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Input and Output Speed Components of Learning-to-Learn

Jon G. Rogers

INPUT AND OUTPUT SPEED COMPONETS OF LEARNING-TO-LEARN ▪ ROGERS

INPUT AND OUTPUT SPEED COMPONENTS
OF LEARNING-TO-LEARN

BY

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A.B., Kansas State Teachers College, 1960
M.A., University of Arkansas, 1963

DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Philosophy in Psychology
in the Graduate School of
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Albuquerque, New Mexico
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This dissertation, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

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INPUT AND OUTPUT SPEED COMPONENTS
OF LEARNING-TO-LEARN

BY

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ABSTRACT OF DISSERTATION

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INPUT AND OUTPUT SPEED COMPONENTS

OF LEARNING-TO-LEARN

Jon G. Rogers, Ph.D.
Department of Psychology
The University of New Mexico, 1967

Input and output speed were investigated to determine if they were components of learning-to-learn. The major criterion used to distinguish learning-to-learn from warm-up has generally (e.g. Hamilton, 1950) been the temporal persistence of learning-to-learn phenomena.

Sixteen paired-associate practice lists consisting of high frequency words were presented for two trials to four acquisition groups in two sessions a day apart. Each acquisition group received input at either a fast (2 sec.) or slow (5 sec.) rate. Input speed (i.e., study interval) was the time the stimulus-response unit appeared. Subjects were required to respond to a light occurring at either a fast (.8 sec. after the onset of anticipation interval), or slow (3 sec. after onset of anticipation interval) rate. The third day each of the four acquisition groups was divided into fourths with one group being changed to the conditions received by each of the other groups and one group continuing under acquisition conditions.

Acquisition data were consistent in showing reliable learning-to-learn in each of the four groups. On the Day 3 transfer task, the data showed that changing input speed and/or output speed resulted in a reliable decrement in learning. The decrement occurred regardless of whether the Day 3 speed was faster or slower than the practiced speed.

These results supported the hypotheses that both speed parameters are components of learning-to-learn. The findings were discussed in terms of

their relationship to micromolar theory. It was contended that general habits with respect to input and output speeds were developed such that learning new material was best if the practiced habits were appropriate. Changing the speed parameter(s) effectively required the subject to learn quantitatively different speed response(s). It was suggested that changing the speed components disrupted learned pacing behavior. Data from an analysis of overt errors occurring in transfer were used to support this explanation.

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[illegible]

learning of material was best if the generalization were appropriate.

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quantitatively different event [illegible]. It was suggested that changing

the event [illegible] and pairing [illegible]. Data from an

analysis of event [illegible] to transfer were used to support this

expectation.

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INTRODUCTION

Recently, Postman and others in a series of experiments (Postman and Schwartz, 1964; Postman, 1964; Keppel and Postman, 1966) have endeavored to specify "what is learned?" in human learning-to-learn. In the first article in this series, Postman and Schwartz postulated without supporting data that learning-to-learn involves the acquisition of instrumental habits (e.g., acquiring effective techniques of mediation) related to learning a particular task. A distinction was then made between learning-to-learn and warm-up. Learning-to-learn involves relatively permanent processes whereas warm-up refers to more transitory effects presumably related to performance "set". Accordingly, improvement in learning successive paired-associate (PA) lists reflects learning-to-learn only insofar as this improvement persists over reasonably long intervals of time.

Postman and Schwartz considered both the development of an optimal rhythm for observing stimuli and the latency of giving overt responses as warm-up phenomena in PA learning. The rhythm of observing stimuli depends upon the speed of S and R presentation and certainly, the "optimal rhythm" is to assimilate items at the speed they are presented. The speed of giving overt responses depends upon the anticipation interval and, to some extent, instructions. An "optimal rhythm" in this sense means that the response (R) is given during the anticipation interval.

Although Postman and Schwartz treated these input and output rhythms as warm-up effects, they may equally well be considered component processes of learning-to-learn. By "component processes" is meant that as learning-to-learn occurs in the sense of making fewer errors on successive PA lists,

a part of what is learned is a rhythm of observing stimuli and a latency of giving overt responses. The temporal requirements of PA learning are quite unlike any the subject is likely to have encountered, and he must somehow learn to accommodate to them.

Furthermore, micromolar theory (Logan, 1956) would contend that quantitative variations in either of the speeds define different responses. Although assimilation speed has not previously been identified as a learnable component of a molar response, a logical extension of the theory would be that if the response of assimilating input were practiced at different speeds by two groups, then each group would learn to assimilate at a particular speed and would subsequently assimilate best at that same speed. The same prediction would hold for changing response latencies, although it should be noted that we are here dealing with a more general effect than heretofore considered. The contention in the learning-to-learn context is not that a particular list is assimilated and reproduced at learned speeds but that general habits with respect to input and output speeds may be developed such that learning new material is best if those habits are appropriate.

Speed of input (presentation rate) has been varied in a number of studies (Bugelski, 1963; Bugelski and Rickwood, 1964; Nodine, 1963, 1965; Newman, 1964; Baumeister and Hawkins, 1966; Postman and Goggins, 1966; Carroll and Burke, 1965; Johnson, 1964; Waugh, 1967) but no efforts were made to provide sustained and/or consistent practice at a specific input speed. Since these studies were not designed to study learning-to-learn, only a few lists were presented with a minimal number of items. The subject was not given sufficient practice to determine whether general habits with respect to assimilation or output rates were acquired.

Although several studies have reported latency (Nodine, 1963, 1965; Theios, 1965; Schlag-Rey et al., 1965; Suppes, et al., 1966) or response speed (Shiffrin and Logan, 1965) in PA learning, these studies were not addressed to the question of whether output speed is a component of learning-to-learn. To answer this question, a general response speed factor must be separated from response speed as related to specific items in a list.

The purpose of this experiment was to determine if speed of assimilating input and speed of producing responses are components of learning-to-learn. Groups of subjects learning with different input and output speeds were given a number of practice lists to insure acquisition of components on a two-trial PA task. At least 12 hours after being exposed to these lists, experimental groups were given three more lists with one or both of the rate parameters changed. It was predicted that if the rate parameters were components of learning-to-learn a decrement in performance would be manifested. If the rate parameters were warm-up phenomena, on the other hand, they should be lost within 60 minutes after the experiment (Hamilton, 1950), and consequently, no performance decrement should be obtained.

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learning-to-learn. In [illegible]

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The purpose of this study [illegible]

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to-learn. Groups of subjects [illegible]

speeds were given a number of [illegible]

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performance would be manifest [illegible]

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the experiment (Postman, 1964) [illegible]

should be observed.

METHOD

Subjects.--Ss were 160 undergraduates from an introductory psychology course, randomly assigned in order of appearance to one of 16 groups.

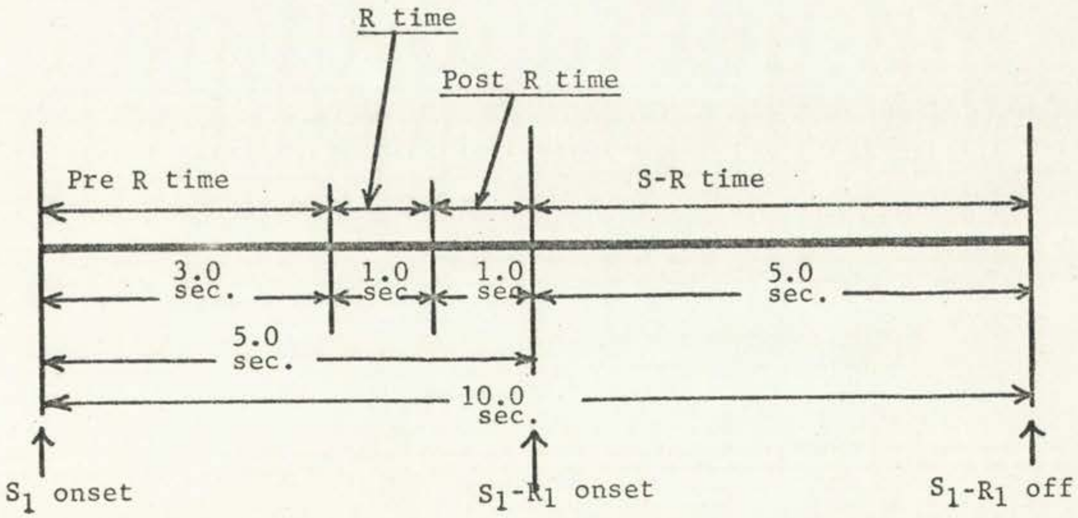
Design.--The design was a 2^4 x 3 factorial design with repeated measurements. The levels of the variables were as follows: acquisition input speed (fast and slow), acquisition output latency (fast and slow), transfer input speed (fast and slow), transfer output latency (fast and slow). Three transfer lists were used as the repeated measure with each S in the transfer conditions. The design also involved a layering procedure. One S from each cell was combined into a layer resulting in a total of 10 layers. Each layer received a different set of 22 lists.

Material.--A total of 440 high frequency words were selected from Thorndike-Lorge (1944) lists by a semi-random procedure. Proper nouns and contractions were excluded. A semi-random procedure was also used in combining the 440 words into 220 pairs. Obvious first order associations and words beginning with the same first letter were excluded. From these 220 pairs, 22 lists of 10 pairs were formed. Treating each pair as a unit within a list, the units were randomly rearranged for the second trial order. The 220 pairs were divided at random into lists nine more times such that there were 10 sets of 22 lists. Since the performance of Ss across days was to be examined to determine loss of warm-up and amount of learning-to-learn, an attempt was made to avoid any performance fluctuations attributable to the composition of a specific list. By having 10 sets of lists, idiosyncrasies of particular lists were averaged out. The 10 sets constituted the layers of the factorial design with one S from each

cell in each layer. Consequently, the first 16 Ss constituted the first layer and each S was randomly assigned to one of the cells. The Ss in this first layer received the first set of 22 lists according to the conditions of the cell to which they were assigned.

Apparatus.--The apparatus was a Stowe memory drum with the light connected to Hunter timers. The light in the memory drum served as the cue to respond, and was wired to come on .8 sec. after the onset of the anticipation interval for the fast group and 3 sec. after the onset of the anticipation interval for the slow group. The light remained on for 1 sec. for both groups.

After the 5 sec. anticipation interval which was the same for all groups, the input interval or the stimulus-response interval was either 2 sec. for the fast group or 5 sec. for the slow input group. For example, the time intervals for the slow output, slow input group were as follows:



Procedure.--Six groups of subjects learned according to the conditions of the design. The two additional groups were formed by dividing the two fast input groups into a short intertrial interval (ITI) and a long ITI group for each one. It is possible that differences between the fast input and the slow input groups might be attributable to the fact that the slow input groups have a longer total learning time (110 sec. per trial) than the fast input (80 sec. per trial) groups. To determine if total learning time produces an effect in this type of task, the fast input groups were initially split in half with half of each group receiving a 10 sec. ITI and the other half receiving a 40 sec. ITI. This effectively lengthened the total learning time for the fast groups to that of the slow input groups.

Each S was given two training sessions from 12 to 24 hours apart before the test task. Each training session consisted of 8 lists of 10 items each. Each list was presented for 2 trials. On the third day, after combining the 2 ITI subgroups within each of the fast input groups, each training group was divided into fourths and 3 more lists were presented for 2 trials each. One-fourth of each group continued under the acquisition conditions and one-fourth was switched to each of the other three conditions. A short ITI was used with all groups on Day 3.

