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The Nature of Errors in Serial Learning

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THE NATURE OF ERRORS IN SERIAL LEARNING

BY

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INTRODUCTION

Since Ebbinghaus began his epochal experiments on memory, problems of retention and learning have become one of the fields in experimental psychology which have been explored most extensively and intensively.

The problem of serial learning itself has been investigated by scores of experimental psychologists employing many different kinds of learning materials and methods. The majority of experiments in serial learning have been done concerning the problem of positional advantage. The study of the nature of errors committed in serial learning has somehow always been neglected.

Thus, in this investigation an experimental attempt was made to throw some light on this particular, overlooked problem of error in serial learning. For this purpose the three different kinds of memory materials of different length were employed with a fairly large number of subjects.

CHAPTER I

PAST EXPERIMENT AND THE PROBLEM

The earlier investigators of the problem of serial learning seemed to be interested mainly in experimental results which revealed a relatively high rate of learning at the very beginning and the last part of the lists. This interesting phenomenon of the primacy and finality effect in serial learning was widely investigated with many different learning materials such as geometrical figures, colors, disconnected words, mazes, etc.

Later investigators' interest has become more specific and the positional advantage of primacy over finality or vice versa has become the point of controversy. Their experiments were conducted almost exclusively with nonsense syllables as their memory materials.

But hardly sufficient attention was given to the problem of error in serial learning. Consequently very few investigations have been done concerning the analysis of errors in serial learning and the findings from these few experiments which touched on this problem were only fragmental in nature.

The experiment of J. Bigham¹ would be one of these few important ones in which an attempt was made to classify the errors in serial learning. He used lists of ten digits, ten nonsense syllables, ten disconnected words, colors and geometrical figures, as memory materials which were presented visually or audibly only once to the subjects.

1. J. Bigham, "Memory," Psychological Review, Vol. I, 1894, pp. 453-461.

After the presentation of memory materials, the subjects were required to write down the recollected words or syllables upon strips of paper or to arrange the numbers as remembered. He used only six subjects in his experiment. The errors were recorded and classified into three categories, such as misplacement, omission or forgotten, and "alien" presentation. The last mentioned category was only obtained from lists of nonsense syllables and disconnected words. Thus he obtained the following results: 1) The combined errors of three categories after two seconds interval were 10 per cent for numbers, 34.4 per cent for words, and 49.2 per cent for nonsense syllables. The most errors occurred in nonsense syllables and the fewest in numbers; 2) The average misplacement errors in three different intervals (two, ten, and thirty seconds) were 7 per cent for numbers, 5.7 per cent for words, and 4.3 per cent for nonsense syllables. The most misplacement errors occurred in numbers and the fewest in nonsense syllables; 3) The total average forgetting in three intervals (two, ten, and thirty seconds) was 1.6 per cent for numbers, 29.9 per cent for words, and 43.2 per cent for nonsense syllables; 4) The intrusion of "alien" responses after two seconds interval was 0.4 per cent for words and 1.0 per cent for nonsense syllables.

Table I shows the location of the three kinds of errors that appeared in his experiment.

Bigham did not make a further analysis of the three kinds of errors which occurred in each serial position of the different learning materials.

TABLE I²

PERCENTAGE OF ERRORS AFTER TWO SECOND INTERVAL - BIGHAM

SERIAL ORDER	1	2	3	4	5	6	7	8	9	10
MISPLACEMENT	2.5	7.5	11.7	12.5	15.7	12.1	10.8	11.3	6.3	2.5
FORGETTING	5.8	11.3	15.0	23.8	20.4	14.6	23.8	14.6	12.1	6.7
ALIEN RESPONSE	3.3	1.3	1.7	2.1	1.3	0.4	0.8	1.3	0.8	0.8

W. G. Smith³ conducted a similar experiment with lists of ten nonsense syllables which were presented visually. The subject was required to read aloud one syllable after another at a rate a little faster than one syllable a second. It was required that the recall be written. Eight subjects served in this experiment. From this experiment Smith found 3.5 per cent for misplacement error, and 17.0 per cent for "alien" presentation. No further analysis of these two types of errors in each serial position was made. The errors in each serial position after the first trial are given in Table II:

TABLE II⁴PERCENTAGE OF INCORRECT RECALL - SMITH
AFTER FIRST PRESENTATION

SERIAL ORDER	1	2	3	4	5	6	7	8	9	10
%	19	48	76	84	84	76	74	74	38	16

2. Ibid., p. 457.

3. W. G. Smith, "The Place of Repetition in Memory," *Psychological Review*, Vol. 3, 1896, pp. 21-32.

4. Ibid., p. 26.

In these two experiments, both Bigham and Smith agreed that the average percentage of misplacement errors in nonsense syllable lists was fairly small. However, the average percentage for "alien" response in Smith's experiment was considerably greater than Bigham's. A general tendency in Smith's Table II is that the most errors occurred in the fourth and the fifth serial position and fewer errors at both ends of the lists with a slight superiority in the last serial position.

In Mitchell's experiment⁵ the lists of 10 three-place numbers were presented visually. The subjects learned the lists by the anticipation method.

Table III shows the percentage of the "place-skipping" errors in each serial position for the first quarter of the learning stage.

TABLE III⁶

"PLACE-SKIPPING" ERRORS FOR THE FIRST QUARTER OF LEARNING TIME - MITCHELL

SERIAL ORDER		1	2	3	4	5	6	7	8	9	10
STIMULUS ASPECT	%	52	4	6	6	6	4	8	4	5	6
REPOSENSE ASPECT	%	4	7	5	9	4	6	4	6	8	47

The stimulus aspect of these errors indicated that the errors came most frequently from the first position. The response aspect revealed that they occurred mostly in the last serial position. However taking all the

5. M. B. Mitchell, "Errors in the Memorization of Numbers," The American Journal of Psychology, Vol. 45, 1933, pp. 1-16.
 6. _____, "Anticipatory Place-Skipping Tendency in the Memorization of Numbers," The American Journal of Psychology, Vol. 46, 1934, p. 85.

cycle of the learning stage the anticipatory errors favored the latter positions in the lists as their sources and locations of occurrence. The percentage of the total number of incorrect responses in each serial position and the ranked order for the ten positions are given in Table IV.

