1 OF 1

ED

038724

DOCUMENT RESUME

ED 038 724 24 CG 005 382

AUTHOR	Judd, Wilson A.; Glaser, Robert
TITLE	Variability of Response Latency in Paired Associate Learning as a Function of Training Procedure.
INSTITUTION	Pittsburgh Univ., Pa. Learning Research and Development Center.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.; Office of Naval Research, Washington, D.C. Psychological Sciences Div.
REPORT NO	TR-9
BUREAU NO	BR-5-0253
PUB DATE	Mar 70
NOTE	45p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$2.35
DESCRIPTORS	Experiments, *Learning, Paired Associate Learning, *Reaction Time, *Research, Research Projects, *Response Mode, *Stimuli, Stimulus Behavior, Training

ABSTRACT

Two procedures were investigated in an attempt to decrease the variability of overlearning response latencies in a study-test paradigm, paired-associate task matching CVC's with response keys: (1) self-pacing the task by presenting test trial stimuli whenever the subject pressed a "home" key; and (2) instructing and shaping subjects to keep home key depressed until they selected a response key and measuring the period of home key depression as the latency of response onset. Self-pacing was found to decrease the variability of S-R latency, but only during the early stages of overlearning drill. There was no apparent utility in timing response onset as opposed to the complete S-R response. (Author)

VARIABILITY OF RESPONSE LATENCY IN PAIRED-ASSOCIATE LEARNING AS A FUNCTION OF TRAINING PROCEDURE

Wilson A. Judd and Robert Glaser

Learning Research and Development Center

University of Pittsburgh

March 1970

The research reported herein was performed pursuant to Contract Nonr-624(18) with the Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research. The document is a publication of the Learning Research and Development Center, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education and Welfare.

VARIABILITY OF RESPONSE LATENCY IN PAIRED-ASSOCIATE LEARNING AS A FUNCTION OF TRAINING PROCEDURE[1]

Wilson A. Judd[2] and Robert Glaser

Learning Research and Development Center

University of Pittsburgh

Abstract

Two procedures were investigated in an attempt to decrease the variability of overlearning response latencies in a study-test paradigm, paired-associate task matching CVC's with response keys: (a) self-pacing the task by presenting test-trial stimuli whenever the subject pressed a "home" key, and (b) instructing and shaping subjects to keep the home key depressed until they selected a response key and measuring the period of home-key depression as the latency of response onset. Self-pacing was found to decrease the variability of S-R latency, but only during the early stages of overlearning drill. There was no apparent utility in timing response onset as opposed to the complete S-R response.

VARIABILITY OF RESPONSE LATENCY IN PAIRED-ASSOCIATE LEARNING AS A FUNCTION OF TRAINING PROCEDURE[1]

Wilson A. Judd[2] and Robert Glaser

Learning Research and Development Center

University of Pittsburgh

Response latency recently has been of considerable theoretical and applied interest in the study of learning and instruction. Experimental work has suggested that latency, i.e., the time elapsing from the onset of the stimulus to the onset of the associated response, may be a useful supplement to response frequency as a measure of the strength or degree of learning. This is true, particularly during overlearning, since frequency measures lose their sensitivity as response probability approaches asymptote. In computer-assisted instruction, latency can be easily measured and stored for making instructional decisions.

While it has been accepted that response latency decreases as a function of learning, the rate of decline has not been of sufficient magnitude nor stability to provide a measure of interest in verbal learning tasks. However, certain recent studies (Kintsch, 1965; Millward, 1964; Peterson, 1965; and Suppes, Groen, & Schlag-Rey, 1966) have demonstrated that the slow, gradual decline of response latency observed when items are averaged together on the basis of trial number may not be the most representative way of viewing changes in latency as a function of practice. In these studies, paired-associate response protocols were aligned on the basis of each item's trial of last error. The trial of last error (TLE) for a particular item is defined as the last trial on which an incorrect response was made prior to the point at which that item reached a criterion of n successive errorless trials in which n is some predetermined value. Item records are aligned so that the TLE serves as a point of origin from which all trials, both prior to and after the TLE, are counted. When such TLE-based protocols are averaged, the result is analogous to a backward learning curve. All responses falling on a particular TLE-relative trial are representative of a similar stage of learning in that each is equi-distant from the point at which the criterion is attained. The TLE may be considered to break the item response protocol into an acquisition phase (prior to the TLE) and an overlearning phase (following the TLE).

When this procedure is followed, it is apparent in studies of paired-associate learning that latencies prior to the TLE remain relatively stable; that is, there is little reduction in latency over trials to indicate that learning is taking place. In contrast, following the TLE, during overlearning, response latency demonstrates a substantial reduction as a function of TLE-relative trial number. It is this reduction in the overlearning phase that accounts for the more gradual decline observed when response latencies are averaged together on the usual basis of temporal trial number. This reduction after the TLE suggests that latencies may provide a valid measure of whatever learning process takes place during overlearning drill. As indicated, this possibility is particularly interesting since the usual measure of learning, correct response probability, is at asymptote during overlearning.

An earlier study (Judd & Glaser, 1969) investigated changes in response latency during both acquisition and overlearning, of a paired-associate task, as a function of training method (a comparison of the anticipation and study-test paradigms) and of information transmission requirements (eight stimuli mapped onto two, four, or eight response alternatives). (For future reference, this experiment will be referred to as PALL I for Paired-Associate Learning Latency Study I.) In general, it was found that latency measures following the TLE were sensitive to differences in intra-subject item difficulty and, to some extent, inter-subject differences in learning rate, as well as to the main experimental variables. These results further supported the hypothesis that post-TLE latencies might be measuring the progress of some further learning or consolidation process taking place during overlearning drill. If this is indeed the case, then post-TLE latency measures might be indicative of the subsequent retention of the individual items. This suggests the possibility of using overlearning response latency as a basis for determining the amount of overlearning drill necessary to obtain a desired probability of recall of various items.