Although it was predicted that changing speeds would initially result in a performance decrement, it is likely that S would gradually adapt to the new conditions. In order to determine the relative independence of acquisition habits, the changed groups were returned to their practice conditions after the 3 test-task lists and exposed to 3 more lists.

Instructions were given prior to each session. The instructions were quite specific to the task in that they informed the S how much time would lapse after the onset of the anticipation interval before he could respond on trial 2 and how the S-R interval would be. Day 3 instructions specifically informed S that the time interval(s) were different from the previous 2 days. (Instructions are given in Appendix II.)

Since the scoring involved experimenter's (E) judgment with regard to whether or not the R occurred within the light-on interval, all of the Day 3 sessions were recorded and the tapes were scored by an independent scorer. All interval changes were audible on the tapes.

RESULTS

Acquisition

Figure 1 shows Day 1 and Day 2 performance for the 4 acquisition groups. The average score on trial 2 of List 1 of Day 1 was 1.75 with the groups relatively homogeneous at this point. By List 8 of Day 1, the average performance was 4.47. At the end of Day 1 a relatively consistent separation can be seen between the 3 sec. and .8 sec. output groups, the former performing somewhat better than the latter. The average performance across groups at the beginning of Day 2, List 1 was 3.21 and increased to 5.49 by List 8. For the groups continuing under their acquisition conditions on Day 3, the average score for List 1 was 4.88 and on List 3 was 5.25.

To determine if there was a significant amount of learning-to-learn between Day 1, Day 2 and Day 3, t tests were used to compare the average performance on the first list of Day 1 with the average performance on the first list of Day 2. The average performance for the unchanged control Ss was compared on List 1, Day 2 and List 1 on Day 3. Both t tests were significant [$t(159) = 10.95$, $p < .01$; $t(39) = 7.18$, $p < .01$, respectively]. Since warm-up loss should be maximal between the last list of each day and the first list of the following day, average performance was compared between List 8 of Day 1 and List 1 of Day 2 [$t(159) = 11.14$, $p < .01$], and for the unchanged groups, between the last list of Day 2 and the first list of Day 3 [$t(39) = 3.70$, $p < .01$]. In each case the amount of learning-to-learn and the amount of warm-up loss was significant.

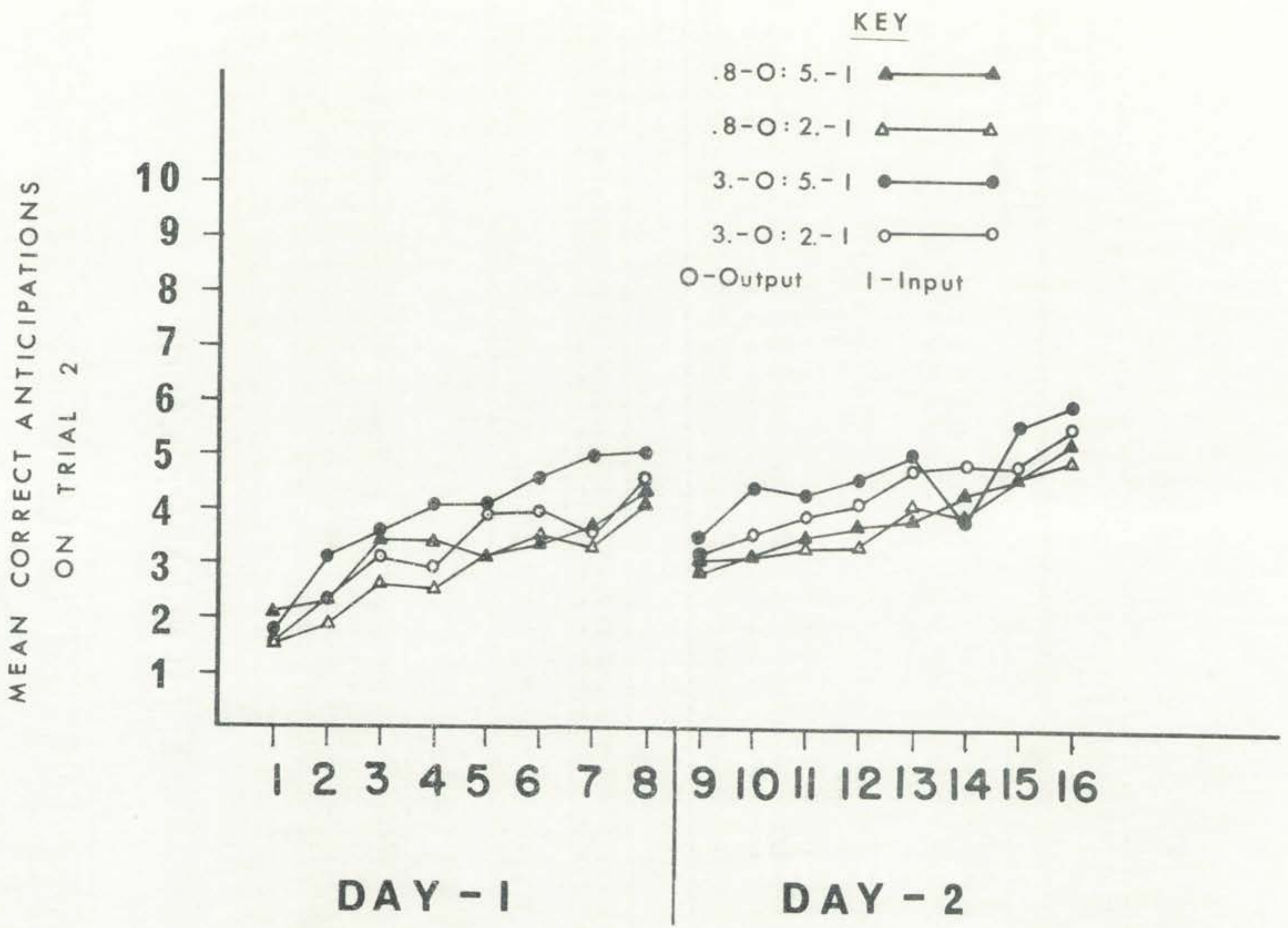


Fig. 1. Day 1 and Day 2 performance for the four acquisition groups.

Figure 2 separates the fast input groups according to ITI. It can be seen that the groups were quite similar in their performance, and consequently, no performance effects can be attributed to this temporal factor.

Transfer

Figures 3, 4, 5 and 6 show Day 3 transfer data for each of the training groups. It is evident that a performance decrement was obtained from changing input speed, output speed or both. There is an indication of some negative transfer in that all but 2 of the changed groups performed at a lower level on the first list of Day 3 than the average performance on Day 1, List 1. Points are also plotted on these figures showing average performance on List 15 and List 16 of Day 2.

The analysis of variance showed that the most powerful effect resulted from changing output speed, $F(1,144) = 165.75$, $p < .01$. The performance decrement obtained from changing input speeds was also quite reliable, $F(1,144) = 70.96$, $p < .01$. The slight negative transfer effect noted above was not persistent in that there was reliable improvement across the 3 transfer lists, $F(2,288) = 25.61$, $p < .01$. One four-way interaction (training input by transfer input by training output by transfer output) was significant, $F(1,144) = 70.15$, $p < .01$. This effect seemingly implies that the training input by transfer input interaction depended upon levels of the training output by transfer output interaction. This interaction could result from some groups not showing as great a decrement as others in transfer. It was not possible, however, to give a meaningful interpretation to this effect.

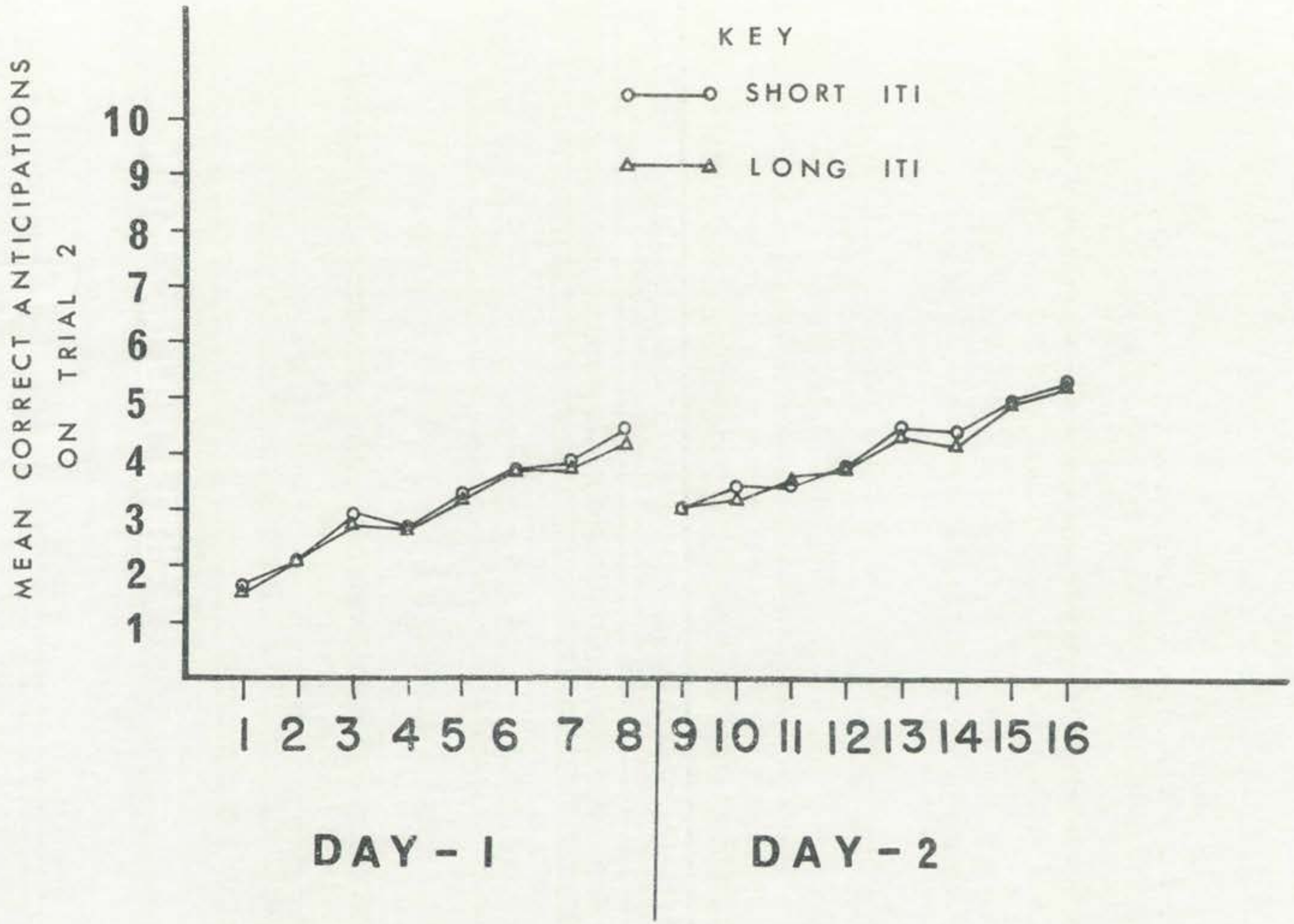


Fig. 2. Day 1 and Day 2 acquisition data for the short and long intertrial intervals.

