIFFERENCE BETWEEN UNCORRELATED MEANS

Groups	s	t	P value
1 and 2	12.51	1.21	0.1
1 and 3	11.08	1.87	0.05
2 and 3	11.28	0.50	0.01

$$a_s \text{ is } \sqrt{\frac{\Sigma(X - M_1)^2 + \Sigma(X - M_2)^2}{N_1 + N_2 - 2}}$$

TABLE V

COMPARISON OF PERFORMANCE OF THE THREE GROUPS UNDER THE VARIABLE RATIO SCHEDULE USING THE t FOR TESTING FOR A SIGNIFICANT DIFFERENCE BETWEEN UNCORRELATED MEANS

Groups	s	t	P Value
1 and 2	6.90	1.23	>0.1
1 and 3	6.27	1.90	>0.05
2 and 3	6.69	0.51	>0.1

a_s is $\sqrt{\frac{\Sigma(X - M_1)^2 + \Sigma(X - M_2)^2}{N_1 + N_2 - 2}}$

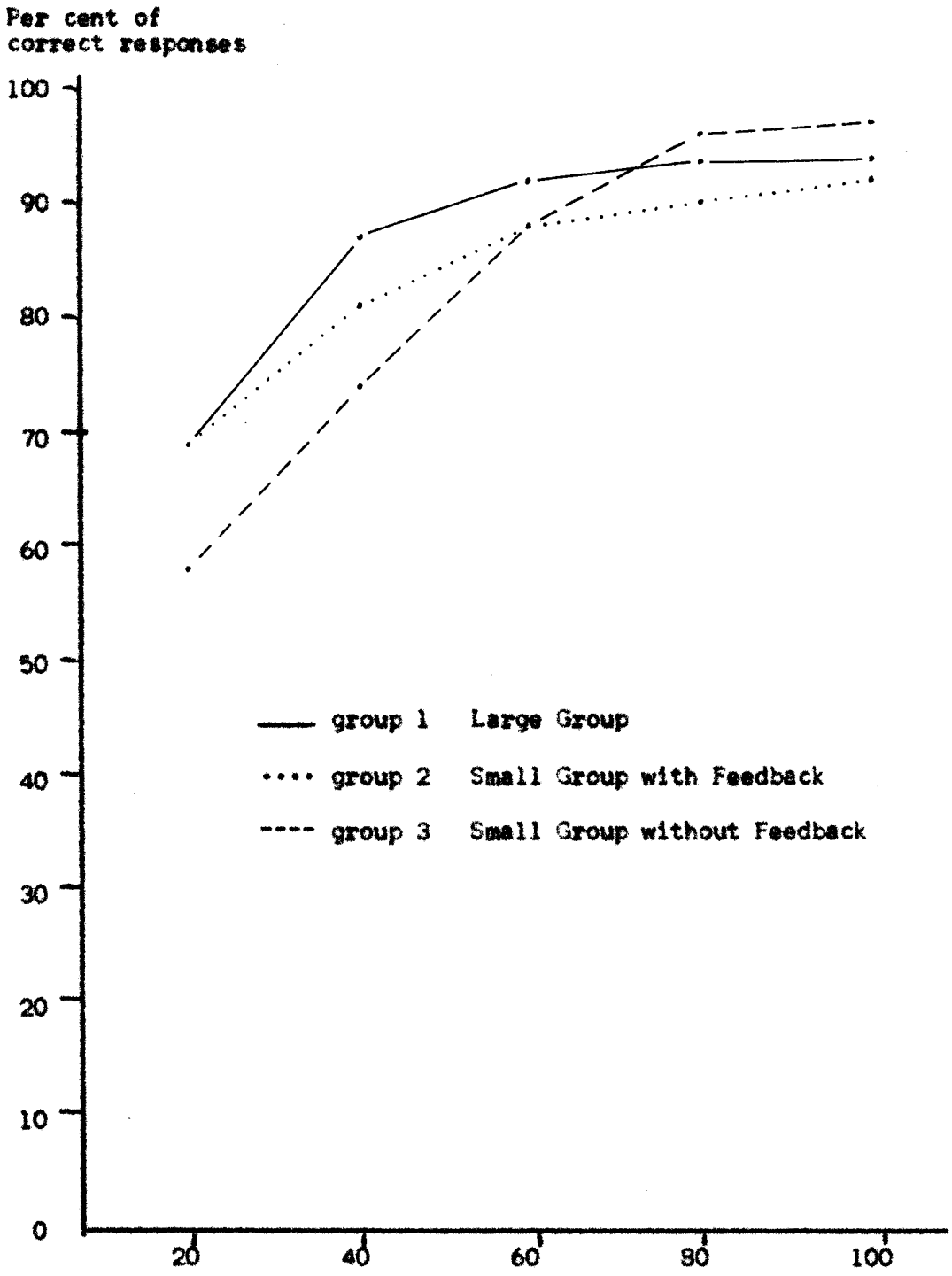

FIGURE 1