An experiment was proposed that would attempt to determine the relationship, if any, between the latency of responses to individual items during overlearning drill and the subsequent retention of those items (Judd, Glaser, & Rosenthal, in preparation, 1970). A serious impediment to this proposed experiment and to any subsequent practical instructional applications, however, was the very high degree of variability of the latency measures which had been observed in the PALL I experiment. In this experiment, the average standard deviation for all experimental treatments was 1174 msec. prior to the TLE and 595 msec. for post-TLE responses; the means corresponding to those values were 1954 msec. prior to the TLE and 1476 msec. following the TLE. It was decided, therefore, that before attempting to determine a relationship between overlearning response latency and subsequent retention, an attempt should be made to find means for reducing the variability of the post-TLE latency measures.

Peterson (1965) had noted that the variability of latency measures prior to the TLE (measured under an anticipation paradigm) was so great as to obscure possible relationships of interest and had suggested that the variance might be reduced by the use of a study-test paradigm. In the PALL I study, a study-test paradigm similar to the one suggested by Peterson was contrasted with an anticipation paradigm. Prior to the TLE, the use of the study-test paradigm actually resulted in a slight though non-significant increase in variability as compared with the anticipation paradigm (an S. D. of 1198 msec. as opposed to an S. D. of 1151 msec. for the anticipation paradigm). Following the TLE, however, the variability of the study-test paradigm measures was significantly less ($p = .004$), although, the difference was not substantial (an S. D. of 524 msec. as opposed to an S. D. of 667 msec. for the anticipation paradigm). Since the study-test paradigm did result in less variable measures during overlearning, only this paradigm was used in the study described in this paper.

In the PALL I study it was hypothesized that if, under the anticipation paradigm, a subject made an incorrect response and was then informed of his error and shown the correct answer, he would attempt to learn this item during the inter-item interval; and this attempt might delay his subsequent attention to the next item; whereas, under the study-test paradigm, in which the subject received no feedback following his response, this effect would not be present. This hypothesis was not substantiated by the PALL I experiment but examination of the data and observation of and interviews with the subjects suggested that they did not always attend to an item as soon as it was presented. In some cases, a subject spent time reflecting on an immediately previous response which he had made quickly and then realized was incorrect. In other cases, the reason for the delay was as mundane as the subject's having to sneeze or blow his nose. For these reasons, which contributed to the variability of response latency, it was decided to allow the subjects to pace the task themselves by determining the time at which each test item was to be presented. The study portion of the study-test paradigm was also self-paced. Since it was of interest to obtain response data throughout an extensive period of overlearning drill for each item, and since items were not dropped as they reached the overlearning criterion, the subjects were required to sit through many presentations of the S-R pairs after most of the pairs had already been learned. PALL I subjects reported that this feature of the experiment had been particularly aggravating and their resultant frustrations may have had adverse effects of their performance in the later stages of the task. In the experiment under discussion, therefore, the S-R pairs were presented for a maximum period of three seconds or until the subject indicated his desire to proceed to the next item.

In addition, it was hypothesized that given appropriate instructions and preliminary training, the total S-R latency could be divided into two sections: (a) a decision period during which the subject determined which response he was going to make and initiated that response and (b) a manual response period during which the subject completed his response by lifting his finger from the resting position and pressing one of the response keys. It was anticipated that the manual response period would not change systematically over trials but would account for that portion of variability in the data due to the subject's actual motor response. If this were the case, the decision period would reflect the major systematic changes in latency as a function of learning but be less variable on an item-to-item basis.

METHOD

One group of subjects was run under conditions incorporating the factors discussed above. The latency data obtained from this group (PALL II) were then compared with the data obtained from a comparable group run in PALL I experiment. The data obtained from PALL II suggested that certain procedural changes were desirable, and another group, designated as PALL III, was run on a task which incorporated these changes. With exceptions which are specifically noted, all of the PALL I, II, and III groups were run under the same task conditions. All subjects were first trained on a short "warm-up" list of four items and then given the experimental list of eight items. Stimulus materials in all cases were CVC trigrams which were matched to eight positions on a specially constructed response panel. The study-test training paradigm was used in all tasks.

Subjects

Subjects were drawn from University of Pittsburgh introductory psychology classes in which students are required to devote four hours of time as experimental subjects and are not paid for their services. Subjects in the PALL I experimental group used as a control had been drawn from similar classes one year earlier. Each of the three groups contained 16 subjects.

Materials

The stimuli were CVC trigrams of 20 to 30 percent association value as determined by Archer (1960). Stimuli were selected so as to increase the difficulty of the task by being highly similar in terms of the composition and placement of the letters. The four trigrams, VAH, VAQ, VEH and VOZ, were used in the warm-up list. The stimuli used in the experimental list were ZAB, ZAF, ZEF, ZEG, ZIK, ZIX, ZOK, and ZOX.

Apparatus

The experiment was controlled by the Learning Research and Development Center's Computer Facility (see Judd, in preparation, 1970). Briefly, this is an on-line, time-shared system using a Digital Equipment Corporation PDP-7 computer. The system presented the stimuli, processed the subject's responses, maintained records of the subject's responses to each item, timed the response latencies and controlled the time limits imposed on responses during the warm-up list. Response latencies were measured with a tolerance of ±1 msec; all other timing was controlled to ± .02 sec. A complete record of each subject's stimuli, responses and response latencies was punched out on paper tape during the course of the experimental run. The contents of these tapes were later summarized and printed by a separate data reduction program.