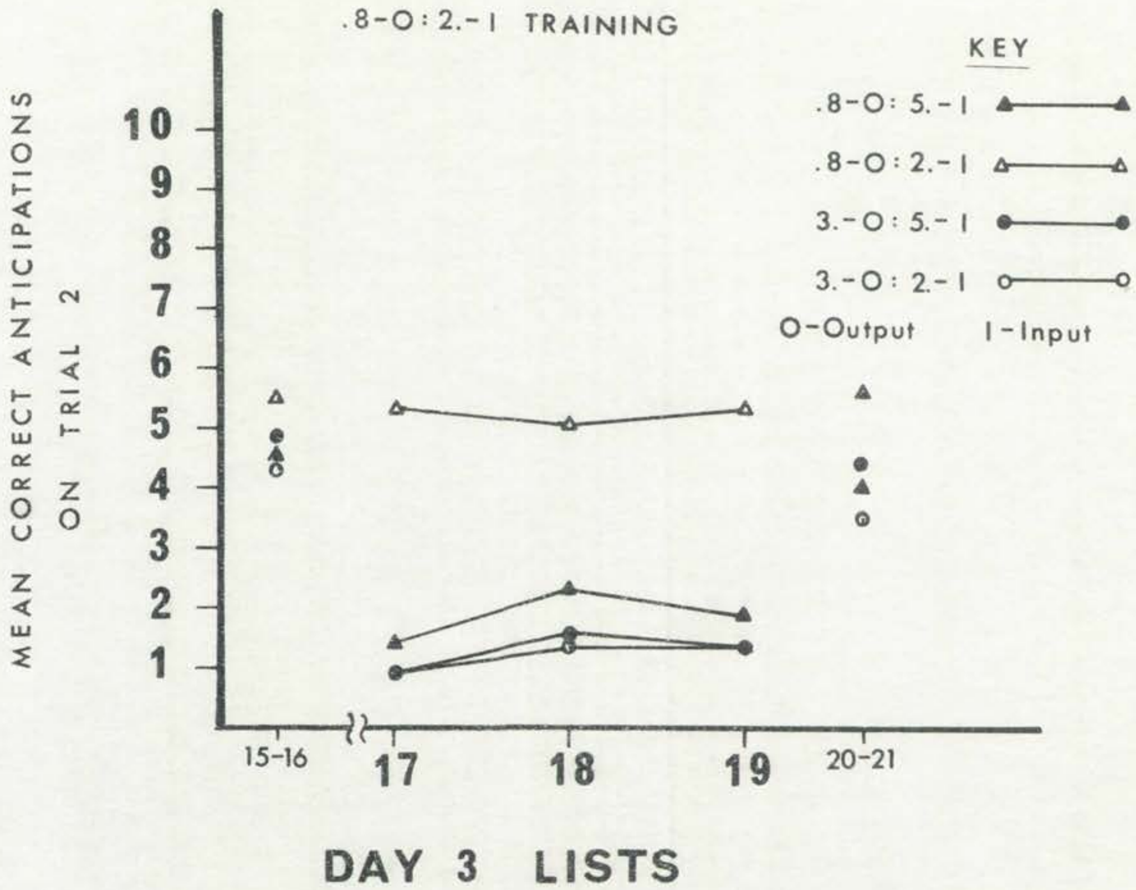


Fig. 3. Day 3 transfer data for the .8 sec. output-2 sec. input acquisition group. Points to left of transfer data represent average performance on last two lists of Day 2. Points to right represent average performance on two lists after being changed back to acquisition conditions.

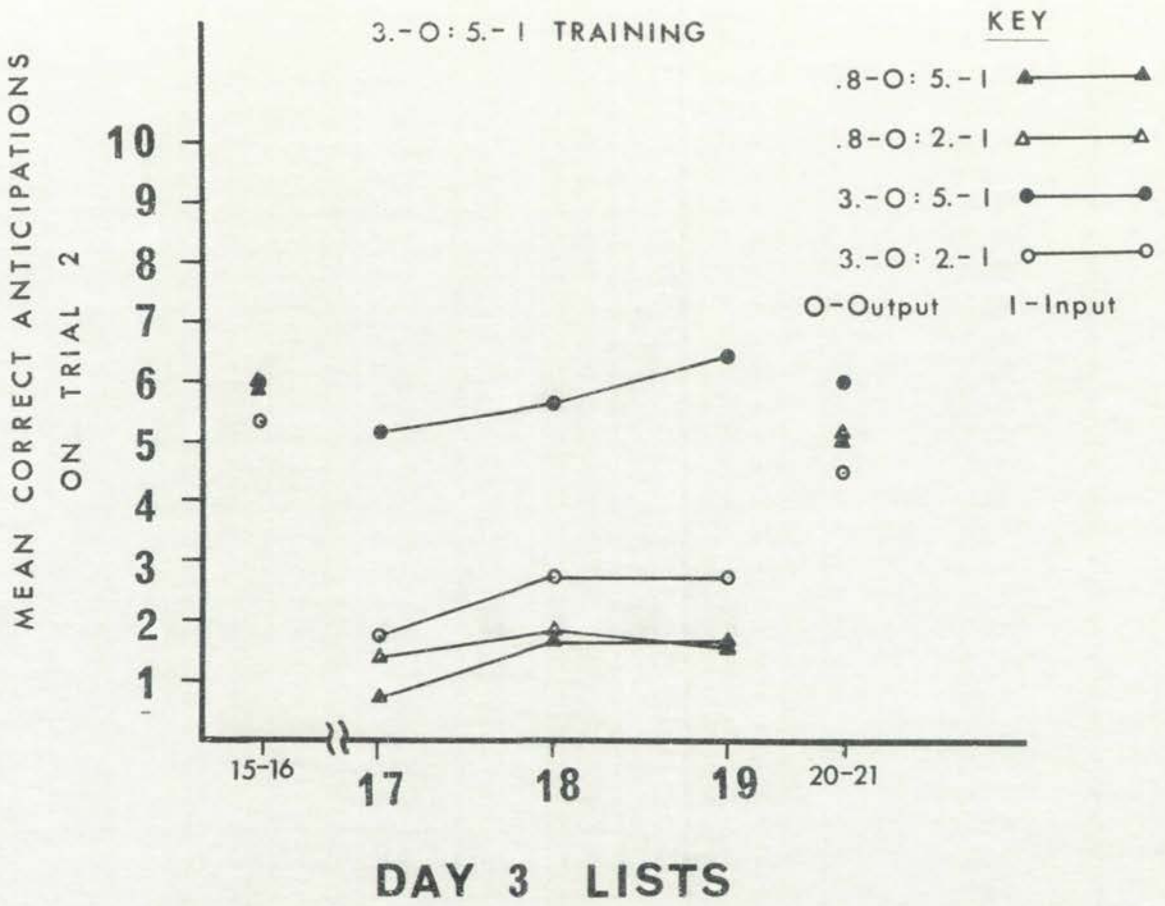


Fig. 4. Day 3 transfer data for the 3 sec. output-5 sec. input acquisition group. Points to left of transfer data represent average performance on last two lists of Day 2. Points to right represent average performance on two lists after being changed back to acquisition conditions.

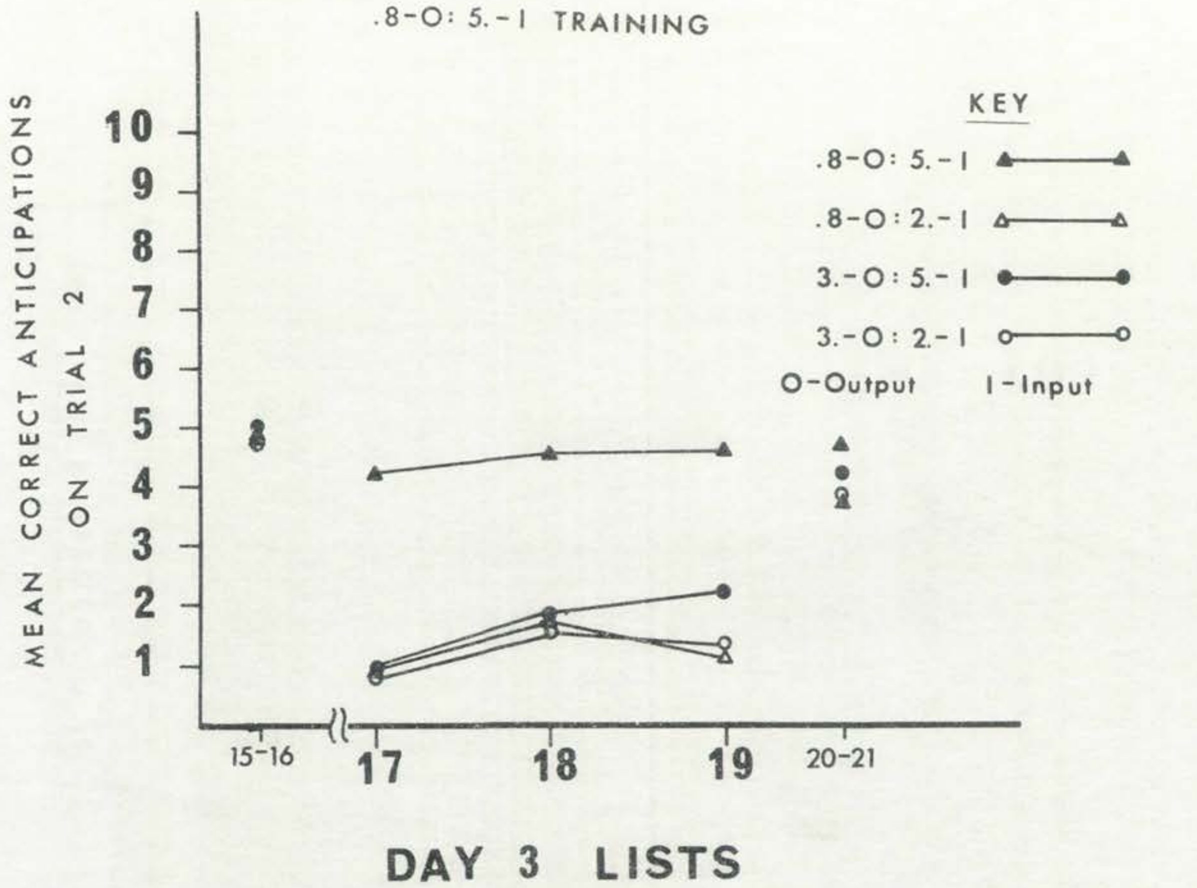


Fig. 5. Day 3 transfer data for the .8 sec. output-5 sec. input acquisition group. Points to left of transfer data represent average performance on last two lists of Day 2. Points to right represent average performance on two lists after being changed back to acquisition conditions.