CHANGES IN CORRECT RESPONSES WITH RESPECT TO THE NUMBER OF TRIALS
FIXED RATIO SCHEDULE

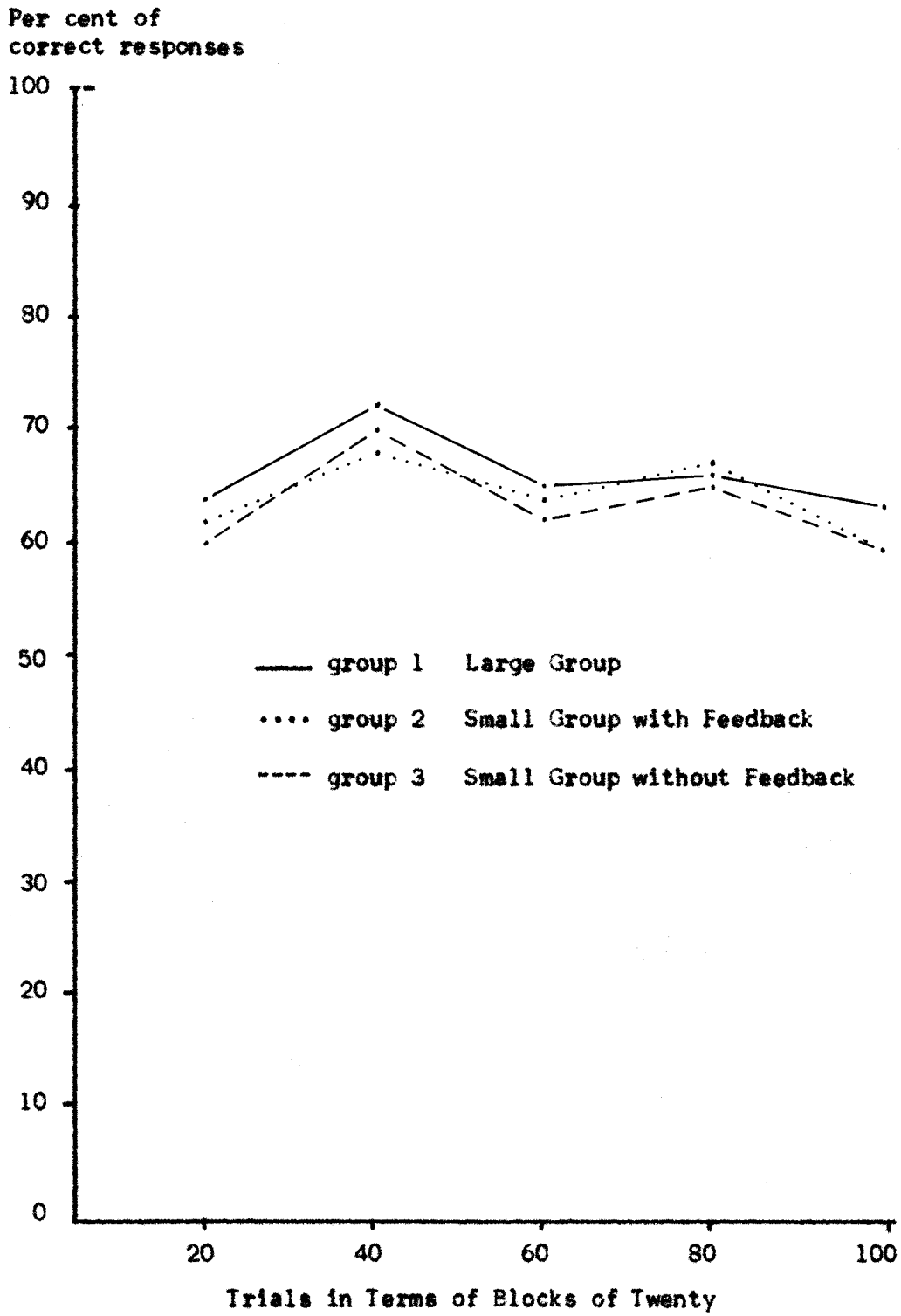

FIGURE 2

CHANGES IN CORRECT RESPONSES WITH RESPECT TO THE NUMBER OF TRIALS
VARIABLE RATIO SCHEDULE

CHAPTER IV

DISCUSSION

The thesis has been concerned with learning, expressed primarily in terms of the number of correct responses in a Humphreys' guessing game situation given in groups working at two levels of difficulty, that is, under fixed and variable reinforcement schedules. The problem is of direct concern to those interested in the role of group behavior in the learning process.