Stimuli were presented on the screen of a cathode-ray tube (CRT). Each letter in a trigram was one-half inch high by three-eighths inch wide and consisted of points selected from a 7 by 5 point matrix. Subjects responded by pressing one of eight unmarked push-button micro-switch keys mounted on a sloping response panel placed on a table in front of the subject. The panel was movable so that the subject could position it for maximum ease of responding. The keys were mounted three-fourths of an inch apart in a semi-circular arc with a two-inch radius. A completed key press required a force of five ounces over a distance of one-eighth of an inch. Pilot lamps located next to each key were used to indicate the correct matching of stimulus trigrams and response keys. (Additional detail on the response panel is given in Judd and Glaser, 1969)

For the PALL II and III tasks, a ninth, "home", key was located at the center of the response key arc, two inches from each of the response keys. This key differed from the response keys in that the system detected its release as well as its depression. During the study trials, the subject could proceed to the presentation of the next item by pressing the home key. During the test trials, pressing the home key caused the stimulus to be presented on the CRT and initiated the decision portion of the subject's response. Release of the home key terminated the decision portion and started the manual portion of the response. Pressing one of the response keys completed the response and caused the stimulus to be erased from the CRT display. The response panel used for the PALL I control group did not have a home key but only a home position, indicated by a white circle on the panel. In all other respects, the panels for the three groups were identical.

PALL II EXPERIMENTS

Pall II Experimental Procedure

Subjects were run one at a time. When the subject was seated at the terminal, he was read a set of instructions which explained the nature of the task and emphasized the fact that for the most part, the subject could pace the task himself by the use of the home position key. The instructions differed from those of the PALL I control group in that they emphasized that the subject was not to release the home key until he knew which response key he was going to press and that once he did release the home key, he was to press a response key immediately. He was further instructed that there were limits as to how long he could hold the home key down and on the time from the release of the home key to the depression of a response key. It was implied that this was the case for both the warm-up and experimental lists, but, in fact, no time limits were imposed during the experimental list.

Following the instructions, the subject began work on the four item warm-up list. This began by the display of the message "LIST I" on the CRT followed by the message "TRAINING." The CVC trigrams with their corresponding pilot lamps illuminated were then presented one at a time for a maximum period of three seconds each. The inter-item interval was 250 msec., the period required to erase the screen and present a new stimulus pair. The subject could allow the program to pace itself at this rate or he could cause the program to proceed to the next item whenever he pressed the home key. During the training trials, depressions of the response keys had no effect on the presentation sequence nor were they recorded. Following a complete presentation of all of the S-R pairs, the message "TEST" was displayed for two seconds. The screen was then erased and remained blank until the subject pressed the home key, indicating that he was ready for a stimulus, and the stimulus was presented. If the subject did not release the home key within two and one-half seconds, the screen was erased, and the item was counted as incorrect. If the key was released in time, the stimulus remained on the screen and the subject was allowed one second in which to press one of the response keys. Again, if he exceeded the time limit, the CRT was erased and the item was counted as incorrect. If he did complete his response within one second, the screen was erased and the response was evaluated for correctness. The CRT then remained blank until the subject pressed the home key to request the presentation of the next item, etc. When all items in the warm-up list had been tested, the subject was given another training trial. The alternation of training and test trials continued until each item on the list had reached a criterion of six successive errorless trials plus two additional trials. When the last item to be learned reached this criterion, the message "END OF LIST 1" was displayed and the subject was given a one minute break.

The presentation procedure for the eight item experimental list differed from that of the warm-up list in only two respects: (a) No time limits were placed on either the time from the home key's depression to its release or from its release to the depression of one of the response keys. The stimulus always remained on the CRT until the subject pressed one of the response keys. (b) The learning criterion for each item was six successive errorless trials plus ten additional trials. When all eight items reached criterion, the subject was informed that the experiment was completed and was dismissed.

PALL II Results

The standard deviations of the response latencies obtained in the PALL II task are shown in columns two and three of Table 1.

Insert Table 1 about here

Consider first the values obtained for the complete S-R response (decision time plus manual response time), shown in column two. These are to be contrasted with the values obtained from the data of the PALL I group which are shown in column one. The average post-TLE standard deviation, for all subjects and all post-TLE trials was 678 msec. This is less than half of the value, 1544 msec., obtained from the PALL I data. Considering each of the 16 post-TLE trials separately, the standard deviation values of the self-paced group were less than those of the PALL I group in 12 of the 16 trials. Considering the average standard deviation for all trials of each of the 16 subjects in each group, a Mann Whitney U-test yielded a U value of 71; the probability of obtaining a value at least this small by chance is less than .025. All in all, it may be concluded that the procedures used for training the PALL II group did result in substantially less variable S-R latency data.

The effect of measuring the decision latency (or response onset) may be observed by contrasting columns two and three in Table 1. The standard deviation for all pre-TLE responses was 105 msec. less for the decision latencies than for the complete S-R response latencies. Following the TLE, the standard deviation of all decision latencies, averaged over trials, was 144 msec. less than the comparable S-R values. Considering the across-subjects average on each of the 16 trials, the decision latency standard deviations were less than the comparable S-R values in all of the 16 cases. Likewise, examination of the average standard deviation over all 16 trials for each of the 16 subjects revelated that the decision latencies were less than the complete S-R latencies for all subjects. The chance probability of such a result, as determined by the Wilcoxon Matched-Pairs Signed Ranks Test, is less than .005. So, as would be anticipated from component variances which are not highly correlated, breaking the complete S-R response into decision and manual portions produced a less variable measure of response latency.

While both self-pacing and the procedure of measuring response onset had the desired effect of reducing the variability of the overlearning latency data, it was found that these procedures also substantially reduced the decrement in latency over post-TLE trials. A comparison of the latency measures obtained over trials for the PALL I and PALL II groups is shown in Figure 1. Considering first

----

Insert Figure 1 about here

----

the complete S-R response latencies for the PALL I group, the mean S-R latency of the sixteenth post-TLE trial was 1081 msec. less than the mean latency of all pre-TLE responses. The comparable reduction for the PALL II group was only 352 msec. As may be seen in Figure 1, this difference was due primarily to a difference in pre-TLE latencies rather than a difference in the latencies obtained during the later stages of overlearning drill. For the PALL I subjects, the mean pre-TLE latency was 2394 msec; for the PALL II subjects, the mean pre-TLE S-R latency was only 1653 msec. Starting from these different baselines, the two groups had achieved similar response latencies halfway through the overlearning drill. The PALL II pre-TLE latencies were apparently already so fast that there was little room for improvement as a function of overlearning drill. One way of assessing the utility of the two training procedures in producing a latency drop is to consider the ratio of the post-TLE latency reduction to the average post-TLE standard deviation. For the original PALL I group, this ratio was .70; for the PALL II group, the ratio was .52.