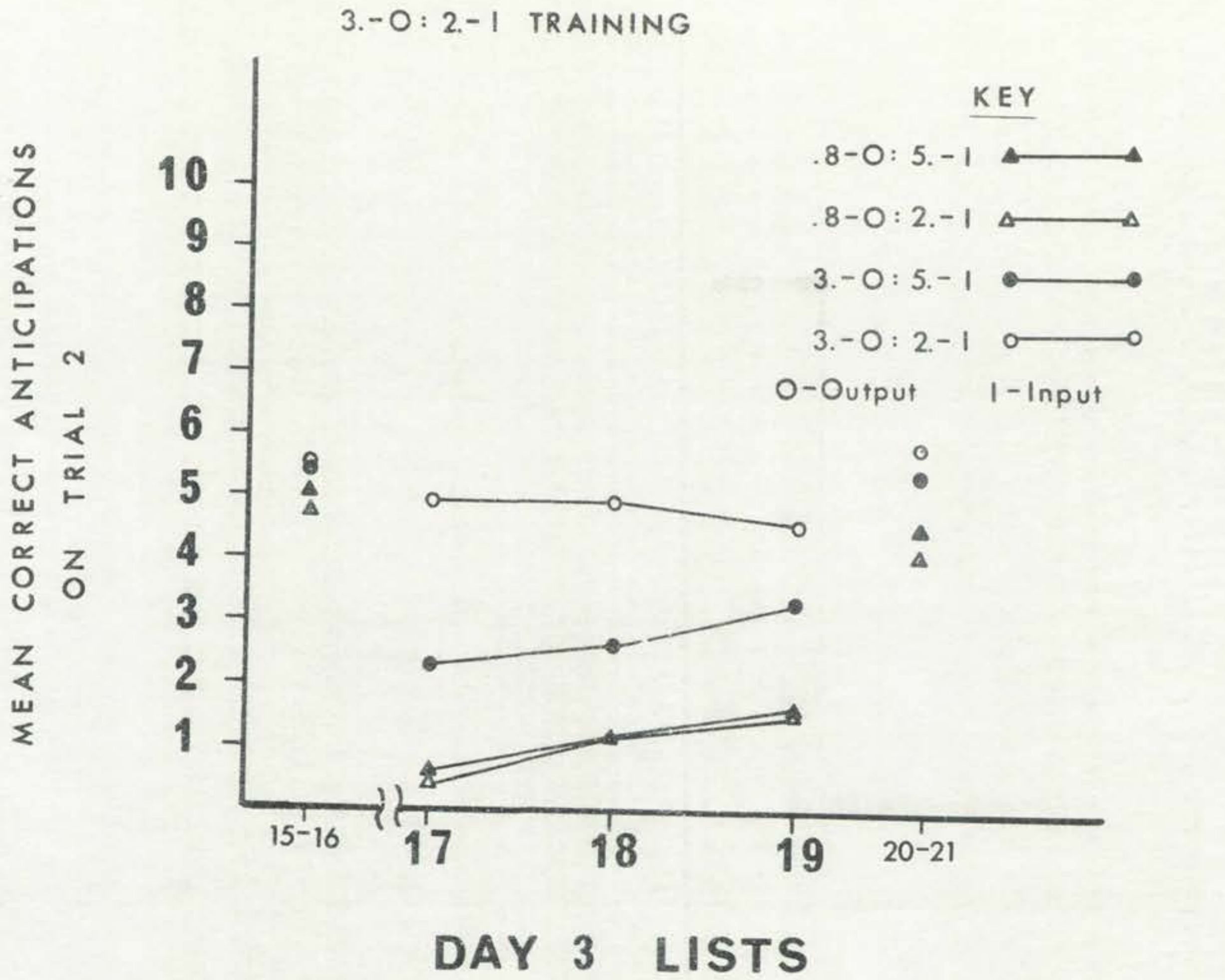


Fig. 6. Day 3 transfer data for the 3 sec. output-2 sec. input acquisition group. Points to left of transfer data represent average performance on last two lists of Day 2. Points to right represent average performance on two lists after being changed back to acquisition conditions.

Figures 3, 4, 5 and 6 also show points which give the results (average performance across 2 lists) of changing back to acquisition conditions. Table 1 gives, in more detail, the results of changing the experimental groups back to their acquisition conditions. Although there is some evidence of a slight negative transfer effect, there was a relatively rapid shift back to a performance level attained in original acquisition. Since there was a relatively rapid shift back to the practice level, the habits could be assumed to have been independent.

Of the 4,800 responses on Day 3, 4,796 were scored identical to Es by the independent scorer. Four responses were given so loudly it was impossible to hear the sound of the light going off. These responses were scored correct, which was against the prediction.

Error analysis acquisition

A complete error analysis was made on both the acquisition and transfer data. A summary of the error analysis can be found in Appendix III-B, Tables 3, 4, 5 and 6. The major error type for all acquisition groups was omissions. Beginning as low as 64% for the 3 sec. output-2 sec. input (3-2) group and as high as 84% for the .8-2 group, the number of omissions reached an average of 90% for all groups quite rapidly. Overt errors were most similar within output groups. The largest error type for both fast output groups (.8-2 and .8-5) was correct responses occurring after the light was off. Although both of the slow output groups (3-2 and 3-5) showed an initial tendency to respond too soon, this error type diminished very rapidly; extraneous response errors were consistently the more frequent overt error for the slow output groups. All overt error types, however, decreased across the course of learning-to-learn as the percent

Table 1

Average Performance for Experimental Groups After

Being Changed Back to Acquisition Conditions

TRAINING

TRANSFER	.8-2			.8-5			3-2			3-5		
	L-4	L-5	L-6	L-4	L-5	L-6	L-4	L-5	L-6	L-4	L-5	L-6
.8-2	5.3	5.0	* 5.3	3.6	3.8	4.5	4.0	4.2	4.5	5.1	5.4	5.8
.8-5	3.8	4.1	4.5	4.2	4.5	* 4.6	4.3	4.8	5.2	4.9	5.2	5.7
3-2	3.7	3.3	3.9	3.3	4.3	4.5	4.9	4.9	* 4.6	4.5	4.6	5.1
3-5	4.3	4.6	5.2	4.5	4.0	5.3	5.3	5.6	5.7	5.1	5.6	* 6.4

*- Performance on L-1,L-2 and L-3 is given for control groups.

of omissions increased. This would imply that Ss were learning to respond within the temporal requirements of the task. Response intrusions were a relatively consistent error in the 3-2 groups. Table 2 gives the error types made by each acquisition group averaged across the last 3 lists of Day 2.

Error analysis transfer

Output changed. Table 2 also shows the error types made during transfer averaged across 3 lists. When output speed was faster, most of the overt errors were either correct late responses or intrusions. When the output speed was slower, the error types were dependent upon the particular acquisition conditions. When changed from .8-2 to 3-2, 70% of the errors were omissions compared to 51% for the .8-5, 3-5 group. When changed to a slower output, the largest overt error type was correct responses occurring too soon. This type of error was considerably more frequent, however, in the .8-5, 3-5 group. The .8-2, 3-2 group made more response errors (39%) than the .8-5, 3-5 group (11%).

Input changed. When the input was faster, error type was again dependent upon acquisition condition. Slightly more omission errors were made by the .8-5, .8-2 group than by the 3-5, 3-2 group. For the .8-5, .8-2 group, by far the largest overt error group was correct late responses. The overt errors emitted when stimulus-response time was lengthened, was again dependent upon acquisition conditions. The .8-2, .8-5 group produced a considerably larger percentage of correct late responses than did the 3-2, 3-5 group which produced more response errors.

Table 2

Error Types Made by Each Acquisition Group Averaged Across the Last Three Lists of Day 2 and Across Day 3 Transfer Lists

		DAY - 2 Lists 14- 16				DAY - 3 LISTS 17 - 19													
						R - time Shortened		R - time Lengthened		S-R time Shortened		S-R time Lengthened		Both Lengthened		Both Shortened		Mixed	
		.8-2	.8-5	3-2	3-5	3-2 .8-2	3-5 .8-5	.8-2 3-2	.8-5 3-5	.8-5 .8-2	3-5 3-2	.8-2 .8-5	3-2 3-5	.8-2 3-5	3-5 .8-2	.8-5 3-2	3-2 .8-5		
Percent Correct		.45	.48	.50	.55	.10	.06	.12	.16	.12	.24	.19	.27	.12	.15	.12	.11		
Percent Omissions		.89	.90	.91	.91	.68	.68	.70	.51	.77	.68	.77	.70	.65	.77	.84	.72		
Percent Overt		.11	.10	.09	.09	.32	.32	.30	.49	.23	.32	.23	.30	.35	.23	.16	.28		
Percent Error Type/Overt																			
Time Error	Early	0	0	.04	.04	0	.09	.33	.56	.03	.04	.02	.09	.61	0	.58	.01		
	Late	.54	.59	.19	.18	.34	.39	.10	.10	.28	.66	.67	.20	.05	.76	.14	.59		
Response Error	Intrusion	.26	.23	.31	.30	.31	.31	.24	.07	.37	.12	.12	.41	.14	.12	.14	.23		
	Extraneous	.19	.16	.46	.48	.27	.18	.15	.04	.07	.09	.18	.27	.07	.05	.02	.11		
Time & Response		0	0	0	0	.08	.03	.19	.23	.15	.10	.02	.03	.14	.07	.12	.05		

Input and output changed. When both intervals were lengthened, correct responses occurring too soon constituted the largest overt error group. When both intervals were shortened, correct late responses accounted for the largest number of overt errors. When the interval change was mixed (one interval faster and the other slower), the pattern of errors conforms, for the most part, to groups in which the output shift was similar.

DISCUSSION

The results support the hypotheses that input and output speed are components of learning-to-learn. A part of what the subject is learning as he is learning how to learn paired associates in this paradigm is a speed of assimilation and a speed of emitting overt responses. Furthermore, this learning is not "list specific" since it is not confined to a particular list of words. Rather, it is operative when new lists are acquired. These findings support the micromolar contention that learning is best at practiced speeds and that changing speed components in either direction makes the task more difficult. Exposure to different values of speed components in a new task effectively requires the learning of quantitatively different micro speed responses.

The magnitude of the obtained decrement suggests that a major part of performance in this type task involves the optimal use of pacing techniques. Additionally, these pacing components are relatively persistent. Exposure to the three transfer lists did not substantially interfere with the subject's ability to perform at the practiced intervals when changed back.

The fact that changing to a faster speed component increased task difficulty is quite open to plausible explanation. Performance decrements resulting from being changed to a slower speed, on the other hand, are more difficult to handle. The requirements of the new task may have been different depending upon the direction of the change.

First, changing to a faster output speed required the subject to give the response sooner than practiced. During the anticipation interval, the subject had to search, find, perhaps hold, and then make the response within the light-on interval. Requiring the subject to produce the correct

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different depending upon the direction of the change.

First, changing to a faster target speed required the subject to [illegible]

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[illegible] the subject to produce the correct response sooner could interfere with learned techniques of eliciting associations, and, as a result, disrupt recall. One might, then, predict a high frequency of correct late responses, and indeed, this was the predominant overt error type. Furthermore, the light coming on sooner than in training might distract the subject in the recall process. This could result in an increase in response type overt errors, i.e., response intrusions, stimulus intrusions, and/or extraneous responses. Again, there was a number of these error types for these groups. All of the changed groups were asked after the Day 3 session if they felt that the change in the time interval(s) affected their performance, and if so, how. The most frequent response given by the groups changed to a faster response time was that they could not think of the word soon enough, and secondly, that the light coming on so much sooner was annoying.

Changing to a faster input interval could be viewed as making the task more difficult since there was less time for rehearsal. The overt error analysis for these groups indicated that the correct associations were perhaps weaker in that there were a number of correct responses occurring too late to be considered correct and also a number of intrusions.

Second, performance decrements obtained from changing to slower speeds may result from disrupting learned pacing techniques or paced processes. It appears unlikely that slowing down output would make it more difficult for the subject to search and find the correct response since more time was available for these processes. Rather, the interval change might have its detrimental effect by requiring the subject to hold the correct response longer. In transfer, the fast output groups were required to hold the correct response two or more seconds longer than in training. That this is

a difficult requirement is evidenced by the fact that the largest overt error category was correct responses occurring too soon. The replies with regard to the effect of this interval change were almost all related to their being afraid they would forget the word. Some subjects said they found themselves directing their attention to the light and when it came on, they had forgotten the word.