TABLE IV⁷

PERCENTAGE OF INCORRECT RESPONSES BY POSITION - MITCHELL

SERIAL ORDER	1	2	3	4	5	6	7	8	9	10
%	85.3	86.1	87.9	90.0	91.4	92.2	91.7	93.3	92.7	89.9
RANK	1	2	3	5	6	8	7	10	9	4

An experiment employing lists of ten digits was reported by Woodworth and Poffenberger⁸. The lists were read aloud by the experimenter after which the class of twenty-six subjects wrote their recollections of each list presented. The errors committed in this experiment are shown in each serial position in Table V.

TABLE V⁹PERCENTAGE OF ERRORS BY SERIAL POSITION
WOODWORTH AND POFFENBERGER

SERIAL ORDER	1	2	3	4	5	6	7	8	9	10
%	1	10	17	23	27	24	24	19	13	2

Contrary to Smith's findings, the least amount of errors occurred in

7. Ibid., p.85.

8. R. S. Woodworth and A. T. Poffenberger, Textbook of Experimental Psychology, Mineog, ed., New York, 1920, pp. 71-72.

9. Ibid., p. 72.

the first serial position. The superiority of the early serial positions over the latter positions was not as consistent as in Table IV.

The experiment of Welch and Burnett¹⁰ was conducted with twenty-six subjects and employed lists of eight nonsense syllables composed entirely of consonants such as VJP, DVT, etc. A tachistoscope was set up for an exposure of 60 ϕ . After a list was shown the subjects wrote down remembered syllables. At the end of the experiment three questions were asked such as, "Did you use any systematic procedure for remembering?", "With what degree of confidence did you approach the experiment, and how confident are you of results?", etc.

Table VI shows errors committed at each serial position in this experiment.

TABLE VI¹¹

PERCENTAGE OF INCORRECT RECALL - WELCH AND BURNETT

SERIAL ORDER	1	2	3	4	5	6	7	8
%	85.6	83.7	82.2	87.0	85.1	86.1	71.2	31.7

In Welch and Burnett's findings the superiority of the last position of the lists was obviously apparent and the first serial position did not show any advantage over the middle positions. As a whole theirs were in agreement with Smith.

 10. G. B. Welch and C. T. Burnett, "Is Primacy a Factor in Association-Formation," *The American Journal of Psychology*, Vol. 35, 1924, pp. 396-401.

11. *Ibid.*, p. 398.

Brown¹² conducted an experiment similar to Mitchell's employing lists of 6, 9, 15, and 18 nonsense syllables and 4, 6, 8, and 10 three-place numbers. Brown's results in the list of 6 and 9 nonsense syllables and 4, 6, and 8 three-place numbers are presented in Tables VII and VIII.

TABLE VII¹³

PERCENTAGE OF INCORRECT ANTICIPATIONS - BROWN
AFTER ONE REPETITION

SERIAL ORDER		2	3	4	5	6	7	8	9
6 SYL. %		26.7	33.4	50.0	65.0	61.7			
9 SYL. %		8.4	38.4	63.4	73.4	80.0	88.4	85.0	80.0

TABLE VIII¹⁴

PERCENTAGE OF INCORRECT ANTICIPATIONS - BROWN
AFTER ONE REPETITION

SERIAL ORDER		2	3	4	5	6	7	8
4 NO. %		10.3	28.4	48.1				
6 NO. %		15.9	37.5	76.1	96.6	85.2		
8 NO. %		21.6	34.1	71.5	95.5	97.7	94.3	89.8

In her results the trend in the data of Welch and Burnett was reversed. The first serial position had fewer errors than in the case of Mitchell's, only its superiority was more distinct. The last serial position did not show any decisive advantage over the middle section of the series.

12. M. E. Brown, "Statistical Studies in Memory," Master's Thesis, The University of Chicago, Chicago, Illinois, 1925.

13. Ibid., p. 12.

14. Ibid., pp. 14-15.

Problems

Bigham classified and studied the errors in serial learning but each type of errors at the serial positions was not examined and compared for each different learning material. Smith's work was done with the lists of ten nonsense syllables and no further attempt of analysis of the errors at each serial position was made. Mitchell made a careful examination of the "place-skipping" errors at each serial position, but his experiment was conducted exclusively with the lists of three-place numbers. The other experiments were concerned with the positional advantage of the lists in serial learning.

Hence there are still more problems to be investigated. For example, it was found in the work of Bigham that misplacement errors showed a uniform rate of increase and decrease from the first serial position to the fifth serial position and from the fifth serial position to the last serial position. No advantage of the first serial position over the final serial position was found. Does such normal distribution of misplacement errors prevail for the lists of nonsense syllables as well as the lists of disconnected words? In what particular serial position do "alien" responses occur most and least frequently? Does any particular serial position consistently show an advantage over others regardless of the learning materials and type of errors? Thus further analysis and comparison of each type of errors which occur in the learning of the lists of nonsense syllables, disconnected words and digits have been set up as the main task of this investigation.

As a subsidiary problem it is intended to examine the controversial issue of primacy over finality from the subject's introspective data.

CHAPTER II
THE PROCEDURE

The Subjects

The subjects of this experiment were fifty college students ranging in age from 18 to 38 years. Twenty-one of these were male and twenty-nine were female students.

None of the subjects were aware of the exact purpose of the experiment yet they were sufficiently motivated so that they were very cooperative.

The Materials

The learning materials consisted of eighteen, size 3" by 5", white cards on which series of stimulus words were printed in the lower keys of the standard size typewriter.

Prior to the final selection of length and lists of learning materials a careful short experiment with a small number of subjects was conducted in order to determine an adequate length of the lists for the main experiment.

1. The List of Nonsense Syllables

Most of the nonsense syllables were selected from Hull's lists¹ of nonsense syllables which had lower meaningful value. An attempt was made to select and construct the lists from nonsense syllables of about the same low value in meaningfulness.

1. C. L. Hull, "The Meaningfulness of 320 Selected Nonsense Syllables,"
The American Journal of Psychology, Vol. 45, 1933, pp. 730-734.

In the formation of the lists of nonsense syllables particular attention was given to the following points:

- a) No two successive syllables were allowed to have the same vowel.
- b) No two extreme end syllables could have the same vowel.
- c) Syllables unnecessarily difficult to pronounce were avoided.
- d) No modified vowel was used.

The lists of five syllables were: a) muj vab tiv jex nof, b) teb foj zik fap tuj, c) zix tov zal kej bup. The lists of seven syllables were: a) buv teb nad pij fov tup vef, b) jat dej maf vok zud kex muv, c) zop mip naf pob mev zux fep.