Comparing decision latency measures with the S-R latency measures, the data showed that while the decision latency variability was consistently less than the comparable S-R latency variability, the magnitude difference between the two measures was not constant over trials. While, as indicated, the total reduction in S-R latency was 352 msec., the total decision latency reduction was 228 msec. Thus, in addition to initiating their manual responses sooner as overlearning drill progress, the subjects also shortened the time used to complete their responses. For the decision latency measures, the ratio of post-TLE latency reduction to post-TLE standard deviation was .43.

While the procedures of self-pacing and measuring responses onset vis-a-vis response completion did indeed reduce the variability of the data following the TLE, these decreases in variability were not considered to be sufficient to compensate for the smaller reduction in latency which was obtained. After re-examining the PALL II experimental conditions, it was concluded that the instructions and response shaping procedures used in the warm-up task were responsible for the short pre-TLE latencies observed in the main list. During the warm-up task, the subjects had been given two and one-half seconds in which to initiate their responses after pressing the home key, and one second in which to complete the response. If either action was too slow, they were punished by having the screen erased, indicating that the item was counted as incorrect. Under these conditions, the subject had two opportunities to be "punished" for a slow response and this apparently prompted the subjects to respond very quickly throughout the task. The habit of fast responding then carried over to the experimental list. It will be recalled that while there were no time limits imposed during the experimental list, the subjects were not made aware of this change in procedure. On the other hand, it also appeared that too much time had been allowed for the manual portion of the response. Contrary to their instructions to press a response key immediately after releasing the home key, it would appear that the subjects' uncertainty as to which response to make during the pre-TLE trials had prolonged the manual portion of the response. As this uncertainty decreased with overlearning, the manual response latency decreased accordingly.

PALL III EXPERIMENT

PALL III Procedure

An attempt was made to alter the task conditions so as to (a) increase the latency of the pre-TLE S-R responses and (b) shorten the latency of the manual responses throughout the task while (c) maintaining the reduced variability demonstrated in the PALL II task. It appeared that the most reasonable step would be to increase the time allowed for the decision period and to reduce the time allowed for the manual response. Warm-up list time limits had originally been imposed in the PALL I study to prevent the subjects from rehearsing several items before responding to an individual item and, more generally, to shape relatively short, and therefore less variable, response latencies. Experience with the self-pacing procedure showed that subjects tended to adopt a strategy of proceeding quickly from one item to another; hence, it was anticipated that if there were no time limit on the decision period, the subjects would still tend to respond at a satisfactory rate. The warm-up list procedure was therefore altered to eliminate the decision period time limit. The warm-up list time limit on the manual portion of the response was retained and shortened to .75 seconds. The instructions given the subjects were modified to correspond to the new procedure. Subjects were informed that they could wait as long as they wished between items and that once they pressed the home key, the stimulus would remain on the screen as long as they held the key depressed. Once they released the home key, however, they were told they had only one second (the actual time was .75 second) in which to complete their response. As in the case of the PALL II group, no time limits were imposed during the experimental list, but again, the subjects were not informed of this. Otherwise, the task conditions were identical to those of the PALL II task.

PALL III Results

The standard deviation values obtained from the PALL III group are shown in columns four and five of Table 1. For all but one trial, the standard deviation values obtained were greater than those obtained under the conditions of the PALL II group. First, let us consider the complete S-R latencies by contrasting them with the PALL I values in column one. The average post-TLE standard deviation, averaged across subjects and trials, was substantially less for the PALL III group., 1229 as opposed to 1544 msec. Considering each of the 16 post-TLE trials separately, however, the PALL III group had smaller standard deviation values in only 7 of the 16 cases. In general, the PALL III group tended to have less variable data on the earlier post-TLE trials while the PALL I group was less variable on the latter half of the overlearning drill. Considering the average standard deviation for all trials of each of the 16 subjects in each group, a Mann-Whitney U-test yielded a U value of 135, indicating no significant difference between the two distributions. It must be concluded that the procedures used in training the PALL III group had little effect in reducing the variability of the post-TLE data as compared with the procedures used in training the PALL I group.

Turning now to decision latency measures, we find that, in general, the average decision latencies were as variable as the latencies of the complete S-R response, implying a higher correlation (or closer tracking) between the component latencies than in the PALL II data. Prior to the TLE, the average standard deviation of the decision latency of all responses was only 3 msec. less than the standard deviation of the complete S-R latencies. The average post-TLE decision latency standard deviation was actually slightly greater than the comparable S-R latency standard deviation, 1248 as opposed to 1229 msec. Considering each of the 16 post-TLE trials separately, it is found that the standard deviations of the decision latencies were less than those of the corresponding S-R latencies for 9 of the 16 trials. Considering the average standard deviations for all post-TLE trials for each of the 16 subjects, it is found that the decision latencies were less variable than the S-R latencies in 13 of the 16 cases. This result was found to be significant ($p < .01$) by the Wilcoxon Signed Ranks test, due to the small magnitude of the differences (a mean difference of 19 msec.), however, this finding is of negligible interest. It may be concluded that, under the self-pacing procedures used in the PALL III task, response onset latency measures were not substantially less variable than measures of the complete S-R response.

