COGNITIVE INFORMATION AND ERROR REPETITION IN HUMAN LEARNING

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by

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ABSTRACT OF THESIS

The purpose of the present investigation was to clarify and experimentally investigate the adequacy of the notion of "rational use of information" as an explanatory concept for the phenomenon of above-chance repetition of punished responses.

Two indices of information, recall of the response made to a choice-point on the previous trial and recall of whether this response was rewarded or punished, were chosen for investigation. Five experimental groups each learned a 30 unit verbal maze to a different level of mastery and were then given a recall trial. On this trial they were asked to recall the responses they made on the previous trial and to say whether they were called right or wrong by the experimenter. A control group learned the complete maze, and repetition proportions of punished responses were obtained from five trials corresponding to the recall trials of the five experimental groups.

The analysis of the recall data was limited to the responses that had been called wrong by the experimenter on the previous trial. When the two recall measures were considered independently, it was found that recall of the last-made response was more accurate than recall of whether this response was called right or wrong, at all stages of learning. From this it was concluded that the learner has a better knowledge of the responses that were made than of whether they were punished or rewarded.

In another method of analysis, the two recall responses at each choice-point were considered as information which the subject would have used rationally had he been under learning rather than recall instructions on that trial. This yielded a "predicted" rate of punished response repetition. When this predicted rate was compared with the repetition of punished responses obtained from the control group, it was found that variations in one were closely paralleled by variations in the other. However, the predicted rate was consistently lower than the obtained rate of punished response repetition. Exactly the same results were obtained when the two measures were determined as a function of serial position.

The most general conclusion that was drawn from these results was that recall of the last-made response and recall of reinforcement may be fruitful measures in the study of punished response repetition; and further, that the concept of rational use of information, though incapable in itself of providing a fully adequate explanation, may nevertheless be useful in understanding verbal learning phenomena.

ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION

One of the incontrovertable facts immediately observable from a study of learning is the efficacy of reward. Behavior which is followed by reward is learned; that which is not is usually not learned. However, in explaining learning, theorists have differed widely in the role assigned to reward. Three modal positions on the role of reward have been defended. The first view, which can be called reinforcement theory, claims that reward is a necessary condition for learning to occur. That is, unless a certain response (R) to a stimulus situation (S) is followed by a rewarding event, that S-R sequence will not be learned. A second view, contiguity theory, holds that temporal proximity or contiguity between stimulus and response is the only necessary, hence sufficient, condition of learning. In this system, the function of reward is simply one of providing an end to the S-R sequence, thereby radically changing the stimulus situation and preventing an individual from unlearning what he has already learned by keeping him from reacting in other ways to the stimuli that lead to the response. Moreover, according to this view, this function of changing the stimulus situation can be mediated by events other than reward; any event which prevents reassociation will preserve learning. The third view, cognitive theory, makes a sharp distinction between learning and performance and claims that reward is not necessary for learning but may facilitate overt performance. The role of reward, in this theory, is simply that of providing information about the "correctness" of a response—information upon which subsequent performance is based.

One phenomenon that has critical relevance to the different theories is that of the above-chance repetition of errors, or punished responses, in verbal multiple-choice learning. What has typically been found is that the percentage of errors repeated[1] in learning a task is well above that expected on the basis of chance. This fact is a source of embarrassment for reinforcement theory because here is a case of what appears to be <u>bona fide</u> learning not only in the absence of reward but in the presence of punishment! Contiguity theorists, on the other hand, have little difficulty in explaining this phenomenon and, in fact, have used it as evidence for their own position.

Cognitive theorists have also been concerned with explaining the above-chance repetition of errors. They, however, have focussed their attention on the role that infor-

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[1]Repetition is defined as the occurrence of a particular response to a specific stimulus when that response occurred upon the last preceding presentation of the stimulus. That is, if the subject makes a particular response on one trial, the question is whether he makes the same response on the next trial.

mation and set play in producing the phenomenon. Thus, errors are selectively repeated because the learner has misinformation about the correctness of that response and because he is set, by the task itself, to repeat responses. This interpretation has received little experimental attention. Perhaps this neglect is due, at least in part, to the reluctance of investigators to employ more direct methods than task performance to determine the type of information the individual has. Asking the learner to report what he recalls about an error would be one such direct method. If information so obtained is found to be related to the repetition of errors, then any theory attempting to explain the phenomenon would have to account for it. The primary purpose of the present study, therefore, is to determine the amount of information the subject has about the learning task and further to see if such information is related in any way to the above-chance repetition of errors.

The following section is devoted to a historical review of the evidence bearing on the problem of the above-chance repetition of errors; the third to the experimental design and results, and the fourth section to a discussion of these results and a theoretical interpretation of the phenomenon. A summary and conclusions are presented in the final section.

CHAPTER II

THE PROBLEM IN HISTORICAL PERSPECTIVE

As far back as the Greek era, philosophers were impressed by the "pleasure-pain" or hedonic principle as a determiner of human action. This principle stated that behavior arises out of man's desire to gain pleasure and avoid pain. The Greeks, however, adopted it mainly as an ethical principle rather than a psychological theory. It was not until the 18th century that the hedonic principle, popularized by the utilitarian ethics of Jeramy Bentham, also received serious consideration as a psychological theory. In fact, the work of the British associationists—Hume, Locke, Spencer—made it the great motivational theory of the 18th and 19th century. But despite the general acceptance of this principle, there was some divergence of opinion on how it operated. The associationists, for example, held that an individual's actions were determined to a large extent by his knowledge of the consequences of such actions. Those acts which were known to produce happiness would tend to be made, whereas those which were known to produce pain would be avoided. Such a "futuristic" doctrine, however, did not appeal to the experimental psychologists of the 19th century. They claimed that it was the pleasure and pain that occurred in the past which were the major determinants of behavior. The chief proponent of this view was E. L. Thorndike who, on the basis of his studies in learning, formulated the Law of Effect. His earliest formulation (20) stated that those responses which are accompanied by satisfaction (reward) will tend to be repeated, whereas those which are accompanied by dissatisfaction (punishment) will be less likely to occur. In other words, reward "stamps in and failure stamps out" (13, p. 493).

In the half century following this formulation, the main interest was focussed on rewards and the manner in which they mediate learning. Thorndike himself believed that satisfying after-effects work in a blind, mechanical manner, "driving in," so to speak, the S-R connections. Hull, who later integrated the law of effect in his formal theory of learning (4), thought that rewards mediate learning by reducing needs. Nevertheless, he too subscribed to a type of "automaticity of reward." A school of thought that was diametrically opposed to this type of theorizing was headed by Tolman and his associates (3, 23). They believed that the effectiveness of reward could be explained in terms of the information which it conveys about the correctness of a response. This, of course, was a return to the old futuristic doctrine held by the British associationists. Despite much experimentation and more argument by both sides, an adequate resolution of the problem was not achieved.