2. The Lists of Disconnected Words

In the selection and formation of the series of disconnected words almost the same consideration and care were taken as in the case of nonsense syllables. Furthermore the possibility of any meaningful association, such as "dog" "run", was eliminated as much as possible.

The lists of six words were: a) wax fog tip den mat sum, b) rug pit hen wag jet kid, c) rim dot cap hum net rob. The lists of eight words were: a) hat fun zip dog bed sun kit nod, b) peg cup sin fad log bus den box, c) pin leg eat dub top net gas fen.

3. The Lists of Digits

In the arrangement of digits the recurrence of a same number in the same series was avoided. In the ten digits series, where it was necessary to repeat some digit, at least three or more other digits were interpolated. Also no ordinary ascending or descending consecutive numbers and no progressive ascending or descending numbers were allowed in the lists. The number zero was not used.

The lists of eight digits were: a) 3 8 6 2 9 1 5 7, b) 7 4 9 2 8 1 5 3, c) 8 1 7 9 3 5 2 6. The lists of ten digits were: a) 2 7 3 1 4 6 9 5 8 3, b) 4 2 8 1 5 9 6 3 5 7, c) 9 4 2 7 3 5 9 6 1 8.

The Instructions to the Subject

The subject took a seat close to the table and the experimenter sat laterally to the subject so that the subject would not be disturbed by watching the recording procedure of the experimenter. During the experiment no other person besides the subject and experimenter was present in the room.

Prior to the experiment each subject was given the following instructions to read himself:

"This is an experiment in learning a few lists of digits, words, and nonsense syllables. It is not a psychological test. We are interested in certain factors in the learning process which are common to all people, rather than with your personal results as compared to others.

"You will be given a card containing a list of some words or numbers or nonsense syllables. When I say 'please,' read them aloud, slowly about

one word a second. After you have read them once, please return the card to me without re-reading. Then recite the list as best you can, just as you did when reading it.

"This will be a short experiment. Before it starts I will give you a few sample cards to show how it should be done."

After the subject read it over, he was asked if it was clearly understood, and if there was any ambiguous point it was explained by the experimenter. However the specific purpose or problem of this experiment was not explained to the subject.

The Preliminary Experiment

After the subject understood the instructions, to further familiarize him with the procedure, the experiment was given with practice cards. This experimental procedure was exactly like the main experiment except the practice cards contained much easier lists of nonsense syllables, disconnected words, and digits. The preliminary experiment was used for practice and as a means of correcting the speed of reading and recall.

The metronome was not used to regulate the rate of reading or recall.

The Main Experiment

The card which was picked in random order was handed to the subject with the printed side down. With the signal to read, "Please", the subject turned the card face up and read a series about one digit or word per second. After the subject had read the card once, it was returned immediately with the printed side down to the experimenter. The subject then recited them in the original order as best he could. Each response recited by the subject

was recorded on a prepared record sheet by the experimenter. The same procedure was repeated for each list. Care was taken not to inform or notify the subject of his result either during or after the experiment.

The time interval between each test was about five seconds.

After the subject had finished about ten cards he was given a short rest in order to avoid fatigue and loss of interest.

After finishing the experiment the subject was asked the following questions:

1. "Did you try to rehearse the first part or any part of the series either when you were reading or before you recited?"
2. "Did you try to memorize any particular part, e.g. the first, more than any other part? In other words, did you pay more attention to any particular part of a series?"
3. "Did you use any special device to memorize the memory materials more effectively?"
4. "In memorizing the series of disconnected words did you try to associate words to make some meaning or sense? Did you succeed?"
5. "Did you try the same method with the series of nonsense syllables? Did you succeed?"

The subject's every answer was recorded on the same recording sheet.

CHAPTER III
QUANTITATIVE RESULTS AND DISCUSSION

Each subject's result was carefully examined and the errors were recorded and classified under four different categories. They were: a) incorrect response, b) misplacement, c) "alien" response, d) repetition or reappearance of same response.

Tables IX, X and XI show frequency and percentage of incorrect responses which occurred in the three different learning materials.

TABLE IX
FREQUENCY AND PERCENTAGE OF INCORRECT RESPONSE
NONSENSE SYLLABLE

SERIAL ORDER		1	2	3	4	5	6	7
5 SYL.	FREQ.	8	29	65	106	79		
LISTS	%	5.3	19.3	43.3	70.6	52.7		
7 SYL.	FREQ.	10	29	83	125	134	129	109
LISTS	%	6.7	19.3	55.3	83.3	89.3	86	72.7

TABLE X
FREQUENCY AND PERCENTAGE OF INCORRECT RESPONSE
DISCONNECTED WORD

SERIAL ORDER		1	2	3	4	5	6	7	8
6 WORD	FREQ.	0	14	24	84	93	67		
LISTS	%	0	9.3	16	56	62	44.7		
8 WORD	FREQ.	5	10	20	67	110	125	107	83
LISTS	%	3.3	6.7	18.3	44.7	73.3	83.3	71.3	55.3

TABLE XI
 FREQUENCY AND PERCENTAGE OF INCORRECT RESPONSE
 DIGITS

SERIAL ORDER		1	2	3	4	5	6	7	8	9	10
8 DIGIT LISTS	FREQ.	0	0	3	10	25	34	40	16		
	%	0	0	2	6.7	16.7	22.7	26.7	10.7		
10 DIGIT LISTS	FREQ.	6	8	9	15	49	71	77	91	77	32
	%	4	5.3	6	10	32.7	47.3	51.3	60.7	51.3	21.3

In nonsense syllable lists the fewest errors were recorded at the beginning of the lists. The most errors were at the fourth serial position in the shorter lists which was the second from the last serial position, and at the fifth serial position in the longer lists which was third from the last serial position. If the serial positions were arranged in the rank order from the smallest to the largest number of errors: 1) the first serial position, 2) the second serial position, 3) the third serial position, 4) the fifth serial position, 5) the fourth serial position would be in that order in the shorter lists, and 1) the first serial position, 2) the second serial position, 3) the third serial position, 4) the seventh serial position 5) the fourth serial position, 6) the sixth serial position, 7) the fifth serial position in the longer lists. Both frequency curves were skewed curves showing a low frequency at the beginning and a relatively high frequency at the end. (Figure I)