Decrements occurring from lengthening input time may also result from disrupting stable pacing behavior. The groups which received the fast input interval in training may have developed a stable technique of associating the stimuli paced in such a way that it could be employed within the interval. If this were the case, then changing the speed could interfere with this technique. The increase in late correct responses and both types of response errors would suggest that the subject's pacing was disrupted. The most frequent replies to the post-test question by these groups were that the interval was too slow and that their minds wandered.

It might have been expected on the basis of the total time hypothesis that changing groups to a longer input interval would improve performance. Further, one might also predict from this hypothesis that there would be a separation between the fast and slow input groups during training. However, since subjects were given only two trials on each list in this experiment, the prediction would not be appropriate. The separation in performance favoring longer input intervals found, for example, by Murdock (1960) may appear at a later stage of list learning.

The fact that this extension of micromolar theory obtains has certain implications in the search for "optimal" temporal units (e.g. Nodine et al., 1967). In the present study, one might contend that the practiced units,

[illegible]

[illegible]
[illegible] than [illegible]
they found [illegible] as [illegible] when they
some of, they had forgotten the word.

For example, [illegible] that [illegible]
[illegible]. The groups which [illegible]
[illegible] in [illegible] a [illegible]
[illegible]
the subjects. If they made the word, [illegible] changing the [illegible]
[illegible]. The [illegible] and [illegible]
[illegible]
difference. The most frequent [illegible] of the [illegible] by [illegible]
groups was that the [illegible] was too [illegible] and that [illegible]

It might have been expected on the basis of the [illegible] hypothesis that changing groups in a [illegible] would [illegible] performance. Further, one might also predict from this hypothesis that there would be a [illegible] between [illegible] groups during training. However, since subjects were given only one [illegible] on each [illegible] in this experiment, the prediction could not be [illegible]. The [illegible] of performance [illegible] upon [illegible], for example, by [illegible] (1953) may appear at a later stage of [illegible] learning.

The fact that this [illegible] of [illegible] theory [illegible] has [illegible] [illegible] (1952). In the present study, [illegible].

regardless of their length, were optimal to the subjects that practiced them since they performed best at these intervals. The question of optimal temporal units, at least for this type of paradigm, would perhaps best be asked in terms of ease of acquisition of particular temporal components. In any event, consideration should be given to the finding that subjects perform best at practiced intervals regardless of any superiority in performance between particular groups.

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APPENDICES

APPENDIX I

REVIEW OF LITERATURE

The first rigorous demonstration of "learning-to-learn" was provided by Ward (1937). Using humans as subjects, he found that trials to criterion in learning nonsense syllables declined as a function of the number of lists previously learned. The change in the rate of acquisition with practice on successive lists has been labeled learning-to-learn or non-specific transfer. An intensive investigation of learning-to-learn with animal subjects was made by Harlow (1949). He found that the number of trials required to learn discrimination problems decreased with increasing experience with such problems. He attributed improvement in solving discrimination problems to the acquisition of a learning set. This learning set involved compound stimulus learning of relevant dimensions specific to the set of successive discriminations. Harlow (1950, 1959) believed that a learning set was somewhat specific to the type of problem practiced and speculated that the apparent efficiency of adult human learning results from their having acquired a large number of learning sets. Beyond this presumed specificity, little attention has been given to "what is learned?" in human learning-to-learn.

Recently, Postman and Schwartz (1964) did consider several aspects of this question. They investigated the effects of type of verbal material (trigrams, adjectives) and type of paradigm (paired-associate, serial) on interlist transfer. Four groups of subjects (Ss) learned one list under one of the following conditions: (1) paired associate adjectives, (2) serial adjectives, (3) paired associate trigrams, or (4) serial trigrams.

Studies of Learning Set

The first rigorous demonstration of "learning-to-learn" was provided by Ward (1937). Using [illegible] he found that trials to [illegible] criterion in learning [illegible] a function of the number of lists previously learned. The change in the rate of acquisition [illegible] than the [illegible] learning-to-learn [illegible] transfer. An [illegible] investigation of learning-to-learn with animal subjects was made by Harlow (1949). He found that the number of trials required to learn discrimination problems decreased with increasing experience with such problems; the [illegible] discrimination problems [illegible] a "learning set." This learning [illegible] involved [illegible] to the use of successive discriminations. Harlow (1950, 1959) believed that a learning set was somewhat specific to the type of problem learned and [illegible] that the [illegible] efficiency of adult human learning [illegible] from their having acquired a large number of learning sets. Beyond this [illegible] specificity, [illegible] to "what is learned" in human learning-to-learn.

Recently, Postman and Schwartz (1964) did consider several aspects of this question. They manipulated the [illegible] type of verbal material (trigrams, adjectives) and type of [illegible] (paired-associate, serial) [illegible]. Four groups of subjects [illegible] under one of the following conditions: (1) paired associate adjectives, (2) serial adjectives, (3) paired associate trigrams, or (4) serial trigrams, Subjects were then transferred to either paired adjectives or serial adjectives for a second list. All groups performed better on list two than on list one with superior learning occurring when paradigm and class of material remained the same across lists. At a more theoretical level, Postman postulated that learning-to-learn involves the acquisition of instrumental habits (e.g., acquiring effective techniques of mediation) related to learning a particular task. Learning-to-learn has generally (Thune, 1950; Hamilton, 1950; Postman and Schwartz, 1964) been carefully distinguished from warm-up. Warm-up refers to a relatively transitory effect and has been postulated to involve developing a performance "set" which maximized efficiency. Learning-to-learn, on the other hand, is viewed as a relatively permanent effect. Postman and Schwartz identified as warm-up phenomena both the development of an optimal rhythm for observing stimuli and the latency of giving overt responses. At the outset a distinction should perhaps be made between these two phenomena as they operate in a paired associate paradigm. The rhythm of observing stimuli is dependent upon the speed of presentation of input (stimulus and response duration). Certainly, to develop what Postman and Schwartz refer to as an "optimal rhythm", S would have to be able to assimilate input at the speed it is presented. The speed of giving overt responses is dependent upon the anticipation interval and, to some extent, instructions. Here again, an "optimal rhythm" for giving overt responses would mean that the response (R) is emitted within the anticipation interval.

With the phenomena specified, an alternative rationale in favor of their being considered component processes of learning-to-learn will be given. By "component processes" is meant that as the subject is

S-R linkage when no attempt [illegible] made to [illegible] covertly.

[illegible] a second [illegible], both [illegible] and [illegible] (1970) [illegible] with [illegible] learning [illegible] their [illegible], and those of [illegible] and [illegible] (19[illegible]).

[illegible] and [illegible] learning-to-learn [illegible] and the acquisition of instrumental habits (e.g., generating effective tactics [illegible]) related to learning a particular task. Learning-to-learn has generally (Adams, 1968; Postman, 1969; Postman and Schwartz, 1964) been carefully distinguished from warm-up. Warm-up is a relatively transitory effect and has been considered to involve developing a perceptual "set" which dissipates with time. Learning-to-learn, on the other hand, is [illegible] relatively permanent effect. Postman and Schwartz identified as a warm-up phenomenon both the development of an internal [illegible] for the [illegible] stimuli and the [illegible] of giving overt responses. In the context a distinction should perhaps be made between these two phenomena as they operate in a paired associate paradigm. The [illegible] of [illegible] stimuli is dependent upon the speed of presentation of items (stimulus and response durations). Certainly, as [illegible] when Postman and Schwartz refer to an "optimal rhythm", S would have to be able to anticipate items at the speed it is presented. The speed of giving overt responses is dependent upon the anticipation interval and, to some extent, intertrial [illegible]. Here again, an "optimal rhythm" for giving overt responses would mean that the response (R) is emitted within the anticipation interval.

With the phenomena specified, an alternative rationale in favor of [illegible] being considered [illegible] phenomenon of [illegible] will be given, or "[illegible]" [illegible] that as the subject [illegible] learning-to-learn, in the sense of making fewer errors on subsequent paired associate (PA) lists, a part of what he is learning is rhythm of observing stimuli and a latency of giving overt responses. In the first place, it is contended that there is justification in assuming that acquiring an "optimal rhythm" for observing stimuli is a necessary component of learning-to-learn a particular task. This would be particularly true if the task were paced in a way rather unlike any ordinarily encountered by S. In the case of paired associate learning, the closest thing outside the laboratory might be learning a list of terms or perhaps, reading. Even these tasks, however, are different from PA learning. Learning lists of terms is rarely paced and the requirements of a reading task with regard to retention are different (to be discussed below). If the rhythm of stimulus (St) presentation were not consistent with S's habitual assimilation rate, then for most efficient learning, S would be forced to change his rate of making observing Rs. Indeed, there may be certain classes of interfering tendencies which S must inhibit if learning is to take place within the requirements of the PA paradigm.

In the second place, there is some justification for assuming that R latency or speed of giving overt Rs is a component of learning-to-learn. As stated previously, to meet the requirements of a PA learning situation the R or output must be emitted during the anticipation interval. To meet this requirements, an effective technique of responding would necessarily be one which searched, found and produced the correct R within the anticipation interval. As in the case of input speed, S might have to eliminate inconsistent R latencies and/or mediational techniques to acquire an effective technique of responding such that it could occur within the anticipation interval.

[illegible] patient [illegible] place. It is [illegible] according to [illegible] of the [illegible] periods of [illegible] some of the [illegible] group to [illegible]. In the case of [illegible] (b) [illegible] rate, then [illegible] the cost of [illegible] is [illegible] within the [illegible]

In the second place, there is [illegible] of [illegible] as stated previously, [illegible] the [illegible] must be [illegible] patient [illegible]. As in the case of [illegible] effective [illegible]

Furthermore, with regard to both of the above phenomena, micromolar theory (Logan, 1956) would contend that quantitative differences in either of the phenomena are different responses. Assimilation speed has not previously been identified as a component of a more molar response. The theoretical contention in this context would be that if the response of assimilating input were acquired under different speeds for two groups, then the subsequent behaviors, once acquired, would be different. Each group would learn to assimilate at a particular speed and would subsequently assimilate best at the speed at which it practiced. If the speed of input were changed, a decrement in performance would be predicted. The same prediction would hold for changing R latencies.

It was the purpose of this study to determine if developing an optimal rhythm for observing stimuli and giving overt responses (as defined above) are component mechanisms of learning-to-learn, or if they are merely transitory warm-up phenomena.

In the subsequent review of literature an attempt will be made to show that, (1) certain assumptions, not necessarily with firm empirical support, have governed the way in which the above phenomena have been treated; and, (2) S was given either inconsistent or a minimum amount of practice in acquiring these proposed micro learning set components.

Speed of Assimilation

Speed reading programs are based, in general, on the assumption that the speed at which one reads or assimilates input is a function of practice speed and efficiency techniques. Furthermore, workers in this area contend that reading speed can be increased without a loss in comprehension. If one uses the most efficient techniques of reading, and practices at

[illegible]

[illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] not previously been identified as a component of a [illegible] skill [illegible]. The theoretical consequence of this finding would be that if the component of [illegible] [illegible] were trained under different speeds for example, then the subjects' performance, when [illegible], would be different. Each group would learn to the acceleration of a particular speed and would consequently perform best at the speed at which it practiced. If the speed of input were changed, a decrement in performance would be predicted. The same prediction would hold for changing a [illegible].

It was the purpose of this study to attempt to [illegible] [illegible] the [illegible] [illegible] [illegible] the component [illegible] of [illegible], or if they are merely transitory warm-up phenomena.