The Phenomenon

When Thorndike first stated his law of effect, he considered that punishment eliminated incorrect responses in the same manner that reward strengthened the correct ones. On the basis of subsequent experiments, however, he revised his position. In these studies (21), he used word-definition tasks in which Spanish or rare English words served as stimuli and five common English words served as response alternatives. Subjects were instructed to choose the correct English meaning of the stimulus words. Correct responses were rewarded by the experimenter saying "Right" and incorrect responses were punished by a pronouncement of "Wrong." The effect of punishment was assessed in terms of the number of repetitions of punished responses that occurred as compared to the number expected on the basis of chance. Thorndike found that the proportion of errors that were repeated was well above the chance level.

The reliability of this phenomenon was further demonstrated by investigators employing word-number tasks (8, 9, 10, 16, 17, 18, 19, 22). Here, typically, the subject was presented with lists of common English words each of which, he was told, was assigned a number from 1 to 10. He was instructed to guess the correct number and was told "Right" or "Wrong" after each guess. The obtained repetition proportions of Wrong responses[2] in these experiments ranged from .20 to

[2]This usage is for economy of expression. Responses which are called wrong by an experimenter are termed "Wrong responses" or simply "Wrongs."

.30 which is clearly above the .10 expected on chance basis.

The above-chance repetition of errors has been demonstrated most recently by Koppenaal (5) who used a multiple-choice verbal maze. Subjects were presented with 20 pairs of common, three-letter words and instructed to learn the "correct" word in each pair. Pronouncements of "Right" for every correct response and "Wrong" for every incorrect response were made. In three separate experiments a significant above-chance repetition of Wrong responses was obtained. However, it was noted that this repetition of errors was consistently above-chance only at the earlier stages of learning and only in the middle portion of the maze. In other words, repetition decreased towards mastery of the maze and also showed a serial position effect similar to those found for errors in serial, paired-associate, and a variety of other learning tasks. These findings are of particular importance because they point to the lawful relationships that hold for error repetition. Pursuing the phenomenon from the point of view of these relationships, therefore, may provide the key to understanding error repetition in general.

Theoretical Interpretations

To account for the high level of repetition of Wrong responses, Thorndike invoked his near-forgotten *law of exercise*. This law stated that the mere occurrence of an S-R connection strengthened that connection more than punishment weakened it. This explanation was challenged by various reinforcement theorists who postulated some source of reward to account for the phenomenon. The numerous alternatives that were proposed have been reviewed recently by Koppenaal (6) and will not be reiterated here. It should be noted, however, that his experimental assessment of these alternatives (5) has shown them to be decidedly inadequate. This is perhaps one of the reasons that he concludes, in his review, that the learning by exercise hypothesis still remains "interestingly healthy."

Unfortunately, relatively little work has been carried out on a cognitive approach to error repetition. Such an approach may have an advantage over a simple contiguity theory because there is nothing suggested in contiguity theory that might help to account for variations in repetition such as occur with stage of learning and serial position. On the other hand, the cognitive conception of punishment functioning as information upon which performance is based may serve to throw some light on the stage of learning and serial position effects, if some measure of the amount of information available at the different stages and serial positions were obtained.

Perhaps the earliest formulation of the cognitive orientation to the problem of above-chance error repetition was made by Wallach and Henle in their study on the role of motivation in the repetition of rewarded and punished responses (26). They contended that "if wrong items were specifically remembered _as wrong items_, such repetition would probably not occur, because the subject would be in a position to vary these responses." It should be noted at the outset that their view, in accordance with classical cognitive theory, accepts the notion of learning by sheer exercise, since the subject could not vary responses unless he knew what responses to vary. In fact, Wallach and Henle present evidence for what they call "incidental memory of wrong responses." They further speculated that if "some of the incidentally recalled responses were remembered without the correct coordination between words and responses and the reactions of the experimenter, they would be reproduced along with the correct responses when the motive to recall these is present." In other words, what Wallach and Henle seem to suggest is that the reason Wrong responses are repeated at an above-chance level is because the subject remembers to a large extent the responses he made, cannot remember whether these responses were correct or incorrect, and, being set to repeat correct responses, repeats the Wrongs along with the correct ones.

Postman and Adams (14) attempted to test this hypothesis. In a simulated ESP setting, where the subject is instructed that responses correct on one trial may or may not be correct on another trial, subjects were presented with a series of 25 three-letter words and instructed to respond to each word with a number from 1 to 10. On the first presentation of the series, responses in positions 3, 13, and 20 were called "Right" and all others were called "Wrong." Prior to the second presentation, different groups received different instructions which were designed to manipulate the motivation to repeat or not repeat responses made during the training series. No rewards or punishments were given on this trial. A third presentation was given to determine what the subjects could recall about their responses on the first trial by asking them to recall the responses they made and to say whether these were right or wrong. That is, for each word the subject was asked what number response he had given on the first trial and whether that response had been called right or wrong by the experimenter.

The results showed that the level of repetition of punished responses on the second trial was greatly influenced by the instructions given prior to that trial. Generally, the more "positive" the instructions for punished responses became ("will be wrong again" to "may or may not be wrong" to "will be right"), the higher was the rate of repetition. Nevertheless, even in the condition where subjects were instructed that both the Right and the Wrong responses would be wrong on the next trial (discouraging any repetition), a significant above-chance repetition of Wrong responses was still obtained. It would appear, therefore, that there was some tendency on the part of the subject to repeat responses over and above that created by the instructions of the task.

The results of the recall test given on the third trial showed a high level of recall of the Wrong responses that had been made on the first trial, thus verifying Wallach and Henle's findings of "incidental memory of wrong responses." But, by far, the most interesting result was that, of the punished responses that were correctly recalled and correctly identified on the third trial as being wrong, a high proportion (.23) had been repeated on the second trial. This occurred in the condition where subjects were told that Right and Wrong responses would again be right and wrong respectively on the second trial, which is comparable to the normal learning situation. Though this finding is surprising in view of Wallach and Henle's contention that Wrong responses would be changed if the subject remembered the responses he made and correctly recalled them as being wrong, its definitiveness as evidence against their position is questionable for two reasons. First, this finding was based on a comparatively few observations, and second, recall of response and identification of reinforcement were obtained after the second trial which itself may have influenced the subjects' recall. As a result, the relevance of Postman and Adams' findings to

Wallach and Henle's hypothesis is indeterminate.

Statement of the Problem

The present study attempts to provide clearer evidence on the relationship of recall of response and identification of reinforcement to the repetition of errors. It is proposed to obtain measures of these two types of recall at various stages of learning and serial positions. This approach is adopted to test one implication of Wallach and Henle's hypothesis, viz., that changes in repetition proportions of punished responses will be systematically related to changes in recall of response and recall of reinforcement. If such relationships are obtained, they will be interpreted as evidence for a cognitive viewpoint. On the other hand, a lack of any systematic relationships between the recall measures and error repetition will be treated as evidence against the utility of a cognitive approach to the problem of above-chance repetition of punished responses.

CHAPTER III

EXPERIMENTAL METHOD AND RESULTS

I. METHOD

Materials. The present study employed a verbal maze of 30 pairs of common, three-letter words, each pair acting as a choice-point. This maze, a lengthened version of one previously described by Koppenaal (5), was constructed so as to minimize the structural and meaningful similarity of choices within and between choice-points. Each pair of words was printed, one above the other, in $\frac{3}{4}$ inch lettering, on the left half of a $6\frac{1}{2} \times 3\frac{1}{2}$ inch white plastic card. These stimulus cards were presented by means of a Hunter Cardmaster #340. The essentials of an earlier model have been described previously by Norcross and Spiker (11). The model used here consisted of a grey metal box with a 6×3 inch apeture in which the stimulus words appeared. Two independent shutters, each covering half the apeture, controlled the exposure of the stimulus cards. Three electronic timers, mounted on a separate panel, governed the length of time each shutter was open or closed.