The self-pacing procedure would still have utility if the post-TLE decrement were sufficiently large. A comparison of the latency measures obtained over trials for the PALL I and PALL III groups is shown in Figure 2. The PALL III pre-TLE average latency

Insert Figure 2 about here

was substantially greater than the value obtained under the PALL II conditions but was still not as great as the pre-TLE average latency observed under the PALL I conditions, 2394 msec. for PALL I and 2288 msec. for PALL III. Removing the warm-up list time limit on response onset did have the anticipated effect of increasing decision latencies during the acquisition phase of the main list but apparently the self-pacing procedure tended to have a general effect of decreasing the subject's latencies during this period. The total decrement in S-R latency from the pre-TLE average to the sixteenth post-TLE trial was 763 msec; the ratio of decrement to post-TLE standard deviation was .62. This was greater than the 352 msec. drop obtained under the PALL II conditions but less than the 1081 msec. decrement obtained under the PALL I conditions.

The post-TLE decrement of the decision latencies was less than that of the total S-R latency, 649 as opposed to 763 msec. Apparently, the subjects still tended to shorten the latency of their manual responses as overlearning drill progressed, despite the .75 second time limit imposed on the manual response during the warm-up list. The ratio of the decision latency decrement to the average post-TLE standard deviation was .52.

DISCUSSION

The results reported demonstrate that the characteristics of response latency are easily influenced by task considerations. For the particular purpose of decreasing the variability of latency, the procedure of breaking the complete S-R response into two components, a decision component and a manual component, does not appear to be beneficial in a task such as the one under consideration. While the response onset measure was substantially less variable under the shaped fast response conditions of the PALL II task than the complete S-R response latency measure, it did not show as much of a decrement over post-TLE trials as did the S-R measure. Under the conditions of the PALL III task, in which the subjects were given unlimited time to begin their response and had been shaped to make the manual response very quickly, the decision period still displayed less of a decrement over trials than did the complete S-R response. In this case, moreover, the decision latency measure tracked the S-R latency measure very closely and thus, both measures were equally variable. The problem in both cases was that the manual response accounted for some of the decrement observed in the S-R latency measure. Comparison of the pre-TLE baseline mean and the sixteenth post-TLE trial, showed that the mean manual response latency was shortened over trials by 155 msec. in the PALL II task and 114 msec. in the PALL III task.

Whatever process (or processes) may underlie the post-TLE latency decrement, it appears to influence both the subject's decision latency and the latency of his manual response. It is of interest to speculate about what this may imply for those tasks for which this is the case. First, let us make the somewhat questionable assumption that the subjects did follow the instructions in that they did not begin the manual response until they had selected a particular response key. If the observed decrement in post-TLE response latency is a function of some alteration in the response retrieval process, it is not at all obvious why the manual response latency should be reduced. If, on the other hand, the observed latency decrement is at least partially some function of the subject's confidence in the correctness of his response, the quickening of the manual response would appear, to the authors, at least, to be more easily explained. It is suggested that once a response has been selected, the subject would be slower to commit himself to this response, i.e., to complete the manual portion of the response, if he had relatively little confidence that the response was correct. As overlearning proceeds and the subject receives additional confirmation that the response is correct, his increased confidence could result in the observed reduction in manual response latency.

This is admittedly not the most parsimonious explanation of the data under discussion but evidence from the area of short-term memory suggests that it is at least a tenable explanation. Using short paired-associate lists and a probe technique, Murdock (1966) found a high negative correlation within any given retention interval between response latencies and subjects' ratings of their confidence in the correctness of their response. When the data were treated with a signal detection theory analysis, it was found that <u>d</u>' remained constant over the probe positions while Beta decreased substantially as the probe position was moved from the earlier to the later items in the list. That is, the subjects apparently employed a less stringent criterion when the probe followed a shorter retention interval (and fewer intervening items). Response latency was found to decrease as a function of retention interval in a fashion similar to the criterion reduction.

A later experiment (Murdock, 1968) further substantiated these findings. The procedure was similar to that discussed above except that in this case, the subjects were allowed only one, two, or four seconds in which to make their response. Shortening the allowed response time resulted in a small but significant reduction in correct response probability but this effect was constant over probe positions. Murdock reasoned that if response latencies were actually an indication of the longer period required for a weaker response to assert itself, then the effect of limiting response time should have been greater for the earlier probe positions which consistently demonstrate lower correct response probabilities.

While these results do not rule out the possibility that response latency is a function of associative strength, they do strongly suggest that at least some component of the latency is a function of the subject's confidence in the correctness of his response.

The procedure of allowing the subject to pace the task himself appears to have some merit for decreasing the variability of the latency measure though not nearly as much as had been anticipated. The procedure used in the PALL II task, in which both the decision period and the manual response were shaped for quick responding was obviously not satisfactory; the two opportunities for aversive contingencies during the warm-up list apparently shaped up such fast responding that there was little room for subsequent improvement. Under the PALL III conditions, in which the task was self-paced and there was no shaping of the response onset latency, the pre-TLE latency mean was still slightly less than the pre-TLE mean obtained under the conditions of the PALL I task. It is difficult to see how this could be attributed to the relaxation of the decision period time limit. It might be a generalization from the shaping of a very fast manual response or it might also be attributable to the self-pacing procedure itself. In the PALL I task, the inter-item interval had been fixed at 1.5 seconds. In the PALL II and III tasks, the inter-item interval was determined by the subjects and most of the subjects requested the presentation of the next item in less than one second. Thus the task as a whole proceeded more quickly, and this may have generalized to the subject's responses as well as his determination of the inter-item interval. An alternative procedure might be to require a minimum inter-item interval by inactivating the home key for the minimum interval and then allowing the subject to determine the exact time of presentation of the item. In addition to demonstrating a faster pre-TLE latency baseline, the PALL III subjects also responded more slowly than the PALL I subjects at the end of the overlearning drill. The reason for this discrepancy is not at all apparent.