In disconnected word lists again the fewest errors were at the beginning but the sharp increase of errors was recorded at the fourth serial position in both the long and short lists. The most errors were recorded

at the fifth serial position, the second from the last serial position in the short lists and at the sixth, the third from the last serial position in the long lists. The rank order from the smallest to the largest number of errors was: 1) the first serial position, 2) the second serial position, 3) the third serial position, 4) the sixth serial position, 5) the fourth serial position, 6) the fifth serial position in the short lists, and 1) the first serial position, 2) the second serial position, 3) the third serial position, 4) the fourth serial position, 5) the eighth serial position, 6) the seventh serial position, 7) the fifth serial position, 8) the sixth serial position in the long lists. Again both frequency curves show skewed curves. (Figure II)

In digits the smallest number of errors was also recorded at the beginning and the most errors were at the seventh position, the second from the last serial position in the short lists and at the eighth serial position in the long lists. A fairly sharp increase of errors was noted at the fifth serial position in both cases. The rank order from the fewest errors to the most was: 1) the first and second serial position with no error, 3) the third serial position, 4) the fourth serial position, 5) the eighth serial position, 6) the fifth serial position, 7) the sixth serial position, 8) the seventh and the ninth serial position with a same amount of errors and the last, 10) the eighth serial position in the long lists. Both curves were approaching a bell shape. (Figure III)

It was evident that the least amount of incorrect responses occurred in the first part of the series and the greatest amount of errors in the mid-section of the last half of the lists, regardless of the memory

materials. The last part of the series generally showed fewer errors than the middle part, but much more than the first part of the lists.

M. E. Brown's experimental results were significantly similar in many points with these present experimental results in spite of the difference in method.

Since she used the anticipation method, in which a first syllable served as a cue for recall of a second syllable, the second serial position in her result was regarded to be equivalent to the first serial position in the results of this present experiment, and her third as to the second and so on.

Thus when her results in nonsense syllable lists of six and nine syllables and the present results in nonsense syllables were compared, two sets of results differ in absolute number and percentage of incorrect responses which were caused by many factors such as the method of recalling, difficulty in the learning materials, subjects, etc. Yet they showed a complete agreement on the following points:

1. The fewest errors occurred in the first serial position.
2. The second place from the last of the list had the greatest amount of errors in Brown's lists of six syllables and six three-place numbers the same as in the present experiment's lists of five syllables and eight digits. The greatest amount of errors occurred at the third from the last of the list in Brown's lists of nine syllables and eight three-place numbers and also in the lists of seven syllables and ten digits in the present experiment.

3. The last serial position did not show a marked advantage over the first serial position.
4. The frequency curves of both Brown's and the present experiment were skewed curves which showed the high frequency of errors near the end of the series.

However the present results are contrary to the results of Smith, Welch and Burnett. Their results revealed that fewer errors were committed at the last serial position and the most errors were reported at the middle section of the list. The first serial position of the lists had more errors than the last serial position. Especially in the results of Welch and Burnett the advantage of the final serial position "preponderated overwhelmingly" over the first serial position. Hence the general trend in their results is inverse to that of Brown, Mitchell and the present findings.

Errors in the First Half and the Second Half of the Lists

In order to compare and examine the first half and the second half of the lists from the standpoint of errors the average percentage was figured for the lists of nonsense syllables, disconnected words, and numbers. In the case of odd items in the list the average was figured for an equal number of items on the first half and the second half, including the data on the middle item in the first half and the second half, thus trying to maintain the general effect of continuity and also make the halves balance.

These figures are shown in Table XII.

TABLE XII
COMPARISON OF HALVES OF LISTS
AS TO PERCENTAGES OF ERRORS

	SYLLABLES		WORDS		DIGITS	
LENGTH OF LISTS	FIVE	SEVEN	SIX	EIGHT	EIGHT	TEN
FIRST HALF	22.6	41.2	8.4	17	2.2	11.6
SECOND HALF	55.5	82.8	54.2	70.8	19.2	46.4

From this table it is evident that the first half of the list had consistently a smaller number of errors than the last half regardless of difference in length and memory material. In the lists of nonsense syllables the first half had about fifty per cent fewer errors than the second half of the lists, but in the lists of disconnected words and numbers the ratio became noticeably greater.

These figures are much greater than those of Bigham's. From Bigham's (Table I) the average amount of forgetting in the first half and the second half of the ten syllable lists was figured for comparison. They were 15.4 per cent for the first half and 14.7 per cent for the second half, indicating more forgetting in the first half than in the second half. However the difference between the first and second half was very small.

From Smith's result the average amount of errors for the first half and the second half was also figured as 62.0 per cent and 45.6 per cent respectively. The percentage in his finding was much greater than in Bigham's but the tendency in Smith's findings agrees with Bigham's conclusion that more errors were committed in the first half of the series.

Welch and Burnett found the same tendency prevailed in their results. Their average amount of errors for the first half was 84.6 per cent and 71.5 per cent for the last half of the lists.

However the findings of Brown, Mitchell, and the results reported by Woodworth and Poffenberger indicated that more errors occurred in the second half than in the first half of the lists, which was found to be true also in this present experiment.

Table XIII shows the average amount of errors in the first and second halves of the lists in Brown's experiment.

TABLE XIII¹COMPARISON OF ERRORS IN HALVES OF LISTS - BROWN
FIRST REPETITION

LENGTH OF LISTS	NONSENSE SYLLABLE		NUMBER		
	6 SYL.	9 SYL.	4 NO.	6 NO.	8 NO.
1st HALF	30.0	63.4	10.2	26.7	42.5
2nd HALF	63.3	82.7	48.9	90.9	93.9

The difference between the average percentage of errors for the first half and the second half in the experiment quoted by Woodworth and Poffenberger was not as great as this experiment's result or Brown's, nevertheless it indicated the general tendency for more errors to be committed in the last half of the series. 15.6 per cent for the first half and 16.4 per cent for the second half of the lists were obtained from their data.

1. Brown, op. cit., p. 30.

Misplacement Error

A syllable or number correctly recalled but in a wrong position was classified as a misplacement error and was recorded as a misplacement error of the original position. For example an original syllable, "rix", in the first position of a series was recalled correctly as such but in the fifth position of the series; then it was recorded as a misplacement error of the first position syllable.

The frequency and percentage of misplacement errors in nonsense syllable, disconnected word, and digit lists are shown in Tables XIV, XV, and XVI respectively.