Conditions. Two indices of information, recall of the postreme response (the response made on the previous trial) and recall of reinforcement (whether that response was called right or wrong), were chosen for investigation. To determine how this information varies with stage of learning, five different groups of subjects learned to different levels of mastery and were then given a recall trial. For one group, the recall trial was given after the attainment of 15 correct responses; for another group, the recall trial was the first trial after the attainment of between 16-19 correct responses. The third group learned to a criterion of between 20-23 correct; the fourth, 24-27 correct; and the fifth, 28-30 correct responses before the recall trial was given.

A comparison of the two indices of information with Wrong response repetition for comparable trials under learning instructions necessitated a "control" group. This group learned the maze in a traditional manner to a criterion of 28-30 correct responses plus one trial. Repetition proportions of Wrong responses were obtained from five stages comparable to the experimental groups, i.e., the first trial after the attainment of 15 correct responses, 16-19 correct, etc.

Reinforcements. For the serial list of choice-points, on the first trial, "rights" and "wrongs" were given by the experimenter in a predetermined order. Two orders were used, each randomly assigned to half the subjects in each group. One was determined by flipping a coin, and the second was exactly the reverse of the first. Reinforcements on subsequent trials were consistent with those on the first trial.

<u>Subjects</u>. The subjects were 168 volunteers, with an approximately equal number of men and women, who were paid for their services. They were drawn from teacher training courses at the Manitoba Teachers College and the University of Manitoba, and from the Summer School introductory course in psychology. They ranged in age from 18-26 and had at least a Grade XII education. All were naive to the task and apparatus. An equal number of subjects were assigned, on a random basis, to each of the six groups.

<u>Procedure</u>. Each subject was seated in front of the apparatus and given the following instructions:

> "This is an experiment in rote learning. What will happen is that several pairs of three-letter words of this nature will appear here (the experimenter placed a sample card containing the words 'cat-dog' in front of the apeture). For each pair, one word has arbitrarily been designated as right and the other as wrong. On this sample card, for example, 'cat' may be the correct word and 'dog' the wrong one. But there is no reason why one particular word is correct and the other incorrect—this has been determined purely by chance. Now, what you have to do is learn the correct word in each pair. Of course, the first time you go through the list you will have no idea which one is right and which one is wrong, so you will simply have to guess. Immediately

after your choice, I will tell you whether you are right or wrong. Thus, if on this sample card, you guessed the word 'dog' and I said 'Wrong,' then the next time you saw this pair of words you would try to say 'cat.' Do you understand what you have to do?"

When the experimenter was convinced that the subject was familiar with the nature of the task, he continued:

"There is another thing I want you to do. There are two shutters covering the window infront of you and these open in sequence. First, the left half will open showing you the pair of words. During this time you will decide on the word you think is correct—do not say it out loud—just think of it. The right half will then open and this will be your signal to tell me the word you chose. I will then tell you whether you are right or wrong; both shutters will close, a new set of words will appear, and you will go through the same procedure again. There are 30 pairs of words. We will go through them from 1 to 30, stop for 20 seconds, then go through them again until you learn all the correct words. A blank card will mark the end of a trial.

"One very important thing is that though the pairs of words and the order in which they appear is always the same, there is no pattern of right answers. Do not look for patterns in the position of words, that is, whether they are on top or the bottom; in the order in which words appear, in the meaning of words, or anything of that nature—no pattern exists! The list has been deliberately designed so that no sequence is present. In other words, it is simply a matter of learning, for each separate pair, which of the two words is correct. Looking for patterns will only hinder your learning in this task. However, the task is not simple; it is difficult and confusing, and you should not expect to learn it too quickly. Are there any questions?"

If the subject had any questions, every effort was made to clarify the instructions. When the subject reported that he was ready, a brief resume was given.

"All right. Now remember, the first time you go through the list you will merely be guessing at the correct word. Answer as soon as the second shutter goes up and not before, and do not look for a pattern of right answers."

The stimulus cards were presented in a constant order on all trials with a five second interval between choice-points. The left shutter was open for two seconds, both were open for one second, and both were closed for two seconds.

For each of the experimental groups, subjects were taken to the appropriate criterion trial and were then given a recall test. The recall instructions read as follows:

"That's fine! Now we will do something different. I will again show you the pairs of words but this time I want you to tell me the word you said <u>just on this last trial</u> and also tell me whether it was right or wrong. Thus, for instance, if you had said the word 'dog' and I said 'Wrong,' then on this trial you would try and say 'dog-wrong.' Do you understand what you have to do?"

If the subject understood the instructions, the experimenter continued:

"By the way, you have a few extra seconds before the second shutter goes up at which time you must tell me the word you said last time and also whether it was right or wrong. If you do not know by that time, just guess."

The pairs of words were presented in the same order as on the learning trials. The subject was given an extra second to allow sufficient time to give the two recall responses; the left shutter was now open for three seconds, both were open for one second, and both were closed for two seconds.

To equate the inter-trial intervals for all six groups, control instructions were given at all stages where recall instructions were not given. These instructions consisted of spontaneously engaging the subject in some conversation either about the test or about the courses he was taking. For example, at Stage I the experimenter said, "Well, those are the 30 pairs of words. Now do you have the general idea? As I said, it is confusing at first but it will become clearer as we go along." At later stages, the subject was asked how he liked his course, how he was progressing in it, whether he had a teaching position, and so on.

II. RESULTS

Methods of analysis. In this experiment, analysis was limited to Wrong responses only. In the control group only the repetition proportions of Wrong responses were obtained. To obtain this proportion on a given trial, the number of Wrong responses on that trial, and the number of the same responses which occurred on the following trial were counted.

In the experimental groups, two major methods of analysis were employed. In one, errors[3] in (a) recall of the postreme punished response (Rppr) and (b) recall that it was called wrong (Rp)[4] were recorded and analyzed as separate measures. The second method of analysis involved predicting at each choice-point were an incorrect response was made on trial *n*, whether or not that response would have been repeated on trial *n* + 1 had the subject been under learning instructions and had he actually used, in the most efficient manner, the

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[3]Hereafter, this term will be used only for incorrect recalls.

[4]The term "recall of reinforcement" is also used for this measure.

information he recalled about the postreme response and its reinforcement. Suppose that on trial n, at a choice-point consisting of the words "bee-day," the subject chose the word "bee" and it was called wrong. The subject is then given the recall test. If he either (a) recalled the postreme response correctly (bee) but recalled it as right, or (b) recalled the postreme response incorrectly (day) and thought it was wrong, then, if he acted rationally, i.e., if his response was based on this information, he would repeat the Wrong response (bee) on trial $n + 1$. On the other hand, if one of the remaining two possibilities occurred, then presumably, he would alternate to the correct response.