It cannot be stated, however, that the self-pacing procedure is completely without merit. At the very least, it assures that the subject's finger is in the home position at the time the stimulus is presented. Furthermore, the PALL III self-pacing did result in somewhat less variable post-TLE latency data, although the reduction was not significant. It is of interest that the greatest decrease in variability due to the self-pacing procedure occurred during the earlier post-TLE trials. Relatively few situations would arise in which one would wish to continue overlearning drill for 16 trials. If we consider only the first six post-TLE trials, corresponding to the degree of overlearning which might be useful for a retention study, we find that the average standard deviation of the PALL I task data was 2167 msec. The standard deviation of the corresponding PALL III data was only 1458 msec. Although less of a decrement occurred under the PALL III conditions than under the PALL I conditions, the ratio of decrement to standard deviation, which has been used above as a measure of utility, was slightly greater for the PALL III task, .48 as opposed to .45.

All in all, it is to be concluded that the procedures tested in these tasks did not limit the variability of response latency measures in the way anticipated. The measurement of response onset rather than response completion would appear to have little if any value in such a paired-associate task. The self-pacing procedure does appear to have some merit but it did not result in substantial reduction in variability. While other training methods might be found which would reduce the variability of latency measures without destroying the information contained in the measures, the authors find it doubtful that any drastic reduction is likely. Response latencies as measured in a learning situation are a function of a host of factors, most of which are currently unknown. While it can be a useful measure for the determination of trends in group or possibly extensive individual subject data, it would appear to be relatively limited in utility as a measure of small samples of behavior except under very tightly controlled conditions.

SUMMARY

Previous research indicated that response latencies measured during overlearning of a paired-associate task might be indicative of a continued increase in associative strength and might, thus, be useful as predictors of subsequent retention. The accuracy of such prediction would be limited, however, by the high degree of variability of latency measures which had been observed. An attempt was made, therefore, to determine task conditions which would result in decreased

variability of the latency measures during overlearning while maintaining the observed reduction in latency as a function of overlearning drill.

The current study investigated two procedures which it was hypothesized would reduce variability without disturbing the major trends of interest. These procedures were: (a) allowing the subject to pace the task himself and to determine the time at which each stimulus was presented and (b) measuring the latency of response onset as well as the time of response completion. Other than these experimental variables, the task conditions were identical to those of one of the experimental conditions of a previously run experiment. The data from this previous experimental group (designated PALL I) were used as a control for the current study.

A group of 16 subjects (designated PALL II) was trained by a study-test paradigm on a task which required the association of eight CVC trigrams with eight response-key positions. During the test trials, a stimulus was presented whenever the subject pressed a "home" key located in the middle of the response key array. He was instructed to keep the "home" key depressed until he had selected one of the response keys and then to press the response key immediately. The time at which he released the home key was recorded as the time of response onset. There were no time limits imposed on any of the subjects' actions, but they had been instructed that they were required to release the home key within two and one-half seconds of its depression and then to press one of the response keys within one second. These limits were actually in force during an immediately preceding warm-up task, and the subject was not informed that the conditions were altered in the experimental task. During the warm-up task, the stimulus was removed and the item counted as incorrect if the subject failed to release the home key or to press a response key within the specified time limits.

The self-pacing procedure had the anticipated effect of reducing the variability of the S-R latency data during overlearning (as contrasted with the PALL I data), but it also resulted in a severe curtailment of the reduction in latency during overlearning which was of fundamental interest. This was due primarily to the presence of very fast responses during acquisition, leaving little room for improvement during overlearning. It appeared that the two opportunities for aversive feedback in the warm-up task were too effective in shaping fast responding behavior.

The response onset latency data were less variable than the complete S-R response data but demonstrated even less of a latency reduction as a function of overlearning than did the S-R response data. Contrary to expectation, the subjects' manual responses became faster as overlearning drill progressed.

A second group of 16 subjects was run on a slightly modified task (designated PALL III). Only the conditions of the warm-up list were altered. No time limit was placed on response onset while the time allowed from response onset to response completion was shortened to .75 seconds. Under these conditions, S-R latency during acquisition was nearly as great as that observed for the PALL I control group but the reduction in latency during overlearning was still not as great as that observed for the PALL I task. Self-pacing did result in less variable data during the earlier trials of overlearning drill, but the data were as variable or more variable during the later overlearning trials. In general, it would appear that the self-pacing procedure has merit for decreasing the variability of the latency measure in the early stages of overlearning drill.

The response onset latency data demonstrated a slightly smaller reduction than the S-R response data and was no less variable than the complete S-R measure. In general, it would appear that there is no additional utility in measuring response onset rather than the latency of the complete S-R response in a task such as the one under consideration.

REFERENCES

Archer, E. J. A re-evaluation of the meaningfulness of all possible CVC trigrams. Psychological Monographs, 1960, 74, No. 10 (Whole No. 497).

Judd, W. A., Glaser, R., & Rosenthal, D. Response latency as a correlate of retention. (in preparation, 1970)

Judd, W. A., & Glaser, R. Response latency as a function of training method, information level, acquisition and overlearning. Journal of Educational Psychology Monograph, 1969, 60 (4), Part 2.

Judd, W. A. An on-line laboratory for behavioral research. (in preparation, 1970)

Kintsch, W. Habituation of the GSR component of the orienting reflex during paired-associate learning before and after learning has taken place. Journal of Mathematical Psychology, 1965, 2, 330-341.

Millward, R. Latency in a modified paired-associate learning experiment. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 309-316.

Murdock, B. B., Jr. The criterion problem in short-term memory. Journal of Experimental Psychology, 1966, 72, 317-324.

Murdock, B. B., Jr. Response latencies in short-term memory. Quarterly Journal of Experimental Psychology, 1968, 20, 79-82.

Peterson, L. B. Paired-associate latencies after the last error. Psychonomic Science, 1965, 2, 167-168.

Suppes, P., Groen, G., & Schlag-Rey, M. A model for response latency in paired-associate learning. Journal of Mathematical Psychology, 1966, 3, 99-128.

FOOTNOTES

[1] The research reported herein was performed pursuant to Contract Nonr-624(18) with the Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research. The document is a publication of the Learning Research and Development Center, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education and Welfare.

[2] Now at the Department of Educational Psychology at the University of Texas at Austin, Texas.