TABLE XIV
FREQUENCY AND PERCENTAGE OF MISPLACEMENT ERRORS
NONSENSE SYLLABLE

SERIAL ORDER		1	2	3	4	5	6	7
5 SYL.	FREQ.	0	1	2	2	3		
LISTS	%	0	.7	1.3	1.3	3		
7 SYL.	FREQ.	0	1	3	1	2	6	3
LISTS	%	0	.7	2	.7	1.3	4	2

In five-syllable lists the last serial position had the most misplacement errors and no misplacement error was recorded at the first serial position. The errors increased gradually from no errors at the first serial position to the most errors at the last serial position. However, in seven-syllable lists the most errors were recorded at the sixth serial position, the second from the last serial position. The last position had a fairly large amount of misplacement errors which were also recorded at the third

serial position. The first serial position did not show any misplacement errors. Thus no gradual increase of errors was found in this case. An average for the misplacement errors was 1.3 per cent for five-syllable lists and it was 1.5 per cent for seven-syllable lists. These were much smaller than Bigham's (4.3%) or Smith's results, (3.5%) probably because the shorter lists were used in this experiment.

The misplacement errors shown in Bigham's Table I indicate a gradual increase from the first serial position to the highest point at its fifth serial position or the mid-point of the series and a gradual decrease from the fifth to the last serial position showing no difference in the first and the last serial position. Of course his figure was obtained by combining the results from the three different learning materials; therefore the results from nonsense syllables in this experiment cannot be compared on the same basis. However no such a beautiful increase and decrease from the first serial position to the mid-point of the list to the last serial position was found in this present experiment.

TABLE XV

FREQUENCY AND PERCENTAGE OF MISPLACEMENT ERRORS
DISCONNECTED WORDS

SERIAL ORDER		1	2	3	4	5	6	7	8
6 WORD LISTS	FREQ.	0	3	8	8	8	7		
	%	0	2	5.3	5.3	5.3	4.7		
8 WORD LISTS	FREQ.	0	0	2	6	14	13	20	14
	%	0	0	1.3	4	9.3	8.7	13.3	9.3

In the disconnected word lists the first serial position did not show

any misplacement error, but the last serial position had a high frequency. The third, fourth and fifth serial positions had the highest frequency in the short list but in the long list the seventh position showed the highest frequency. The last serial position and the fifth serial position had the same amount of errors which was second highest. More errors were committed in the last half of the serial order.

The average percentage for the six-word lists was 3.8 per cent and 5.7 per cent for the eight-word lists. The average misplacement error for the eight-word lists was the same as Bigham's ten-word lists in three different intervals (two, ten, and thirty seconds).

In eight-digit lists no misplacement error was committed at the first two serial position. It increased to reach the highest point at the sixth serial position and then it decreased. The last serial position did not show high frequency. The first three and the last serial positions showed a marked advantage over the rest.

In ten-digit lists again the first serial position was free from misplacement errors and the first three serial positions showed noticeably low frequency of errors but, unlike the eight-digit lists, the last serial position showed a fairly high frequency. The highest point was reached at the eighth serial position. It was also indicated that a higher rate of error was in the last half of the list.

An average misplacement error for eight-digit lists was 4.6 per cent and 11.4 per cent for the ten-digit lists. The average misplacement error for ten-digit lists was a little higher than Bigham's ten-digit lists (7%).

TABLE XVI
 FREQUENCY AND PERCENTAGE OF MISPLACEMENT ERRORS
 DIGIT

SERIAL ORDER		1	2	3	4	5	6	7	8	9	10
8 DIGIT LISTS	FREQ.	0	0	1	4	13	18	14	2		
	%	0	0	.7	4.7	8.7	12	9.3	1.3		
10 DIGIT LISTS	FREQ.	0	3	3	10	15	29	32	40	24	15
	%	0	2	2	6.7	10	19.3	21.3	26.7	16	10

Regardless of the learning materials, the present results indicated a general tendency for misplacement errors to occur more in the last half of the series. No misplacement errors occurred in the first serial position. In general, the first two or three positions showed a definite advantage over the middle or the last part of the series. This tendency was not sufficiently definite to make a general conclusion, but it seemed that the misplacement errors occurred most frequently between the middle and the last serial positions.

Bigham's result indicated a fair uniformity in the increase and decrease of the amount of misplacement errors from the first serial position to the last of the list, reaching its high point at the middle. But it did not show any positional advantage of the first over the last. (Table I)

When the percentage of misplacement errors in the first half (first to fifth serial positions inclusive) and the last half (sixth to tenth positions inclusive) were figured from Bigham's reported data in Table I, the last half showed a fair advantage over the first half, i.e., a total percentage of 49.9 for the first half and 43.0 for the last half. The

present experiment's result showed consistently an advantage of the first half over the last half. When the total percentage for the first five positions and the last five positions were figured from the ten-digit lists, they were 20.7 per cent for the first half and 93.3 per cent for the last half respectively. This difference was great. A probable reason for this difference can be that in this present experiment the subjects' introspective reports revealed that the majority of the subjects attempted to group the first four or five syllables or numbers in order to remember them as a unit. Therefore a distinct advantage of the first half might be maintained. Another possible reason was that in Bigham's experiment the subjects were not required to write the lists in the order in which they were given. They were free to write the last syllables before the first ones thus the time factor could be accounted as an advantage for the last half.

The "Alien" Presentation

In the event that a word or syllable which was not in the stimulus list was reported in the recalling, such an error was recorded as "alien" presentation in this experiment.

Since all nine numbers were used in a list this particular kind of error was not recorded. The frequency and percentage of this type of error in nonsense syllable lists and disconnected word lists are shown in Tables XVII and XVIII.

TABLE XVII
 FREQUENCY AND PERCENTAGE OF "ALIEN" PRESENTATION
 NONSENSE SYLLABLE

SERIAL ORDER		1	2	3	4	5	6	7
5 SYL.	FREQ.	7	21	50	52	40		
LISTS	%	4.7	14	33	34.7	26.7		
7 SYL.	FREQ.	4	18	62	42	39	27	24
LISTS	%	2.7	12	41.3	28	26	18	16

TABLE XVIII
 FREQUENCY AND PERCENTAGE OF "ALIEN" PRESENTATION
 DISCONNECTED WORD

SERIAL ORDER		1	2	3	4	5	6	7	8
6 WORD	FREQ.	0	7	15	28	22	17		
LISTS	%	0	4.7	10	18.7	14.6	11.3		
8 WORD	FREQ.	4	2	6	24	20	9	8	9
LISTS	%	2.7	1.3	4	16	13.3	6	5.3	4.7

The results in this experiment show that most "alien" errors occurred in the middle part of the list and the least amount of errors in the first part of the list. The last serial position had a considerably larger number of errors.