Since all the scores obtained by these methods of analysis were in the form of proportions, a conversion of these proportions into radians (24) was carried out before any statistical analysis was attempted.

Stage of Learning Effects

To determine the differences between errors in Rppr and Rp at the five stages of learning, an analysis of variance described by Edwards (1, p. 288) was employed. A preliminary test on the converted scores showed no significant heterogeneity of variance (Hartley's $F = 2.67$; $F_{.05} = 3.29$). The results of the analysis of variance are presented in Table I.

TABLE I

ANALYSIS OF VARIANCE OF RECALL OF THE POSTREME PUNISHED RESPONSE AND ITS REINFORCEMENT AT FIVE STAGES OF LEARNING*

Source	df	MS	F
Between stages	4	1.88	8.95**
Between subjects at same stage	131	.21	
Between recalls (Rppr; Rp)	1	4.21	30.07**
Interaction: recalls × stages	4	.57	4.07**
Interaction: pooled subjects × recalls	131	.14	

*Only 24 subjects contributed to the data at Stage V; 4 subjects reached a criterion of 30 correct before the recall test.

*p <.01

The F ratios for the differences between stages, between the recall measures, and the interaction of stages × recalls were all highly significant. Referring to the graphic representation of the data (Fig. 1), it can be seen that Rp is consistently poorer than Rppr at all stages of learning but that the changes in Rp are not paralleled by changes in Rppr. Whereas the mean proportion of errors in Rp decreases with stage of learning, the mean proportion of errors in Rppr in-

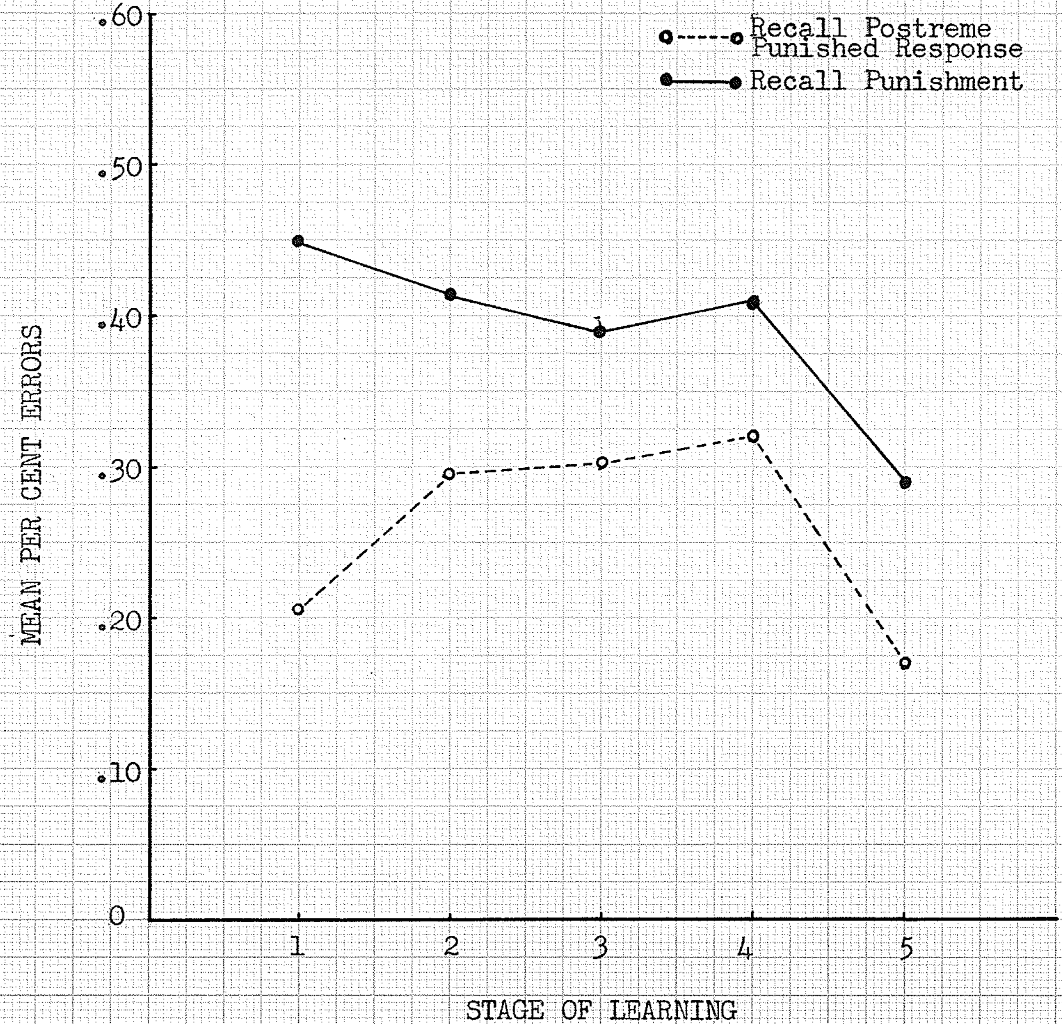

Figure 1. Mean per cent errors in recall of the postreme punished response and its reinforcement at five stages of learning.

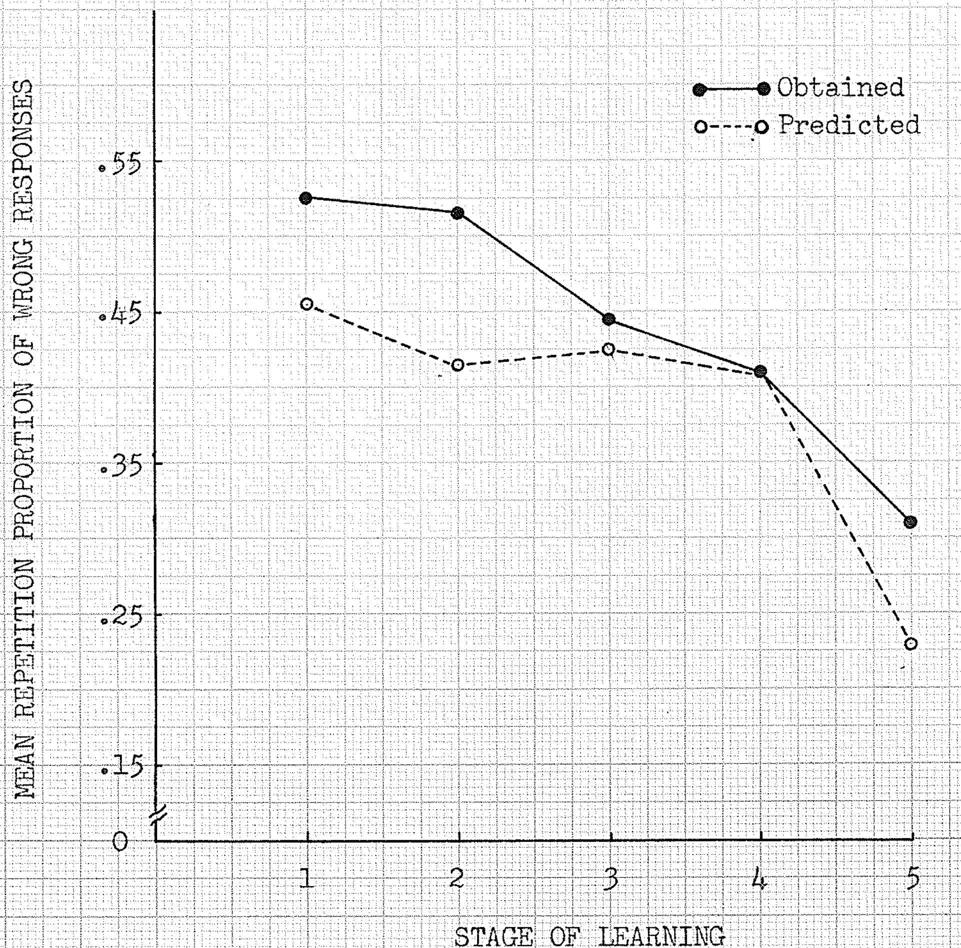

Figure 2. Mean obtained and predicted repetition proportions of Wrong responses at five stages of learning.

creases up to the fourth stage and then rapidly decreases.