Table 1

Standard Deviations of Response Latencies Obtained under Three Different Experimental Procedures

(Values shown are means of the 16 Subjects in each group)

	PALL I	PALL II		PALL III	
	S-R	S-R	DECISION	S-R	DECISION
Pre-TLE Average	*	966	861	1506	1503
Trial TLE+1	3178	771	606	1426	1880
TLE+2	1187	501	494	1862	1863
TLE+3	2959	689	545	1988	2002
TLE+4	2286	651	431	1351	1335
TLE+5	1257	541	484	789	772
TLE+6	842	1187	1072	777	775
TLE+7	1119	841	600	1182	1026
TLE+8	928	596	465	1619	1621
TLE+9	1845	498	383	868	862
TLE+10	704	936	379	1064	1034
TLE+11	652	462	427	677	597
TLE+12	753	517	437	896	800
TLE+13	838	482	388	845	849
TLE+14	507	543	381	833	829
TLE+15	465	547	531	1179	1185
TLE+16	1027	477	397	966	969
Post-TLE Average	1544	678	534	1229	1248

* Due to a filing error, the PALL I acquisition data were destroyed. Mean latency values were retained and are shown in Figures 1 and 2.

FIGURE CAPTIONS

Figure 1. Response latencies from the PALL I and II tasks as a function of TLE-relative trial number. (Data points given in Appendix A)

Figure 2. Response latencies from the PALL I and III tasks as a function of TLE-relative trial number. (Data points given in Appendix A)

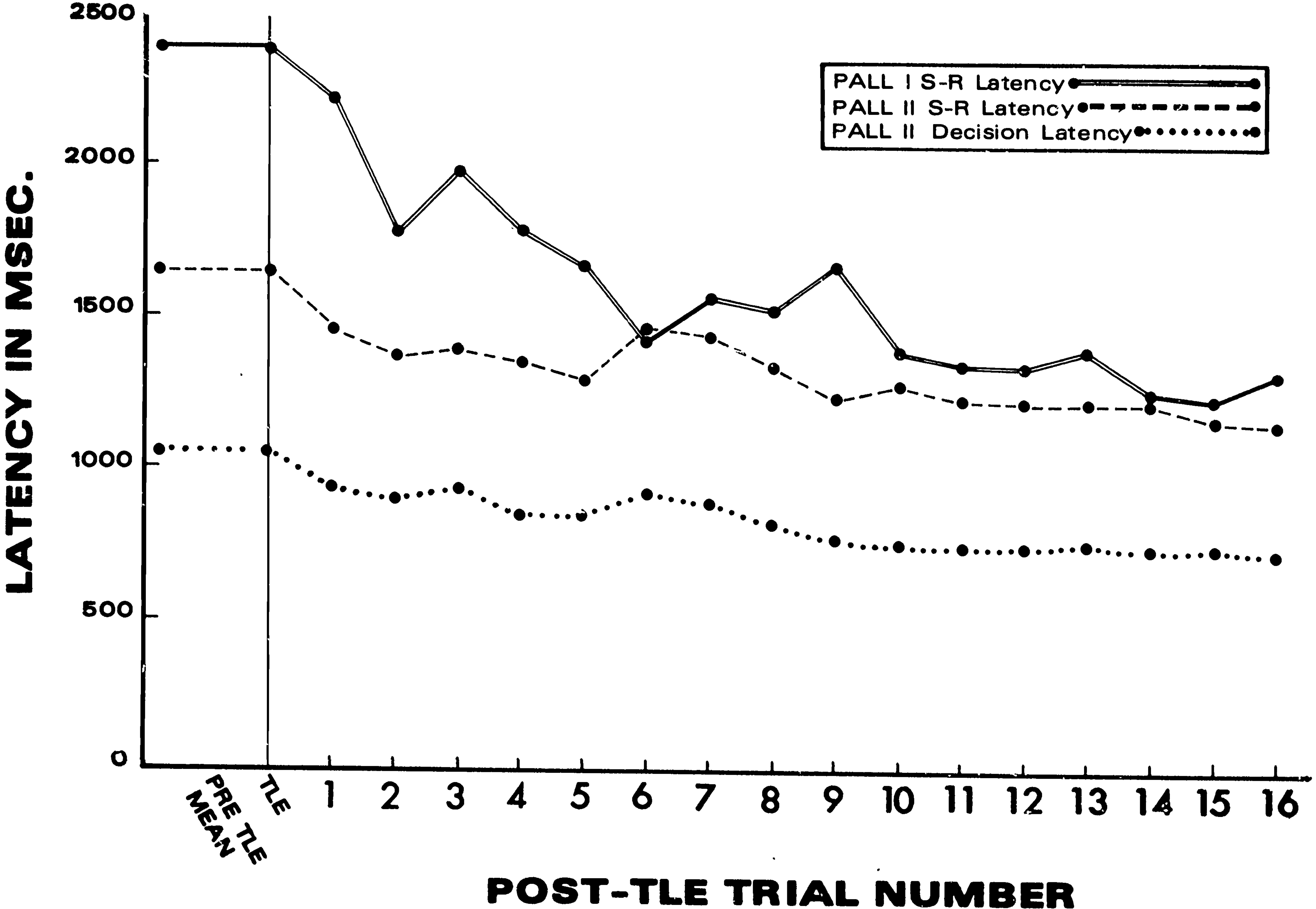

Figure 1. Response latencies from the PALL I and II tasks as a function of TLE-relative trial number. (Data points given in Appendix A)