This general tendency was evident in lists both of nonsense syllables and disconnected words. In the short lists a much higher rate of error was committed in the last serial position than in the long lists. In the long lists such a rate of increase and decrease from the beginning to the middle and from the middle to the last position was not as great as in the case of the short lists.

The average percentage of incorrect responses in nonsense syllable lists was greater than in disconnected word lists. For the former 22.6 per cent was recorded for the five-syllable lists and 20.4 per cent for the seven-syllable lists. For the latter 9.9 per cent was recorded for the six-word lists and 6.7 per cent for the eight-word lists.

Bigham's finding also showed a higher rate of errors for the nonsense syllable list than for the disconnected word list. But contrary to the present findings, "alien" responses were most frequently given at the beginning of the list and the fewest at the end.

Reappearance of the Stimulus Word

It was probably due to the fact the the reproduction of the stimulus word was made orally that some of them were recalled by the subject more than once in a single recall. For example "run" was correctly recalled in the second serial position, yet it was again recalled at the seventh serial position of the same list for the original word "pin". Such an error was recorded in this experiment as a reappearance or repetition error.

In the nonsense syllable lists the occurrences of the repetition error were very few; in the lists of five syllables it happened only once which was a syllable in the second serial position. In the lists of seven syllables it happened six times. The syllable in the first serial position reappeared twice as many times as the syllable in the seventh serial position. The syllables in the second and the third serial positions were repeated once each. The error occurred mostly around the middle of the serial order.

In disconnected word lists it happened more frequently than in nonsense syllable lists. In the lists of six words the stimulus word in the second serial position reappeared twelve times, the word in the first position reappeared three times, and the word in the sixth position was repeated once.

In the eight-word lists the word in the second serial position reappeared most, as in the case of the six word lists. It was recorded twenty-three times. The word in the third serial position reappeared less than the word in the second serial position (five times). The word in the first serial position was repeated three times, and once each for the words in the fourth, fifth and eighth positions.

They occurred mostly in the last half of the series with their most frequent appearance in the second or third from the last position of the lists.

In the lists of numbers, this kind of error was committed mostly in the middle part of the last half of the list. In the lists of eight digits the item in the first serial position reappeared eleven times and the digit in the second serial position was repeated nine times. The digits in the third and the fourth serial positions reappeared four times each and once for the digit in the fifth and eighth serial position.

In the lists of ten digits the most frequently repeated was the number in the second serial position in the series with twenty-seven times, the next most repeated was the digit in the third serial position with fifteen times. The first serial position had eight repetitions and the fourth eleven. The fifth serial position was repeated six times. The

sixth and the ninth positions had three each. The eighth and the tenth had four repetitions each; the seventh serial position had five repetition errors.

Regardless of the type of memory materials the first and the second serial positions had the highest rate of reappearance and as the lists became longer the third position and the fourth serial position increased their rates of repetition. When the lists were shorter the amount of errors increased at the first position.