In the subsequent review of literature an attempt will be made to show that, (1) certain activities, and more [illegible] with [illegible], [illegible], have governed the way in which the above processes have been treated; and, (2) a [illegible] [illegible] of practice in modifying these proposed [illegible] learning and [illegible].

Speed of [illegible]

Speed reading programs are based, in general, on the assumption that the speed at which the input of information takes in a function of practice time spent and [illegible]. [illegible], reading in [illegible] were carried [illegible] [illegible] successively faster rates, one will soon learn to read comfortably at a faster rate. The techniques suggested for increasing efficiency involve increasing the word attention span (thereby decreasing the number of eye fixations), pacing, and the elimination of regressions. In some cases, diagnostic photographs are made of eye movement while reading to determine Ss attention span and whether or not regressions are a problem. He is then asked to view tachistoscopically sets of numbers in an attempt to increase the number of letters or numbers in a given interval. Practice at successively higher speeds is given with a timed film-strip apparatus which advances the strip at a constant rate controlling the rate of word presentation. Investigators such as Spache (1962) and Taylor (1963, 1965) have demonstrated that reading speed (average 250 wpm for college students) can be improved upwards of 600 to 800 wpm without a drop in comprehension.

There are some similarities between reading and PA learning. Both can employ exposure to verbal material and can involve assimilating input under relatively paced conditions. The attention span requirements of PA learning are very similar to the tachistoscopic training used in speed reading courses. In the following paragraphs, however, certain contradictions will be noted between the contentions of speed reading advocates and a portion of the PA learning literature. Speed reading researchers suggest that speed of input can be increased without a drop in comprehension. In the PA literature (e.g., Murdock, 1960), on the other hand, there is evidence that increasing the speed of input (St-R duration) results in poorer comprehension or performance. Certainly when one attempts to compare the procedures and requirements of the two tasks, several differences are immediately evident. The nature of the R, for example, is different. In PA learning [illegible] Taylor points out, with such [illegible] as [illegible] controlled reader, [illegible] reading speed. The [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] and the [illegible] [illegible] [illegible]. [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] the [illegible] [illegible] [illegible] a [illegible]. It is [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to [illegible] the [illegible] of [illegible] a [illegible] in a given [illegible]. [illegible] of [illegible] [illegible] [illegible] is given [illegible] a [illegible] [illegible] [illegible] which [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] [illegible]. [illegible] [illegible] [illegible] of [illegible] (1962) and Taylor (1962, 1963) have demonstrated that [illegible] [illegible] [illegible] [illegible] wpm [illegible] [illegible] can be improved upward of 500 to 600 wpm without a drop in [illegible] [illegible].

There are some similarities between reading and FL learning — both [illegible] [illegible] [illegible] to [illegible] material and both involve assimilating input under relatively rapid conditions. The [illegible] [illegible] requirements of FL learning are very similar to the [illegible] training used in speed reading courses. In the following paragraphs, however, certain contradictions will be noted between the assumptions of speed reading advocates and a portion of the FL learning literature. Speed reading enthusiasts suggest that speed of input can be increased without a drop in comprehension. In the FL literature (e.g., [illegible], 1962), on the other hand, there is evidence that increasing the speed of input [illegible] results in poorer [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] and requirements of the two [illegible] [illegible] differences are immediately evident. The nature of the [illegible], for example, is different. In FL learning there is a more specifiable R than in reading. In a reading situation responses are rarely overt but rather are implicit. Consequently, to measure learning in a reading task, S is given some type of comprehension test. These tests are different from a recall trial on a PA task in the way it is presented, the rate it is presented, etc.

It might be asked, for example, why it takes S so many trials to master a 10 item PA task at a 2 sec. anticipation-2 sec. St-R interval rate. Looking at this PA task from the standpoint of ordinary reading, this would be assimilating 30 wpm which is only about one-eighth the average reading assimilation rate. It is here that the differences in the requirements of the two tasks become evident. These differences can be seen in terms of the content of the input material and in terms of the way in which criterion performance is measured. Whereas in reading, the words bear some meaningful relationship to each other within sentences and across long spans of material, in PA learning the meaningfulness across words within a list is rarely, if ever, constructed to resemble a sentence. Consequently, in PA learning S is required to form an association between words or even nonsense syllables which may or may not bear a relationship to each other, and which rarely bear a meaningful relationship to the subsequent pairs of items in the list.

With regard to criterion performance in the two situations, there are also differences. Most PA paradigms fit the conservation model (Posner, 1964). Within this model, for optimal performance, the output must equal the specific input as it was presented on previous trials. A reading criterion test, however, is rarely of the conservation type. Usually, reading criterion tasks fit either the reduction model where S condenses

input for optimal performance or the creation model where optimal output involves combining input with other material available from S's experience.

In the PA learning literature, presentation time or speed of input has been assumed to interact multiplicatively with trials to produce a constant total learning time (Murdock, 1960). A rather impressive number of studies is accumulating in support of this contention (Bugelski, 1963; Bugelski and Rickwood, 1964; Nodine, 1963, 1965; Neuman, 1964). These studies, in general, demonstrate that when presentation rate is fast, S requires more trials to learn than when the presentation rate is slower. The slower the input rate, regardless of practice conditions, the fewer trials S will require to learn.

Murdock (1960) proposed that if list length and presentation time were varied simultaneously while keeping total presentation time constant, equivalent recall for all lists would be obtained. To test this he presented lists of varying length (20, 30, 40 and 60 items) and varied the presentation interval (3 sec., 2 sec., 1.5 sec. and 1 sec. respectively). Subjects were administered the four lists in random order and were then asked to recall as many of the words as possible. About the same number of words were recalled from each list. In another experiment, Murdock tested the same hypothesis in a slightly different way. He reasoned that since more words are recalled from longer lists because the longer lists require more time to present, then if lists of different length are presented for the same length of time, no differences in recall should be obtained. He then presented 3 list lengths (25, 50 and 75 items) for a constant 30 sec. free study time. Each subject received all lists. Again recall was the

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[illegible] has been reported to decrease as list length increased [illegible]

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[illegible]

[illegible]

[illegible] were tested simultaneously while keeping total presentation time constant, equivalent recall for all lists would be obtained. To test this he gave subjects lists of varying length (20, 30, 40 and 60 items) and varied the presentation interval (3 sec., 2 sec., 1.5 sec., and 1 sec.) respectively. [illegible] asked to recall as many of the words as possible. [illegible] the time hypothesis in a slightly different way. He reasoned that since [illegible] more time to process, then if lists of different length are presented for the same length of time, no differences in recall should be obtained. [illegible] same regardless of list length. Murdock contended this demonstrated that time to learn is constant and is a multiplicative function of list length and presentation time.

Several things are evident with regard to these studies: (1) In the first experiment no attempt was made to provide sustained practice at any one speed and order and sequence effects were ignored; and, (2) In the second study, since free study time was given, there was no control with regard to pacing input.

Bugelski, in two studies (1962, 1963) varied input speed and held time available for output or the anticipation interval constant. In the first study (1962), he had a group of Ss learn a paired associate task in which the presentation rate for the stimuli was held constant at 2 sec., and the St-R exposure time was either 2, 4, 6, 8 or 15 seconds to 5 different groups of Ss. Using the product of list length and presentation time per item as a measure of total time per trial he computed the total time to learn the list. He found that when total time to learn was used as the dependent variable the 5 groups did not differ. Bugelski and Rickwood (1963) attempted to determine if the groups given long presentation time were wasting time on the longer presentation trials and thereby introducing some artifact. They allowed Ss free control over their presentation time (2 sec. anticipation held constant) and essentially replicated Bugelski's earlier study. They concluded that total learning time was fairly constant even when Ss were allowed to study the S-R paired associate combinations as long as they desired.

In the Bugelski studies it is noteworthy that possible order and/or sequence effects were not confounded with presentation rate; but, again, the repetition of list length, however, confounded this comparison when time to learn is compared and [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] are [illegible] above.

Several [illegible] with respect to these studies: (1) in the first [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible], (2) in the second study, since [illegible] study time was given, there was no control which [illegible] to pacing times.

Regarding the more [illegible] study, [illegible] [illegible] [illegible] time available for [illegible] [illegible] [illegible] [illegible] conducted. In the first study (1962), he had a group of [illegible] learn a paired associate task in which the presentation rate for the [illegible] [illegible] [illegible] [illegible] and the [illegible] [illegible] [illegible] [illegible] 2, 4, 6, 8, or 10 [illegible] to a different group of Ss. Using the product of list length and presentation time per item as a measure of total time per trial he [illegible] the total time to learn the list. He found that when total time to learn was used as the dependent variable the 5 groups did not differ. Bugelski and Rickerd [illegible] attempted to determine if the groups given long presentation times were wasting time on the longer presentation trials and thereby introducing some artifact. They allowed Ss free control over their presentation rate (Ss [illegible] [illegible] [illegible] [illegible]) and essentially replicated Bugelski's earlier study. They concluded that total learning time was fairly constant even when Ss were allowed to study the [illegible] paired associate combinations as long as they desired.

In the Bugelski studies it is noteworthy that possible order and/or [illegible] effects were not confounded with presentation rate, list length, [illegible] there was little opportunity for S to learn a rate of assimilation. The lists he used were short and were presented for only a few trials.

Nodine, in two studies (1963, 1965) used a factorial design and varied both St and St-R exposure rates. In the former study, he examined all combinations of the following durations: ½, 1, 2 and 4 sec. Using 3 R measures (recall, anticipation and latency), all groups were given 21 anticipation trials and 4 systematically interpolated recall test trials during which R latency was measured. The procedure was as follows: 4 sets of 5 anticipation trials followed by a recall trial with one last anticipation trial following the last recall trial. During the recall trial the St alone was presented for 4 sec. and R latencies were measured with a voice key. No R or an incorrect R within a recall interval were arbitrarily assigned 4 sec. latencies. This obviously invalidates this as a pure latency measure since it was confounded with incorrect Rs. Also, no anticipations could be given by the ½ sec. St alone groups, therefore, recall proved the more sensitive measure for all groups. Although both St alone duration and St-R duration had statistically significant effects on the number of correct Rs, the effect of the St-R duration was more powerful. He postulated that this was due to an increased opportunity to integrate responses in the longer St-R durations. Indeed, in post experimental questioning of Ss he found an increasing percentage (½ sec.-45%, 1 sec.-55%, 2 sec.-62%, 4 sec.-82%) of Ss reported rehearsing the Rs during the St-R presentation interval.

In his second study (Nodine, 1965) Ss were given trials until they mastered the list, otherwise using the same procedures as before. This study revealed only St-R duration as a significant determiner of learning

rate. Also, he found that increasing the St alone durations beyond 1 sec. resulted in more total learning time than intervals of ½ or 1 sec.

In both of these studies some of the groups were given incompatible practice conditions with respect to the development of an optimal rhythm for observing stimuli. The incompatible trials were the 4 sec. St alone recall trials which were incompatible with all groups having St and/or St-R interval other than 4 sec. Indeed, an alternative interpretation could be offered for the superiority of the slow groups in terms of the compatibility of the anticipation-recall trials for the slow group and consequently postulate that these groups had, in essence, more opportunity for positive transfer since the St conditions were more similar. On the other hand, interference effects may have been introduced impeding the performance of the fast groups.

Newman (1964) examined the effect of pairing time (St and R presented together) and test time (St alone) on PA learning. He used 4 groups each of which learned a single list under one of the following conditions for 12 trials: (1) 2 sec. pairing-time (P.T.), 2 sec. test-time (T.T.), (2) 2 sec. P.T., 4 sec. T.T., (3) 4 sec. P.T., 2 sec. T.T., or (4) 4 sec. P.T., 4 sec. T.T. Consistent with Nodine (1963) he found that increasing either pairing-time or test-time facilitated performance in terms of the number of correct responses learned in 12 trials.