Before a comparison could be made between the pattern of errors in Rppr and Rp and the pattern of repetition proportions of Wrong responses obtained from the control group, it was first necessary to determine whether the criterion number of correct responses defining the stages of learning were similar for both the experimental and control groups (see p. 14). The greatest discrepancy occurred at Stage IV where the mean number of correct responses for the experimental group was 24.86 and for the control group 25.32. This difference, however, was not statistically significant ($t = 1.61$; $p > .05$), hence the stages of learning reached by the experimental and control groups were regarded as comparable.

In comparing the trends of Rppr and Rp with the actual repetition proportions, the method of testing the goodness of fit to *a priori* trends (7, p. 344) was employed. The mean errors in Rppr and Rp were regarded, *for statistical purposes only*, as hypothetical means, and deviations of these means from the pattern of means for repetition of Wrong responses were then determined. For Rppr the F ratio for departure from pattern was 4.68 which is significant beyond the .01 level of confidence. However, for Rp this same ratio was not statistically significant ($F = 1.04$; $F_{.05} = 2.45$). It thus appears that changes in the repetition of

Wrong responses are closely paralleled by changes in Rp but not in Rppr.

In the second method of analysis, the per cent repetition of Wrong responses was predicted at each stage from the recall data, on the assumption that the information evidenced in recall is used to determine the response. The changes in the predicted rate with stage of learning and a comparison of this predicted rate with the repetition of punished responses obtained from the control group is shown in Fig. 2. A test of the two trends by the method described above showed that they do not differ significantly ($F = 1.12$; $F_{.05} = 2.45$). However, the *level* of repetition for the predicted rate is lower than that of the obtained rate. The F value for the vertical displacement of the two patterns of means is 6.26 ($p < .01$). The obtained changes in repetition of Wrongs with stage of learning, therefore, follow the predicted changes, but the obtained repetition proportions are consistently greater than those predicted on the basis of the information the experimental groups evidenced.

Serial Position Effects

For purposes of analysis, the 30 unit maze was arbitrarily divided into six blocks of five choice-points each. For the control group, the repetition proportions of Wrong responses over serial positions were computed in two ways. A "sampled" serial position curve was first obtained by using only the five trials corresponding to the stages of learning (p. 14). At each serial position block, repetition proportions on the five "stage" trials were averaged to obtain the rate of repetition for each subject. A "treatments × subjects" analysis of variance on the serial position effect obtained in this manner showed it to be highly significant ($\underline{F}$ = 4.54; $\underline{F}_{.01}$ = 3.78). However, to determine whether this sampled serial position effect was representative of the total, a comparable serial position curve, but based on all trials, was also computed. The resulting curve, along with the sampled one, is shown in Fig. 3. Clearly, the shapes of the two curves are very similar. The small but rather consistent difference between the absolute levels of the two curves is probably due to the utilization of more trials with a high level of repetition in the sampled serial position curve. As a matter of fact, since fewer trials separated earlier stages of learning than later ones, the sampled serial position curve did not give enough weight to the later stages where repetition is lower (see Fig. 1).

The prime purpose of computing a sampled serial position curve of repetition was to enable a comparison to be made between this curve and the serial position effects for the recall measures (available only on stage trials) and the predicted rate of repetition (based on the recall measures). The serial position effects for Rppr, Rp, and the predicted rate of repetition were obtained again by averaging over the five stage

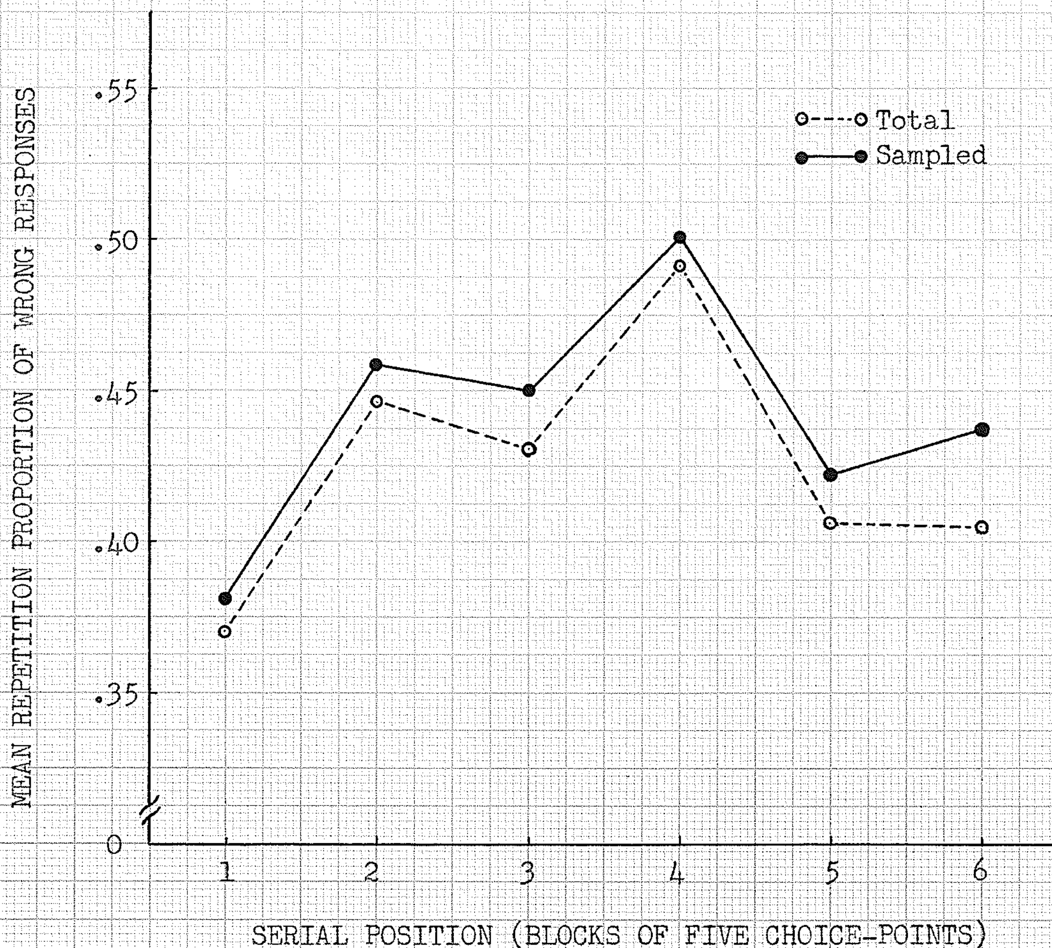

Figure 3. Total and sampled serial position effects of repetition of Wrong responses.