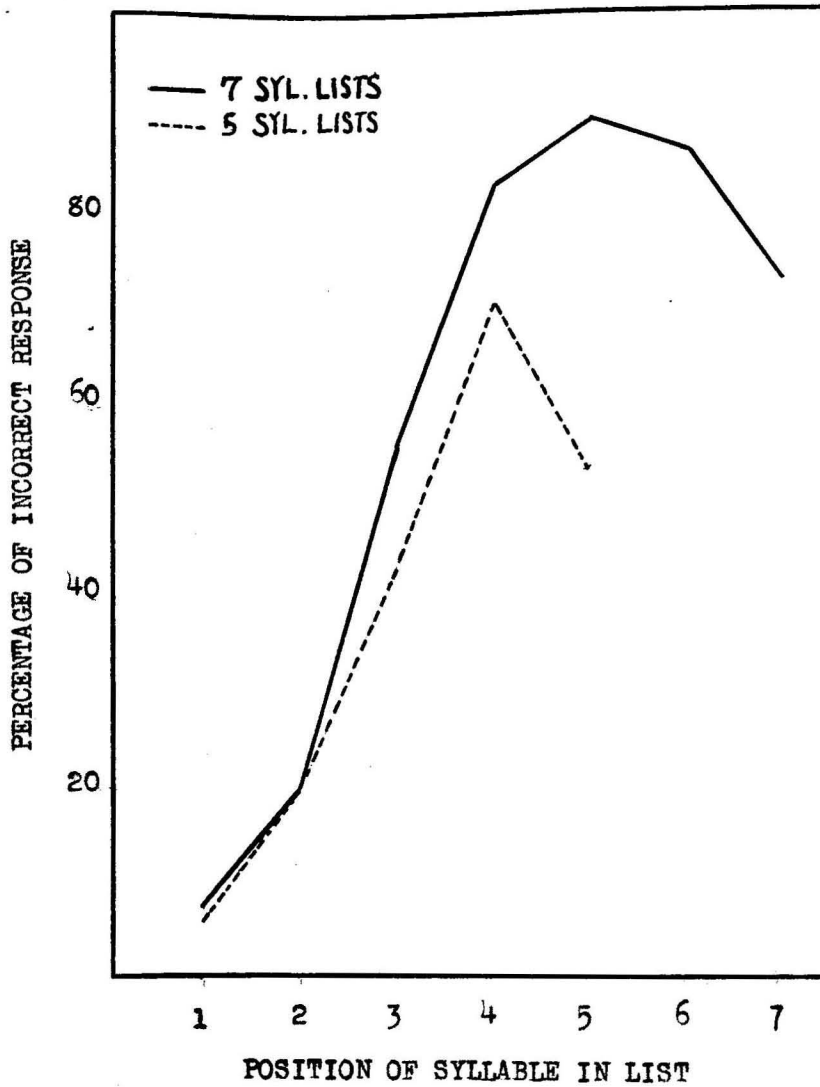


FIGURE I. SERIAL POSITION CURVES FOR NONSENSE SYLLABLE LISTS OBTAINED BY METHOD OF CONTROLLED RECALL

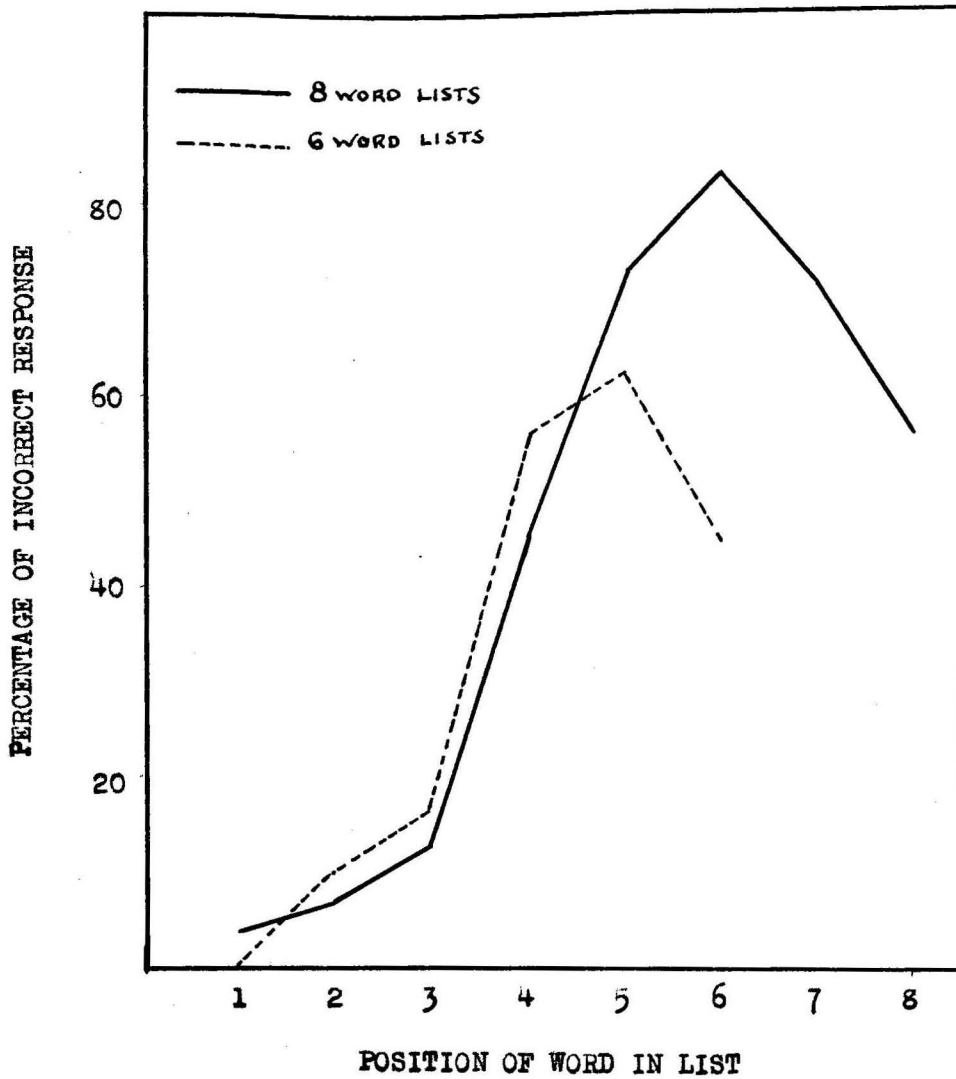


FIGURE II. SERIAL POSITION CURVES FOR DISCONNECTED WORD LISTS
OBTAINED BY METHOD OF CONTROLLED RECALL

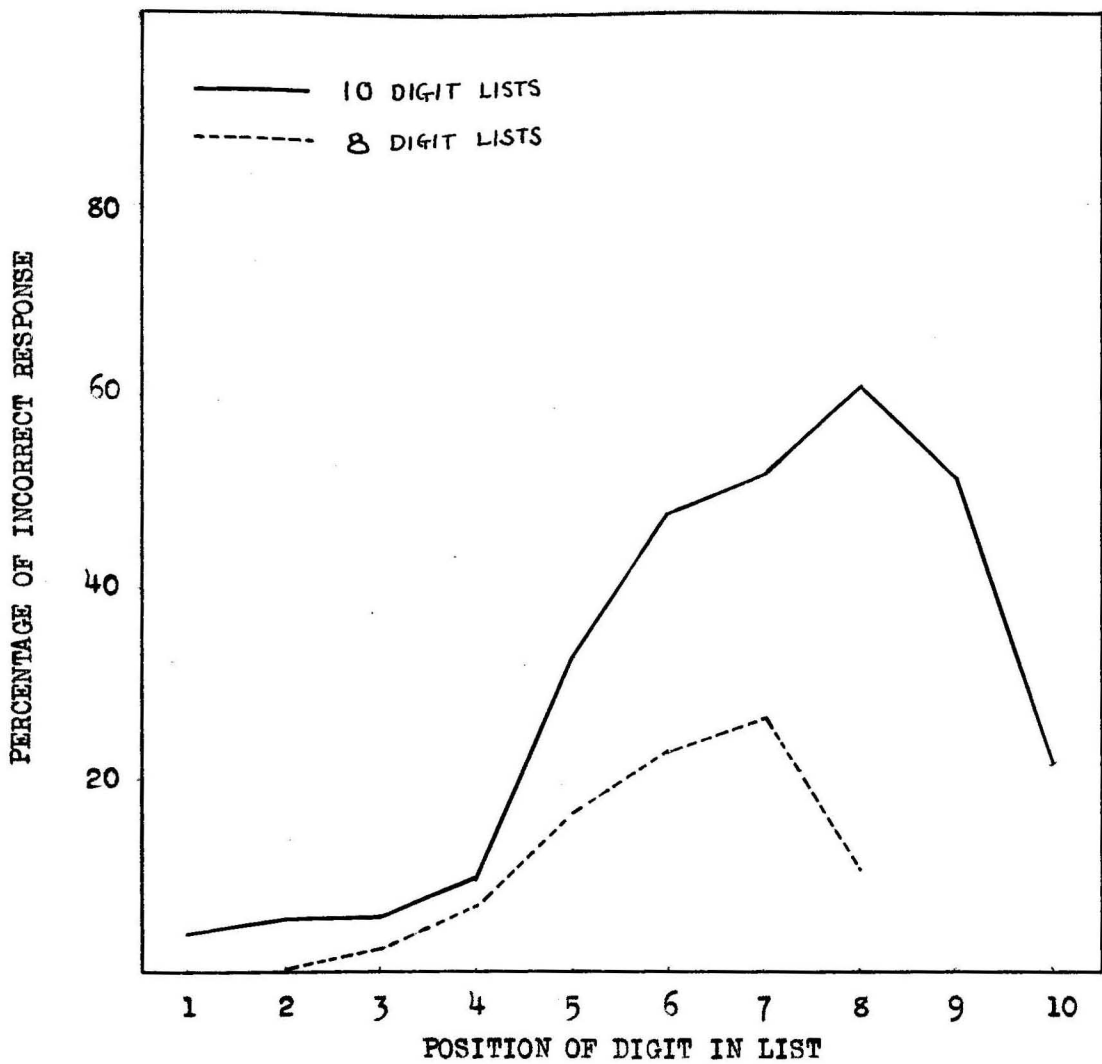


FIGURE III. SERIAL POSITION CURVES FOR DIGIT LISTS OBTAINED BY METHOD OF CONTROLLED RECALL

CHAPTER IV
QUALITATIVE RESULTS AND DISCUSSION

Welch and Burnett claimed that the primacy effect was caused merely by a factor of frequency or was a function of rehearsal. The primacy effect resulted only when the subjects were allowed to repeat the earlier items of a list while the later items were presented.