Again, however, the list of items was quite short (6 items) and they were presented for only 12 trials allowing S hardly any practice at a particular input rate.

Returning to the previously stated purpose of this study with respect to whether assimilation speed is a learning-to-learn or warm-up phenomena,

it is evident that: (1) the studies cited above either were not designed in such a way to be sensitive to this (speed of assimilation) effect due to the few number of trials or short lists, or (2) they were designed in such a way as to interfere with Ss learning to assimilate input at a particular speed. Furthermore, these PA data seem to conflict with the research dealing with speed reading. The PA data imply that speed obtains at the expense of accuracy possibly implying that as one reads faster one comprehends less. The research in speed reading, although it is in some respects different from a PA paradigm and, additionally, cannot be considered rigorous, seems to be consistent in showing that increases in reading rate up to a certain point do not have a detrimental effect on comprehension, but, in some cases may improve it. It may be that speed reading programs in emphasizing speed force S to find more efficient ways of reading such that S reduces the number of stimuli to which he responds thereby "shortening the list" in PA terminology. On the other hand, a careful examination of the speed reading training procedures with their emphasis on pacing and rhythm of eye movement could quite easily be interpreted as learning-to-learn with one component being learning to assimilate input at a particular speed. Therefore, in order to clarify, to some extent, the relation of the rate parameter to learning-to-learn, an attempt was made to determine if learning an optimal technique of assimilating input is a component of learning-to-learn or is a transitory warm-up phenomena.

Response Latency

Response latency was identified above as another possible component of learning-to-learn. If, indeed, S is to conform to the requirements of

the PA paradigm, he must learn a technique of responding which finds and produces the correct R in the anticipation interval. Several studies have attempted to specify more precisely the nature of the R within the anticipation interval of a PA paradigm by taking measures of actual R latency. Nodine, for example, in both of his studies measured R latency. During the recall-test trials in both of his experiments S was equipped with a voice key. A timer was activated concurrent with the appearance of the St members and was stopped with S's verbal response. Unfortunately, if S failed to respond or if he gave an incorrect R, a maximum latency was assigned. As a result, latency measures for correct Rs which did occur were invalidated since maximum latencies for incorrect Rs and/or no responses were averaged in with the actual latencies of correct Rs.

Several studies (Theios, 1965; Schlag-Rey, et al., 1965; Suppes, et al., 1966) testing predictions with regard to a three-state, two-element mathematical model have also measured R latency in a PA type task. It is predicted from this model that latency varies as a function of the state of conditioning S happens to be in. They predict that in each conditioning state there is a population of R latencies and that the mean and variance of these latency distributions decreases as Ss pass from state one to state three. On the basis of the predicted means and variances of latency for each of the 3 conditioning states, a predicted mean and variance of latency for each trial is derived. The result is a predicted latency curve showing an extremely rapid initial increase followed by a somewhat slower decrease across trials. There is some leveling off in the decrease during the last few trials (e.g., Suppes, et al.). The procedure used by these researchers in testing their predictions has involved a modified PA task where S

learned to depress one of three keys to each of twelve nonsense syllables. A light occurring above the correct key after S's R served as the reinforcer. Ss are generally run in 2 sessions a week apart until they complete 5 trials after the trial on which all responses were correct. For the most part, the observed curves were well approximated by the predicted curves.

An examination of the procedure reveals that the reinforcement contingencies were arranged such that the pay-off was greatest if S responded as rapidly as possible. In the first place, the faster he responded the sooner he would obtain feedback in terms of reinforcer lights. In the second place, by responding rapidly, he would shorten the intrastimulus interval and subsequently shorten the trial, and ultimately, the experimental session. Therefore, the declining latency curves may be reflecting more than the state of conditioning S happens to be in. They may, in addition, reflect the learning of a technique of responding which produces the correct R as rapidly as possible.

Another relevant study in human verbal learning is that of Shiffrin and Logan (1965). Rather than measuring latency directly, they allowed Ss to respond freely after giving them practice at either a fast or a slow response speed. Subjects were presented with patterns of lights for 4 sec. followed by a response light identifying each pattern with a response number. The task was to anticipate the response number correctly. Seventy-five one-hundredths of a second after the onset of the stimulus for the fast group and 2.25 sec. for the slow group a buzzer sounded and was the cue for S to call out the response he thought had been previously associated with the S.

[illegible] For the most part, the converted curves were well approximated by the predicted curves.

The construction of the procedure ensured that the reinforcement contingencies were arranged such that the payoff was greatest if S responded as rapidly as possible. In the first place, the faster he responded the sooner he could obtain feedback in terms of reinforcing lights. In the second place, by responding rapidly, he would shorten the intertrial interval and subsequently shorten the trial, and ultimately, the experimental session. Therefore, the declining latency curves may be reflecting more than the trend of conditioning [illegible] to be [illegible]. They may, in addition, reflect the learning of a technique of responding which produces the correct R as rapidly as possible.

Another relevant study in human verbal learning is that of [illegible] and [illegible] ([illegible]). Rather than measuring latency directly, they allowed Ss to respond freely after giving them practice at either a fast or a slow response speed. Subjects were presented with patterns of lights for [illegible] sec. followed by a response light [illegible] each pattern with a response number. The task was to anticipate the response number correctly. [illegible] of a second after the onset of the stimulus for the fast group and [illegible] sec. for the slow group [illegible]

After S attained a criterion of 50 out of 52 correct consecutive patterns, he was presented a free responding test task such that each time he responded, the next pattern would appear immediately. The Ss were instructed to attempt to get as many patterns correct as he could in 2 min. The fast practice group made significantly more correct responses than the slow practice group during the test. There were no differences in the number of trials required by the 2 groups to attain the 50 out of 52 consecutive correct criterion. Two months after the first session, the Ss were recalled and were run through another session similar to the first with the previously fast group now the slow group and vice versa. Essentially the same results were obtained with regard to the number of correct responses in the 2 min. test task. The authors concluded that Ss learned to respond best at the speed at which they practiced. Although the more general question with regard to acquisition of a generalized output latency as a possible component of learning-to-learn was not dealt with, the findings of Shiffrin and Logan demonstrate that for their task, Ss learned a speed or rhythm of emitting specific overt responses.

Lordahl and Archer (1958) suggested that one specific component acquired in motor learning is a rhythm of responding. This conclusion resulted from their rotary pursuit experiment in which 3 groups of Ss were given Day 1 practice at either 40, 60 or 80 RPMs. On Day 2, all groups were given an additional 30 trials at 60 RPMs. They found that the group which received trials on Day 1 and Day 2 at 60 RPMs performed better than either of the switched (i.e., 40-60 or 80-60 RPMs) groups. A decrement in performance was obtained in the switched groups.

In another experiment (Namikas & Archer, 1960) an attempt was made to determine the relative persistence of the performance decrement in the Switched groups. Three groups of Ss were trained for 20 trials at either 40, 60 or 80 RPMs. At either 2, 4, 8 or 16 minutes after training 20 trials on a transfer task were given at 60 RPMs for all groups. As in the previous study transferring to the same speed gave the best performance. Again, a performance decrement was obtained in the changed groups regardless of the intertask interval.

The authors concluded that the component skills involved in learning a task at one speed persist across the intertask intervals used in the experiments.

It is evident that the studies cited above are not addressed to the original question with respect to whether response latency is a component of learning-to-learn paired associates. To answer this question one would have to extract response speed per se from response speed as related to a specific list of items. The question, then, becomes whether or not S, as he is learning how to learn paired associates, develops a technique of responding such that the R is produced after a particular period of time. Posner (1962) has suggested that verbal learning experiments require S to serve as a hold circuit and thus delay the R a specified period of time. Posner was referring to the length of time elapsing between the first presentation of St-R combinations and subsequent anticipation trials. At a more micro level, however, it is likely that S also has learned a technique of emitting the correct R within the confines of the anticipation interval. This would involve developing a technique or rhythm of emitting

overt responses which is "optimal" to the extent that the Rs are produced during the anticipation interval.

The criterion used to distinguish between warm-up and learning-to-learn is the degree of temporal persistence of the practice effects with learning-to-learn being more persistent than warm-up (Postman and Schwartz). Hamilton (1950) found that the facilitative effects of warm-up were lost within 60 minutes after the experiment. Several things would seem to be necessary in trying to separate and examine component processes of learning-to-learn. In the first place, S must be exposed to enough lists so that the acquisition of all learning-to-learn components can be assumed. Secondly, once acquisition was assured, if the input or output rate were changed at a certain interval after the last list, the decrement in performance would be predicted.

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APPENDIX II

INSTRUCTIONS TO SUBJECTS

Day 1

"The apparatus before you is a memory drum. When I turn it on you will see a word in the window. Three seconds (.8 sec. for fast output group) after it appears a light comes on for 1 sec. and then goes off. After 5 sec. exposure, the shutter on the right side of the window will open and you will see this same word along with another word. When you see the word, pronounce it out loud and try to remember the first word that appears along with it.

"After 5 sec. (2 sec. for fast input group) exposure to this frame, the drum will again turn and you will see a different word alone. Three seconds (.8 sec. for fast output group) after it appears a light will come on for 1 sec. and go off. Five seconds later the shutter will open, exposing this word with another word. Again, pronounce this second word aloud and try to remember which word appeared with it.

"This procedure will continue until you have seen 10 such pairs of words.

"You will then go through this same procedure one more time, but this time the pairs will appear in a different order. When you see the first word of each pair alone, try to anticipate the word that went with it by pronouncing what you think is correct during the time when the light is on. Remember, you are to give me the second word ONLY when the light is on in order for the trial to be considered correct. After 5 sec., the shutter will open and you will find out if you were right.

"Let's go through the procedure once more to make sure you understand what's going to be happening: first a word appears on the drum, then a light comes on 3 sec. (.8 sec. for fast output group) after the first word appears, then the second word appears for 5 sec. (2 sec. for fast input group). The second time through the list you are to try to give the second word aloud only when the light is on. You will see each list only 2 times and there are several lists.

"Are there any questions?

"I will now start the drum."

Day 2

"Today, you will be learning lists of words as you did yesterday. Let's go through the procedure again to make sure you remember what you're supposed to do: first, a word appears on the drum; then a light comes on 3 sec. (.8 sec. for fast output group) after the first word appears; then the second word appears for 5 sec. (2 sec. for fast input group). The second time through the list you are to try to give the second word aloud only when the light is on.

"Any questions?

"I will now start the drum."

Day 3

"Today, you will be learning lists of words as you did yesterday. Let's go through the procedure again to make sure you remember what you're supposed to do: first, a word appears on the drum; then a light comes on 3 sec. (.8 sec. for fast output group) after the first word appears. (This interval is different from yesterday.) Then, the second word appears for 5 sec.

(2 sec. for fast input group). (This also is different from yesterday.) The second time through the list you are to try to give the second word aloud only when the light is on.

"Any questions?

"I will now start the drum."

Day 3--Post Test Lists Instructions (Changed Groups)

"You will now receive more lists at the time intervals used during the first 2 days. That is, the light will again come on for 3 sec. (.8 sec. for fast output group) after the first word appears; the second word will again appear for 5 sec. (2 sec. for fast input group)."