trials. It should be noted, however, that while only 28 subjects (control group) contributed to the sampled serial position curve, 140 (28 at each stage) were used in obtaining the curves for errors in Rppr, Rp, and the predicted rate of repetition. The resulting curves are shown in Fig. 4. A test of the goodness of fit of these curves to the sampled serial position curve showed no marked departure from pattern; the $\underline{F}$ ratios of .63 for Rppr, .85 for Rp, and .50 for the predicted rate were not significant ($\underline{F}_{.05}$ = 2.27). Once again it should be noted that the obtained rate is at a higher level than the predicted rate; the $\underline{F}$ ratio for the vertical displacement of the obtained and predicted curves was 7.18 ($\underline{F}_{.05}$= 2.27).

To obtain more data on the serial position effects of Wrong response repetition, an attempt was made to determine the changes in the obtained and predicted serial position curves with each stage of learning. To increase the reliability of the data, the maze was divided, for all groups, into three blocks of 10 choice-points each. At each stage, only those subjects who had at least one Wrong response per block could be used to ensure that an equal number of observations contributed to each serial position block. As a result, no serial position curves were computed at Stage V, and the curves at Stages II, III, and IV, were based on less than the original number of subjects. Both the obtained and predicted serial position effects for the first four stages

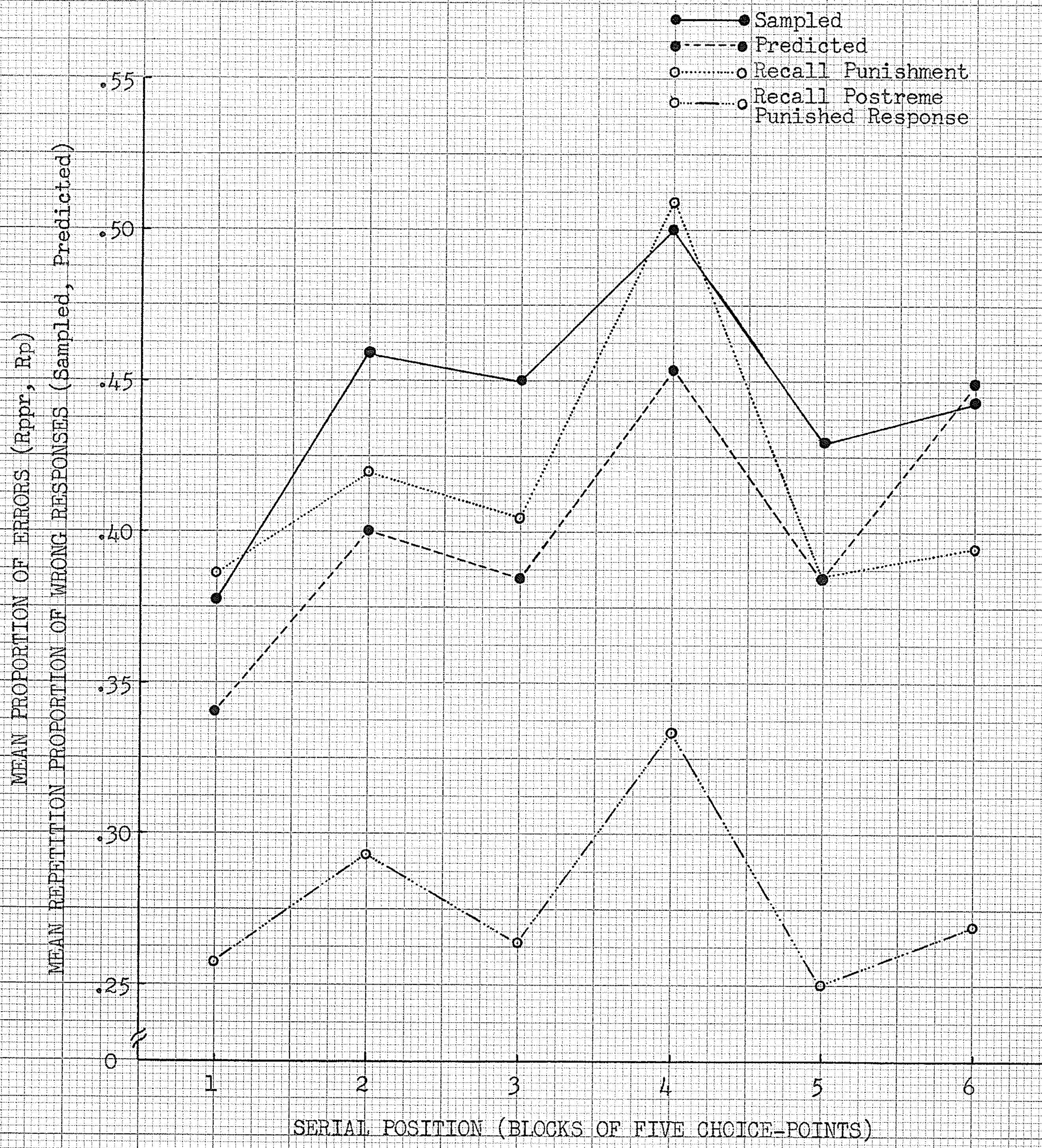

Figure 4. A comparison of the sampled serial position effect with serial position effects in recall of the postreme punished response, recall of punishment, and the predicted rate of repetition.

of learning are shown in Fig. 5.

A so-called "methods" analysis of variance (1, p. 288) on the obtained and predicted serial position effects was carried out separately for each of the four stages of learning. A summary of the F ratios is shown in Table II.

TABLE II

SUMMARY OF F SCORES BETWEEN OBTAINED AND PREDICTED SERIAL POSITION EFFECTS AT FOUR STAGES OF LEARNING

Source	Stage of Learning 1	2	3	4
Between obtained and predicted (M)	4.95*	5.87*	.12	.53
Between serial positions (S)	1.38	1.30	.76	1.67
Interaction (M S)	.15	.80	.03	.00

*$p < .01$

Only the F scores between the obtained and predicted levels of repetition at Stages I and II were statistically significant. The difference between the results of these analyses and the one performed earlier (p. 24) which showed that the differences over all stages between the obtained and predicted rates of repetition were highly significant, is probably due to the use of a fewer number of subjects and less reliable proportions (obtained from each block) in the present analyses. The lack of statistically signi-