This explanation was rejected by Brown and Robinson, on the basis that rehearsal was hardly possible when the syllables were presented at a fairly rapid rate and the subjects were required to read each item aloud at each presentation. McGeoch¹ also maintains that a chance of rehearsal is doubtful under such conditions. But Brown and Robinson did not verify this by taking any introspective reports to discover whether or not their subjects actually rehearsed any part of the lists.

The introspective accounts of the subjects in this experiment revealed that some subjects rehearsed not only the first few items but the middle or the last part of the lists. Eleven subjects rehearsed or attempted to rehearse a certain part of the lists while they were reading aloud the items in the later serial positions or before they recited them. Seven subjects rehearsed the beginning part of the lists, but only one rehearsed the last part of the lists. The other three subjects rehearsed "the last and the middle parts" or "the first and middle parts" or "the first and last parts"

1. J. A. McGeoch, *The Psychology of Human Learning*, Longmans, Green and Co., New York, 1946, p. 107.

of the lists.

Therefore, the factor of rehearsal was brought forth under the conditions provided by this experiment which were somewhat similar to Brown's. There seems to be no doubt that the factor of rehearsal facilitated the primacy effect in this experimental data. Raffel² demonstrated the primacy effect which was caused by rehearsal of the first item or items.

However it is doubtful whether this factor alone can be looked on as the major determiner of the primacy effect. On the basis of the experimental data obtained it is hardly justified to assume the factor of rehearsal of the first part of the lists in the few cases as the only dominant factor for overwhelming superiority of primacy in this experiment. It may explain the cases of the subjects who rehearsed the first part of the lists, but such an explanation does not substantiate the primacy effect for a majority of the subjects in this experiment, who did not rehearse at all.

Brown seemed to regard the primacy effect as a function of the controlled recall. When a list of items is recalled in an original order the first item acts as a cue for the recall of the second, the second helps to recall the third, and so on. In this way the first item is emphasized by the fact that it is to be recalled first. Also it may be recalled before it has been crowded out of memory by the other items of the lists. "Where the order of recall is fixed," states Brown³, "and the items at the first of the list are recalled first, primacy is a more significant factor

2. C. Raffel, "Two Determinants of the Effect of Primacy," The American Journal of Psychology, Vol. 48, 1936, p. 657.

3. Brown, op. cit., p. 27.

than finality." Similarly, Raffel suggests that with the controlled recall in which the instruction is given to recall a list in an original order the subject is set to memorize the beginning and thus an advantage for primacy is shown.

A further analysis of the subjects' introspective data seemed to substantiate the explanation presented by Brown and Raffel.

Concerning the direction of effort or attention approximately a half of the subjects (24) exerted their attention evenly to each item in the lists. But eleven subjects concentrated more on the first part of the lists, and seven more subjects reported that they exerted slightly more attention to the first part of the lists despite the fact that they attempted to attend to each item as evenly as possible. Five subjects directed their attention to both the first and last parts of the lists. Hence a total of twenty-three subjects paid more attention to the first part.

Such favorable set toward the beginning part of the lists, which was taken by nearly a half of the subjects, seemed to be the major factor of the primacy effect rather than rehearsal. As McGeoch points out, the relation between the amount of error and the serial positions in the lists is a function of the direction of the subjects' efforts or attention.

Concerning the device for better memory twenty-seven subjects adopted some kind of grouping system. Particularly in learning the lists of digits a majority of the subjects attempted to divide a list into two parts. Twenty subjects reported no such device but depended on rote memory with auditory or visual images as a cue.

Only three subjects attempted to use a unique system such as adding up two successive digits or making up a story with disconnected words. But the effect of such systems was reported to be more distracting and confusing than helpful at the first recall.

With lists of nonsense syllables only six subjects attempted to make a meaningful connection or association and only one subject considered that such a device was effective. A few complained of the difficulty of pronouncing nonsense syllables as a disturbing factor in memorizing the lists.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in order to investigate four different types of errors committed in learning the lists of nonsense syllables, disconnected words and digits. These errors were analyzed and compared at each serial position for each different learning material.

Eighteen white cards of size 3" by 5", containing the lists of nonsense syllables, disconnected words and digits were presented once to fifty adult subjects individually. The recall of the items was required to be made in the original order. All errors were recorded on the prepared sheets.

The general conclusions were as follow:

1. Regardless of the variety of learning materials, the incorrect responses were lowest at the first serial position. For the long lists the effect of primacy was usually extended over the first few serial positions. This conclusion was in agreement with the works of Brown, Bigham, and Mitchell.
2. Fewer incorrect responses, misplacement errors, and "alien" responses were found in the first half than in the last half of the lists.
3. The finality effect was evident but it was much more limited in scope.
4. The misplacement errors were much more common for digits and less

for disconnected words and least for nonsense syllables. A similar conclusion was reached by Brown.

5. No misplacement error occurred at the first serial position. The errors were committed most frequently toward the end of the lists. The last serial position showed high frequency of these errors. Unlike the incorrect responses no uninterrupted increase and decrease of errors was evident.

6. The "alien" responses were more common for nonsense syllables than disconnected words. This confirmed Bigham's conclusion, but the intrusion of "alien" responses was most frequent at the middle portion of the lists in this experiment, which was contrary to his finding.

7. The repetition errors were committed most frequently in the lists of digits, and least in the lists of nonsense syllables. The items in the first and second serial positions were repeated most.

8. On the basis of the introspective data obtained it was concluded that the direction of the subject's attention was significantly related to the primacy effect rather than the factor of rehearsal.

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for

THE NATURE OF ERRORS IN SERIAL LEARNING

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APPROVAL SHEET

The thesis submitted by Kiyoshi Matsukuma 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 necessary 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.

May 20, 1949
Date

Charles L. Dwyer, Jr.
Signature of Adviser