Many attempts have been made in the past to establish stochastic learning models which purport to predict the performance of groups of subjects in a binary choice problem (Bush and Mosteller, 1955: Estes, 1959; Bush, 1960; Coleman, 1960). Although such learning models may often be effective, they are restricted to prescribed conditions. If any of the parameters change, the model becomes ineffective. For example, the models predict with greater accuracy at higher levels of conditional probability, where the ratio of presentation of two stimuli deviate from 50:50 toward 100:0 (Anderson and Whalen, 1960). The models do not give information as to how learning occurs and thus do not emphasize the central problem; in fact, they may lead the investigator away from the essential questions.

A more recent approach, which seems to be more promising, consists of the collation of existing experimental data, from whose analysis models are

constructed. As an example, the Lorge-Solomon model began with results of previous workers and thus obviated any possibility of slanting data to fit the model (Lorge and Solomon, 1955). This model is restricted, however, to comparing the ability of groups and individuals in solving only eureka-type problems.

Hays (as reported in Coleman, 1960) undertook to study learning by analyzing the interaction of individuals within groups and by having each subject, rather than the group, make selections in binary choice problems. His data were not suitable for the construction of an experimentally derived model, but they introduced a way to analyze the effects of interaction.

Based upon the type of investigation undertaken by Hays, the present work studies the effects of interaction in groups upon the learning performance. Correct responses have been selected as the chief data to be analyzed, because the writer believes that it is the accuracy of the subject's performance rather than his guessing performance which should be of primary importance. This choice of the number (and rate) of correct responses also lends itself to comparison with the ideal or the best statistical solution. The learning curve for the fixed ratio schedule test (Figure 1) shows that learning does take place for all experimental groups.

For the complex variable ratio schedule test, no significant learning took place in any group (Figure 2). It is felt that since the best solution to this problem was an imperfect statistical one, this reduced the attainable number of correct responses and the differential performance between trials one and one hundred. In other words, the range of correct responses is necessarily less in this test than in the fixed ratio schedule test for any individual between

the beginning and the end of the test. There are thus significant differences between tests, i.e., levels of difficulty, for all experimental groups.

The effects of the levels of difficulty should be apparent. The effects of feedback and of group size may next be considered. Under the fixed ratio schedule, individuals in large groups (Group 1) have the best learning performance, i.e., number of total correct responses. Individuals in small groups who are not receiving feedback (Group 3) demonstrate learning performance, and individuals in groups receiving feedback (Group 2) also show learning performance. The learning curves are presented in Figure 1.

Though not significant, individuals in large groups (Group 1) perform better than individuals in small groups (Group 3 and Group 2) in terms of total correct responses. Apparently, individuals who are solving simple problems within a large group without feedback are at a slight advantage in terms of learning performance as compared with individuals who are solving problems in a small group.

There is no significant difference between individuals in small groups with feedback (Group 2) and individuals in small groups not receiving feedback (Group 3).

Under the variable ratio schedule, none of the experimental groups demonstrates the best statistical solution to the variable ratio schedule. The results agree with the probability matching hypothesis in that individuals in all groups guess the blank stimulus 75 per cent of the time and the X stimulus 25 per cent of the time, producing a plateau at approximately (.75) (.75) + (.25) (.25) or 62.5 per cent correct responses. The data are presented in Figure 2.

Though the differences among the groups were not significant, individuals in large groups (Group 1) attained a higher number of total correct responses than individuals in small groups (Group 3 and Group 2).

There is no significant difference between individuals in small groups with feedback (Group 2) and individuals in small groups not receiving feedback (Group 3). No differences in rates of learning are readily seen.

As a general statement, the difficulty of the task has a significant effect upon learning performance, feedback has no significant effect, whereas the size of the group may be of importance.

CHAPTER V

CONCLUSION

All groups (Group 1, Group 2 and Group 3) show a significant difference in learning performance between the fixed ratio and variable ratio conditions. The difficulty of the task therefore has a significant effect upon learning performance.

Under the fixed ratio condition, the following results have been obtained:

(1) Individuals tested in all groups (Group 1, Group 2 and Group 3) demonstrate learning performance.

(2) Though not significant, individuals in large groups (Group 1) attain a higher number of total correct responses than individuals in small groups (Group 3 and Group 2).

(3) There is no significant difference between individuals in small groups with feedback (Group 2) and individuals in small groups not receiving feedback (Group 3).

Under the variable ratio condition, the following results have been obtained:

(1) None of the experimental groups demonstrates the best statistical solution to the variable ratio schedule.

(2) Though the differences among the groups were not significant,

individuals in large groups (Group 1) attained a higher number of total correct responses than individuals in small groups (Group 3 and Group 2).

(3) There is no significant difference between individuals in small groups with feedback (Group 2) and individuals in small groups not receiving feedback (Group 3).

As a final point, the writer hopes that this study may also show the importance of experimentally ascertaining those variables which affect learning performance. Such experiments should precede and lay the ground-work for more complex mathematical theories.

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Approval Sheet

The thesis submitted by Frederick Ronald Oberman has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

June 1, 1964
Date

W W Kerr SJ
Signature of Adviser