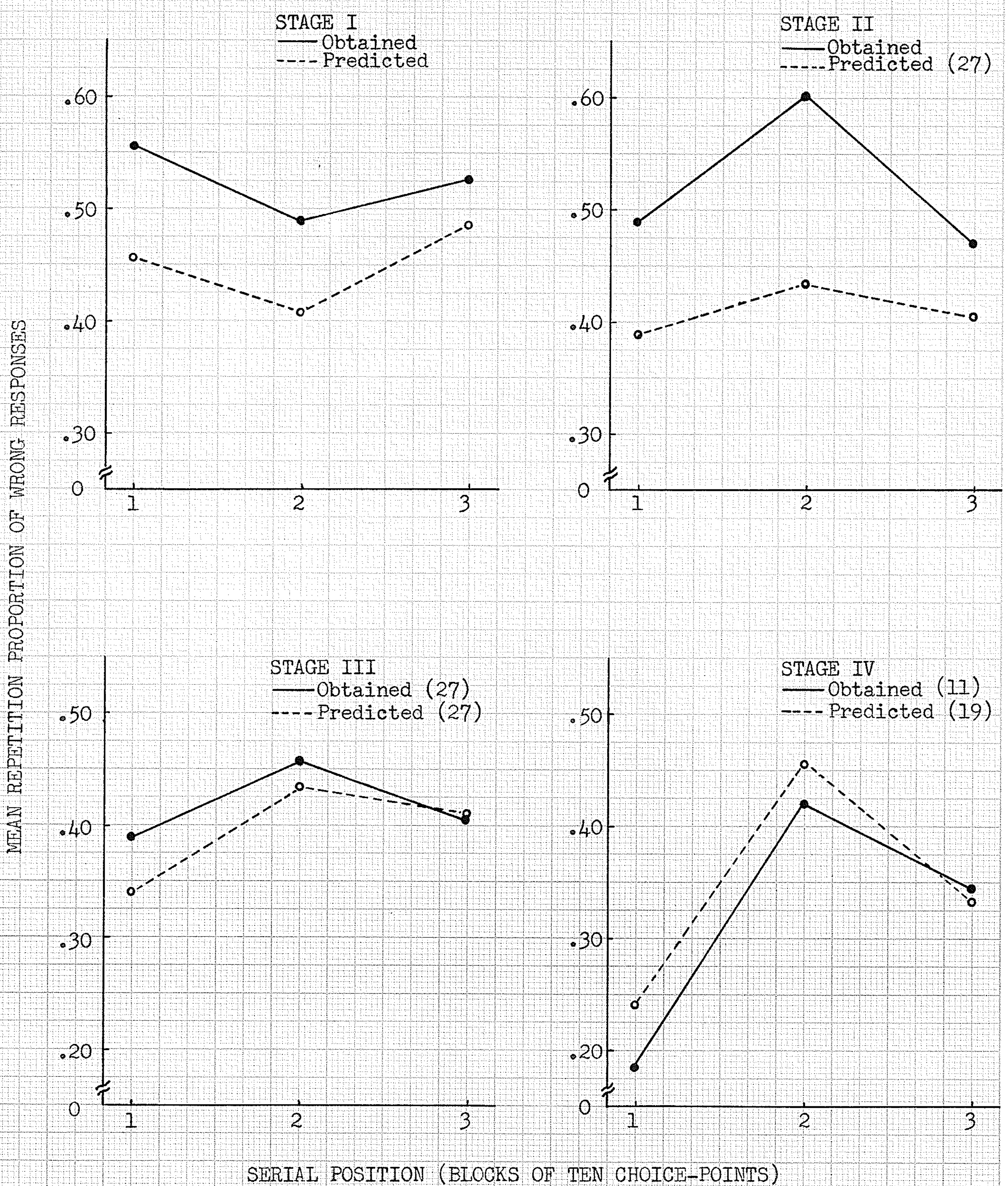

Figure 5. Obtained and predicted serial position effects at four stages of learning. The number of subjects contributing to each curve is given in parentheses when this was less than the original 28.

ficant serial position effects at the four stages of learning is probably due to the same reasons, since it seems contradictory to have a serial position effect for the whole maze (p. 26) and no serial position effect for any part of the maze.

Further reliability for the obtained serial position effects at each of the four stages was found by utilizing the <u>experimental</u> groups from which repetition proportions of Wrongs were available. Thus, for example, for Stage I, experimental groups II, III, IV, and V were used; for Stage II, groups III, IV, and V were employed, and so on. The serial position curves obtained in this manner were found to have essentially the same shapes as those obtained only from the control group.

There are two interesting features in connection with the serial position curves at the four stages of learning. First, as was found previously, the predicted curves parallel the obtained serial position effects but occur at a lower level. The one exception, Stage IV, is probably due to the non-equivalence of the stages reached by the experimental and control groups (see p. 23). The second point worthy of mention is the fact that, at Stage I not only is the traditional serial position effect absent, but in fact, the trend appears to be reversed. Stages II, III, and IV, on the other hand, have the highest repetition at the center of the maze.

CHAPTER IV

DISCUSSION

The results of this study demonstrate that in serial multiple-choice learning there is a high degree of recall of the postreme punished response. This finding is in line with that of others (14, 25, 26) who have investigated this variable. Recall of punishment, on the other hand, is considerably poorer than recall of the postreme punished response at all stages of learning and at all serial positions. It would thus seem that, at least for the punished responses the learner has a better knowledge of the identity of such responses than of whether they were punished or rewarded.

The changes in the two recall measures with stage of learning and serial position provide information which is more interesting theoretically. In all cases where the ability to recall punishment increases, there is a concomitant decrease in repetition of Wrong responses. Though the same relationship holds true for recall of the postreme punished response over serial positions, the function is reversed for some stages of learning. At the earlier stages, a <u>decrease</u> in recall of the postreme punished response is followed by a decrease in repetition. Of these two measures, then, recall of punishment appears to correlate better with alternation from Wrong responses to correct ones. This point is perhaps what Wallach and Henle had in mind when they hypothesized that Wrong responses, which are specifically recalled as wrong, would not be repeated.

However, the point of view taken here is that an individual's behavior at a particular choice-point depends on some combined effect of the two types of information. Wallach and Henle allude to some such effect when they talk of the "coordination between words and responses, and the reactions of the experimenter" (26, p. 160). In the present study a direct attempt was made to get at this interrelation of recall of response and recall of punishment in producing repetition or non-repetition by making two assumptions. First, that the information given on the recall trial would have been present had the subject still been under learning instructions on that trial; and second, that such information would have been used rationally, i.e., in terms of the task objective of making correct responses. When repetition proportions of Wrongs were predicted in this manner, one of the major findings was that the variations in the predicted rate of repetition are, on the whole, closely paralleled by variations in the obtained repetition proportions of Wrong responses. This close correlation between the predicted and obtained measures of punished response repetition may indicate that the recall measures upon which the predicted repetition is based are fruitful ones; and further, that the concept of rational use of information that an individual has about a response and its reinforcement may be important in the explanation of punished response repetition.

However, an acceptance of a simple rational-use-of-information model as a complete explanation of multiple-choice learning is militated against by the fact that, in every case where the comparison was made, with inconsequential exceptions, the predicted rate of repetition was less than the obtained rate. In other words, had the subjects in the experimental groups acted rationally on comparable learning trials in terms of the information they gave on the recall trials, the number of Wrong responses they repeated would have been less than that actually shown by the control subjects. The explanation for this difference between the obtained and predicted rates of repetition is not altogether clear. One suggestion that follows from a cognitive viewpoint is that this difference is due to a <u>set</u> to repeat responses (26). In a learning task, performance instructions may set the subject to repeat responses so that the Wrong responses, unless they are known to be wrong, are repeated regularly along with the correct ones rather than at a chance rate. The recall instructions, on the other hand, create a different set, forcing the subject to recall (even guess) the reinforcing event. In this situation, then, some of the Wrong responses, which are not specifically recalled as wrong, will be correctly <u>guessed</u>

as such and alternation will be predicted, whereas, under learning instructions, repetition would probably occur.