APPENDIX III-A

Table 3

Analysis of Variance Summary Table: Number of Correct Responses over Three Lists on Day 3 Transfer

Source	df	F
Between subjects	159	
O (training output)	1	2.806
I (training input)	1	.002
R (transfer output)	1	4.435
N (transfer input)	1	.827
OI	1	2.062
OR	1	165.754**
ON	1	.147
IR	1	1.010
IN	1	70.955**
RN	1	1.670
OIR	1	2.648
OIN	1	2.201
ORN	1	.147
IRN	1	.229
OIRN	1	70.151**
Error (S/O, I, R, N)	144	
Within subjects	320	
L (lists)	2	25.606*
LO	2	.979
LI	2	1.515
LR	2	.099
LN	2	2.204
LOI	2	.603
LOR	2	1.457
LON	2	.386
LIR	2	1.904
LIN	2	.960
LRN	2	.297
LOIR	2	.290
LOIN	2	2.012
LORN	2	.022
LIRN	2	.788
LOIRN	2	3.639
Error (subject × lists)	288	

*$p < .05$
**$p < .01$

Table 4

Summary of Errors Occurring During Acquisition for the .8 sec. Output-2 sec. Input Group

		DAY - 1								DAY - 2							
		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-1	L-2	L-3	L-4	L-5	L-6	L-7.	L-8
Number Correct		61	73	104	100	125	142	132	165	121	123	129	132	163	156	184	149
Number Omissions		277	267	243	251	235	231	241	199	246	256	245	243	217	222	191	226
Number Overt		62	60	53	49	40	27	27	36	33	21	26	25	20	22	25	25
Time Error	Early	2				1		1									
	Late	39	32	26	30	17	21	13	20	13	9	12	8	14	9	17	13
Response Error	Intrusion	18	16	15	12	13	2	8	9	13	5	7	12	3	10	4	5
	Extraneous	3	10	8	7	9	4	4	7	6	6	7	5	2	3	4	7
Time & Response Error			3	8				4		3	5			5			

Table 5

Summary of Errors Occurring During Acquisition for the .8 sec. Output-5 sec. Input Group

		DAY - 1								DAY - 2							
		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8
Number Correct		82	92	137	136	126	131	151	176	114	124	139	151	154	172	186	211
Number Omissions		253	273	224	232	233	230	211	202	262	255	227	212	222	205	195	167
Number Overt		65	35	39	32	41	39	38	22	24	21	34	37	24	23	19	22
Time Error	Early																
	Late	33	18	26	25	26	27	23	13	13	9	17	20	9	14	9	15
Response Error	Intrusion	26	12	6	3	11	8	11	6	9	10	14	13	9	5	6	4
	Extraneous	4	5	7	4	3	3	3	2		2	3	4	4	3	4	3
Time & Response Error		2				1	1	1	1	2				2			

Table 6

Summary of Errors Occurring During Acquisition for the 3 sec. Output-2 sec. Input Group

		DAY - 1									DAY - 2							
		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8
Number Correct		62	95	126	117	157	159	144	177		123	143	153	163	189	193	193	222
Number Omissions		218	242	205	229	201	206	224	200		242	220	221	216	290	290	188	162
Number Overt		120	63	69	54	42	35	32	23		35	37	26	21	21	17	19	16
Time Error	Early	44	23	19	18	7	7	2	5		4	5	5		3	1		1
	Late	3	5	6	8	8	6	3	1		3	3	3		1	4	2	4
Response Error	Intrusion	52	23	17	16	13	11	15	9		22	8	11	7	11	2	8	6
	Extraneous	7	9	16	7	14	9	12	5		6	21	7	14	5	10	9	5
Time & Response Error		14	3	11	5		2		3						1			

Table 7

Summary of Errors Occurring During Acquisition for the 3 sec. Output-5 sec. Input Group

		DAY - 1								DAY - 2							
		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-1	L-2	L-3	L-4	L-5	L-6	L-7.	L-8
Number Correct		75	121	146	164	164	184	200	201	151	179	173	187	201	198	225	242
Number Omissions		227	209	196	185	194	177	175	183	222	201	205	195	184	185	153	147
Number Overt		98	70	58	51	42	39	25	16	27	20	22	18	15	17	22	11
Time Error	Early	52	29	18	15	7	3	2	1	1		2	2	1		2	
	Late	4	3	7	9	3	6	2	5	1	2	2	3	3	4	3	2
Response Error	Intrusion	28	19	13	12	13	13	7	2	12	5	6	6	3	6	6	3
	Extraneous	4	15	17	15	18	17	14	8	13	13	12	7	8	7	11	6
Time & Response Error		10	4	3		1											

APPENDIX IV

RAW DATA

		Output	Input
Condition:	Training	.8 Fast	2.0 Fast
	Transfer	.8 Fast	2.0 Fast

Subject	List 1	List 2	List 3
1	4	4	4
2	7	7	6
3	4	4	5
4	6	4	4
5	8	6	7
6	4	4	4
7	4	5	5
8	5	5	5
9	5	7	8
10	6	4	5

		Output	Input
Condition:	Training	.8 Fast	2.0 Fast
	Transfer	3.0 Slow	2.0 Fast

Subject	List 1	List 2	List 3
1	0	0	2
2	3	5	2
3	1	2	2
4	0	1	2
5	0	0	0
6	0	0	0
7	0	2	1
8	0	0	0
9	2	2	1
10	3	1	3

		Output	Input
Condition:	Training	.8 Fast	2.0 Fast
	Transfer	.8 Fast	5.0 Slow

Subject	List 1	List 2	List 3
1	4	5	3
2	1	4	3
3	1	3	3
4	3	2	2
5	1	2	1
6	0	2	2
7	0	1	1
8	1	0	0
9	2	2	2
10	1	2	2

		Output	Input
Condition:	Training	.8 Fast	2.0 Fast
	Transfer	3.0 Slow	5.0 Slow

Subject	List 1	List 2	List 3
1	1	4	3
2	4	3	3
3	0	0	0
4	0	0	0
5	3	4	3
6	0	0	1
7	1	1	0
8	0	0	0
9	0	3	3
10	0	0	0

		Output	Input
Condition:	Training	.8 Fast	5.0 Slow
	Transfer	.8 Fast	5.0 Slow

Subject	List 1	List 2	List 3
1	4	3	4
2	3	3	3
3	3	3	4
4	5	6	6
5	4	6	5
6	5	4	3
7	5	6	6
8	5	6	6
9	4	4	4
10	4	4	5

		Output	Input
Condition:	Training	.8 Fast	5.0 Slow
	Transfer	3.0 Slow	5.0 Slow

Subject	List 1	List 2	List 3
1	1	2	3
2	0	0	0
3	0	1	1
4	0	2	4
5	0	1	1
6	1	0	1
7	3	5	5
8	2	2	2
9	2	3	3
10	0	2	2

		Output	Input
Condition:	Training	.8 Fast	5.0 Slow
	Transfer	.8 Fast	2.0 Fast

Subject	List 1	List 2	List 3
1	1	2	2
2	2	2	0
3	0	1	1
4	0	2	0
5	0	0	0
6	1	2	1
7	2	1	1
8	0	1	1
9	0	2	1
10	3	4	4

		Output	Input
Condition:	Training	.8 Fast	5.0 Slow
	Transfer	3.0 Slow	2.0 Fast

Subject	List 1	List 2	List 3
1	0	2	1
2	2	3	1
3	0	2	3
4	0	0	1
5	1	2	2
6	1	1	0
7	1	0	1
8	2	1	0
9	1	3	3
10	0	1	1

		Output	Input
Condition:	Training	3.0 Slow	2.0 Fast
	Transfer	3.0 Slow	2.0 Fast

Subject	List 1	List 2	List 3
1	2	3	3
2	3	3	4
3	5	5	5
4	5	4	4
5	5	4	5
6	8	8	5
7	3	5	3
8	7	7	7
9	4	4	5
10	7	6	5

Condition:		Output	Input
	Training	3.0 Slow	2.0 Fast
	Transfer	.8 Fast	2.0 Fast

Subject	List 1	List 2	List 3
1	1	0	1
2	0	0	1
3	0	2	3
4	0	1	0
5	0	2	1
6	1	0	1
7	0	1	1
8	0	1	1
9	0	1	2
10	2	3	4

Condition:		Output	Input
	Training	3.0 Slow	2.0 Fast
	Transfer	3.0 Slow	5.0 Slow

Subject	List 1	List 2	List 3
1	5	6	6
2	4	3	4
3	0	2	4
4	3	3	4
5	1	1	4
6	0	2	1
7	0	2	2
8	4	4	4
9	3	3	2
10	3	0	2

Condition:		Output	Input
	Training	3.0 Slow	2.0 Fast
	Transfer	.8 Fast	5.0 Slow

Subject	List 1	List 2	List 3
1	1	1	2
2	2	2	0
3	1	2	4
4	0	0	1
5	0	0	0
6	0	1	0
7	0	1	4
8	1	0	1
9	1	2	2
10	0	2	2

		Output	Input
Condition:	Training	3.0 Slow	5.0 Slow
	Transfer	3.0 Slow	5.0 Slow

Subject	List 1	List 2	List 3
1	3	4	4
2	5	7	6
3	5	6	5
4	4	4	4
5	4	6	6
6	4	4	5
7	7	8	8
8	8	6	7
9	6	7	7
10	5	4	5

		Output	Input
Condition:	Training	3.0 Slow	5.0 Slow
	Transfer	.8 Fast	5.0 Slow

Subject	List 1	List 2	List 3
1	1	3	1
2	1	1	2
3	1	2	3
4	0	1	2
5	0	0	0
6	1	3	1
7	0	0	0
8	1	2	3
9	0	1	1
10	2	3	3

		Output	Input
Condition:	Training	3.0 Slow	5.0 Slow
	Transfer	3.0 Slow	2.0 Fast

Subject	List 1	List 2	List 3
1	2	4	3
2	0	1	1
3	2	2	3
4	2	2	3
5	2	2	2
6	1	3	4
7	3	5	3
8	2	3	3
9	2	2	3
10	1	3	2

		Output	Input
Condition:	Training	3.0 Slow	5.0 Slow
	Transfer	.8 Fast	2.0 Fast
Subject	List 1	List 2	List 3
1	1	2	2
2	1	5	3
3	0	1	2
4	2	1	1
5	0	0	0
6	1	2	1
7	3	3	4
8	2	3	1
9	1	1	0
10	2	0	1

APPENDIX V

VITA

Jon G. Rogers

Personal Data:

Born: 17 January 1938; Kansas City, Kansas.

Education:

Undergraduate: Kansas State Teachers College; Emporia, A.B., 1960.
Graduate: University of Arkansas; Fayetteville, M.A., 1963.

Honors:

Sigma Xi
N.D.E.A. Fellow, University of New Mexico, Albuquerque, N. M.
National Science Summer Research Participation Fellow, Florida State University, Tallahassee, Florida.
Iben Scholar, Kansas State Teachers College, Emporia, Kansas.

Publications:

Avoidance behavior instigated by x-irradiation in backward conditioning paradigms, Psychological Reports, 1964, 14, 475-481.

Factors affecting low altitude target acquisition, JTF-2 Tech. Report, in press.

Appointments:

Teaching Assistant, University of New Mexico, 1965-66.
Human Factors Staff Members, Sandia Corporation, Summer, 1966.
Assistant Professor, Hendrix College; Conway, Arkansas, 1962-65.
Visiting Faculty, Arkansas State Teachers College, Conway, Arkansas, Summer, 1965.
Instructor, United States Air Force Base, Little Rock, Arkansas, 1962-63.
Research Assistant, University of Arkansas, 1961-62.