The cognitive interpretation thus places a great deal of emphasis on the repetitional set created by instructions as an explanation of the high rate of repetition of Wrong responses. While Wallach and Henle's own studies (25, 26) present only dubious evidence for this position, Postman and Adams' findings (14) indicate that such sets do tend to raise the level of repetition, but also that above-chance repetition occurs even when the instructions are explicitly for non-repetition. A repetitional set created by instructions thus appears insufficient in itself to account for above-chance repetition of punished responses. One possible additional factor may be the simple contiguous association that is built up between the seeing of a word and the saying of it. The very fact that a certain response is made at a choice-point may increase the probability of occurrence of that response when the choice-point is again presented. This, of course, is a statement of classical contiguity theory (2) and some evidence in this experiment points to the necessity of some such conception. For example, after only one trial of learning, there is a high degree of accuracy in recall of the responses that were made (80% correct for Wrong responses). This result certainly points to the effectiveness of the contiguity of stimulus and response in <u>learning</u>, and the evidence of repetition above that predicted on the basis of a cognitive view points to the direct influence of this contiguity on performance also. In fact, as Postman and Adams have suggested, the recall or "information" data presented here insists that a conceptual distinction be made between learning and performance—a distinction which is common in general theories of learning but, as yet, very infrequently present in accounts of verbal learning data.[5]

It should be noted that the recall data obtained in this experiment has more than a casual resemblance to the data of the long discredited method of introspection. In view of the suspicion that such data may engender in many, it must be re-emphasized that the data in question do show an interesting correlation with the more acceptable learning data. It seems obvious, therefore, that it would be desirable to have an account of the verbal learning data that is also capable of accounting for this correlation.

Such an accounting for human verbal maze learning can be formulated by employing (and probably somewhat distorting) both the traditional contiguity and cognitive conceptions of the determination of learning and performance. This will be

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[5]It is interesting to conjecture that the relations between recall and performance data on humans may actually prove helpful in understanding the learning and performance distinction in infra-human learning behavior, a nice reversal of the traditional emphasis. Anthropomorphizing may prove to be of some value after all!

outlined only for punished response repetition but should eventually be capable of extention to response determination in general. Assume that at each choice-point two processes, perhaps similar to those proposed by Runquist and Freeman (15) for serial and paired-associate learning, occur successively in time. First, an S-R association is formed between the perception of the stimuli and the response to them; this can be called the "response-learning" phase. A second association, the "reinforcement-learning" process, is then formed between the first connection and the experimenter's reaction of "Wrong." Generally, if the first association is strong and the second weak, the learner will tend to perform in terms of the first association. As the second association becomes stronger, however, performance in terms of the first association will be inhibited and alternation will occur.

In learning a verbal maze, there is imperfect learning (and retention) of both associations because of the large number of choice-points present. However, learning of the first association occurs to a relatively high degree since the presence of different stimuli, both within and between choice-points, produces a minimal amount of interference. Learning of the second (reinforcement) association, on the other hand, is greatly interfered with because of the random alternation of only two types of reinforcements, i.e., the words "right" and "wrong." Moreover, the fact that the two reinforcements are opposite in meaning may add to the interference. Osgood (12), for example, found that in paired-associate learning, more interference is produced when competing responses are opposite in meaning than when they are meaningfully unrelated. In a multiple-choice learning task, a similar situation may be present.

The impairment in the reinforcement-learning process is greatest in the middle of the maze where, it is known from studies in serial and paired-associate learning, interference tends to summate. As a result, at this point, performance is almost entirely in terms of the first association which, of course, produces a high rate of Wrong response repetition. With an increase in practice, however, there is a better opportunity to learn the reinforcing event and, consequently, there is a decrease in the number of Wrong responses that are repeated.

This conceptual scheme of two processes operating in multiple-choice learning not only helps us to understand the results obtained in this experiment, but also enables us to make several predictions. For example, increasing the similarity of stimuli within and between choice-points should make the response-learning phase more difficult, thus produce more variable behavior, hence lower the rate of repetition of punished responses. Alternatively, increasing the discriminability of the reinforcements should facilitate the learning of the second association and once again decrease the rate of repetition of Wrong responses. These hypotheses should be investigated to determine the adequacy of the outlined system and to throw further light on the relationships that obtain between the response-learning and reinforcement-learning phases.

CHAPTER V

SUMMARY AND CONCLUSIONS

This investigation was concerned primarily with the cognitive orientation to the problem of above-chance repetition of punished responses in human multiple-choice learning. The one statement that has been made of the cognitive approach stresses the use of such concepts as rational use of information and repetitional set in explaining the phenomenon. However, the lack of a rigorous explication of the concept of "information" has resulted in the experimental emphasis being placed on the role that set, created by instructions, plays in the repetition of Wrong responses. Data on the kind and amount of information the learner has about the task has been largely incidental.

In this study, the relationships of two types of information, recall of the postreme punished response and recall of punishment, to punished response repetition were investigated. The two recall measures were obtained from five groups of subjects who learned a 30 unit verbal maze to different levels of mastery. Serial position effects were also obtained by dividing the maze into six blocks and determining, from all five groups, the mean error in recall of the postreme punished response and recall of punishment at each block. Comparable stage of learning and serial position effects of actual repetition proportions of Wrong responses were obtained from a control group who learned the maze to criterion.

In comparing the recall measures with punished response repetition, the recalls were considered, first as independent measures, and second, as information which the subject would have used rationally had he been under learning instead of recall instructions on that trial. This latter measure yielded a "predicted" rate of punished response repetition.

Analysis of stage of learning and serial position effects yielded the following conclusions.

(1) Recall of the postreme punished response is consistently more accurate than recall of punishment at all stages of learning and all serial positions.

(2) Over both stages of learning and serial positions, recall of punishment correlates with punished response repetition; specifically, whenever recall of punishment increases, punished response repetition decreases. For recall of the postreme punished response, on the other hand, the same relationship holds only over serial positions and not over stages of learning.

(3) Variations in the predicted rate of repetition are closely paralleled by obtained variations in punished response repetition over both stages of learning and serial positions. However, the predicted rate is always lower than the obtained rate.

The most general conclusion from the results of this experiment is that recall of the postreme punished response and recall of punishment are fruitful measures in the study of punished response repetition; and further, that the concept of rational use of information may be useful in understanding the phenomenon, though incapable by itself of providing a fully adequate explanation of it.

In the discussion of results, a model, based on the concepts of rational use of information and the effects of simple S-R contiguity was outlined to account for above-chance repetition of punished responses. Two predictions, derived from this model, were outlined to test the adequacy of the model and to provide further information on the function of identification of response and its reinforcement in human multiple-choice learning.

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