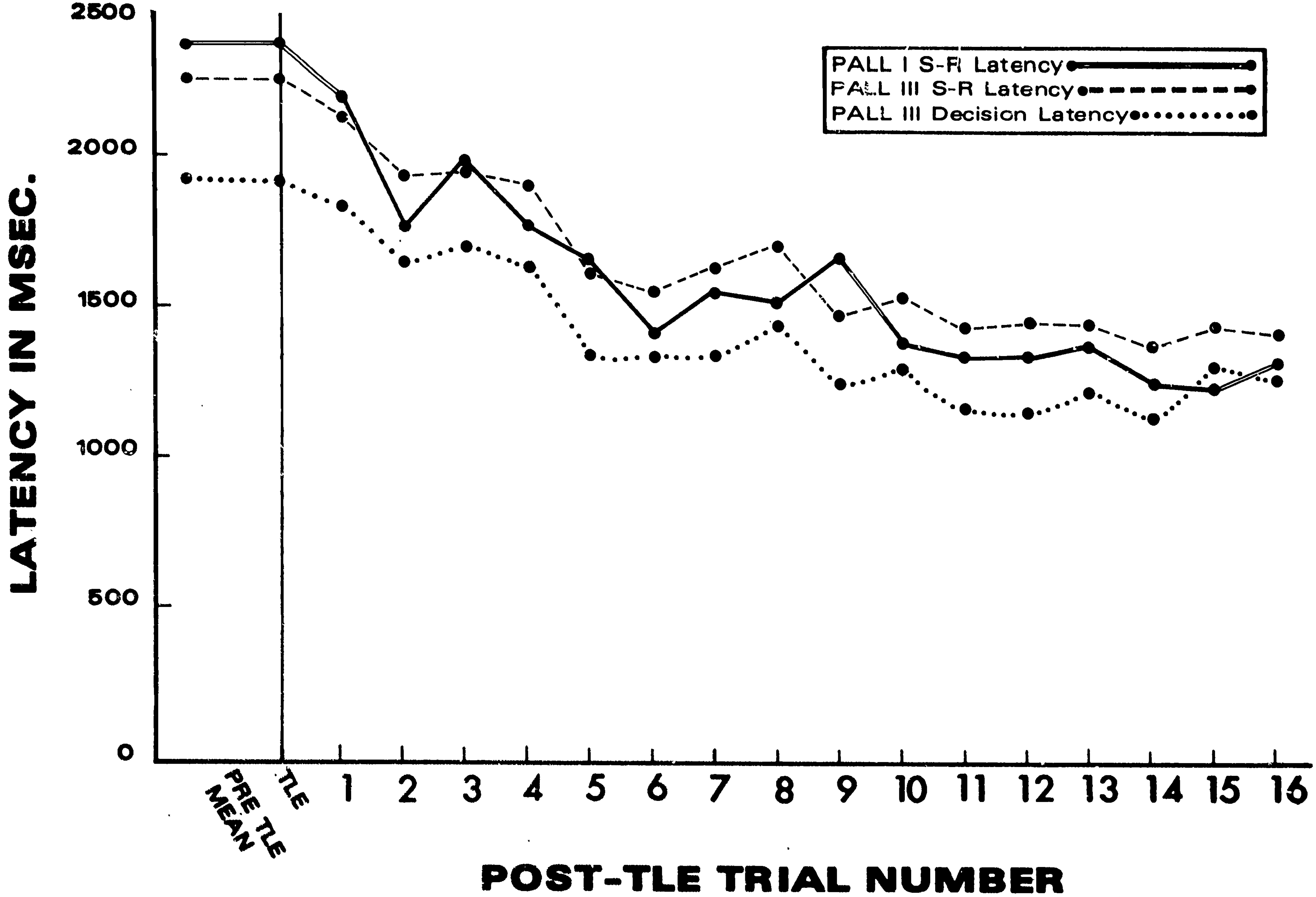

Figure 2. Response latencies from the PALL I and III tasks as a function of TLE-relative trial number. (Data points given in Appendix A)

APPENDIX A

Data for data points in Figures 1 and 2

(All values are in terms of milleseconds)

PALL I S-R latency (used in both figures one and two)

pre-TLE mean	2394		
trial TLE+1	2202	trial TLE+11	1356
2	1773	12	1357
3	1998	13	1397
4	1791	14	1262
5	1671	15	1239
6	1411	16	1313
7	1562		
8	1519		
9	1683		
10	1395		

Figure 1, PALL II Task

Trial Number	S-R Latency	Decision Latency
pre-TLE Mean	1653	1049
trial TLE+1	1459	928
2	1374	899
3	1397	916
4	1348	848
5	1298	865
6	1438	916
7	1432	892
8	1335	819
9	1231	772
10	1282	762
11	1229	763
12	1213	769
13	1218	774
14	1230	755
15	1180	755
16	1167	718

Figure 2, PALL III Task

Trial Number	S-R Latency	Decision Latency
pre-TLE Mean	2288	1938
trial TLE+1	2148	1861
2	1951	1666
3	1981	1704
4	1911	1648
5	1608	1356
6	1586	1350
7	1651	1366
8	1707	1460
9	1494	1264
10	1565	1304
11	1456	1186
12	1471	1179
13	1462	1239
14	1387	1148
15	1549	1317
16	1525	1289

ONR Distribution List

NAVY

4 Chief of Naval Research
Code 458
Department of the Navy
Washington, D. C. 20360

1 Director
ONR Branch Office
495 Summer Street
Boston, Massachusetts 02210

1 Director
ONR Branch Office
219 South Dearborn Street
Chicago, Illinois 60604

1 Director
ONR Branch Office
1030 East Green Street
Pasadena, California 91101

6 Director
Naval Research Laboratory
Washington, D. C. 20390
Attn: Technical Information Division

6 Director
Naval Research Laboratory
Attn: Library, Code 2029 (ONRL)
Washington, D. C. 20390

1 Office of Naval Research
Area Office
207 West Summer Street
New York, New York 10011

1 Office of Naval Research
Area Office
1076 Mission Street
San Francisco, California 94103

20 Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, Virginia 22314

1 Superintendent
Naval Postgraduate School
Monterey, California 93940
Attn: Code 2124

1 Head, Psychology Branch
Neuropsychiatric Service
U. S. Naval Hospital
Oakland, California 94627

1 Commanding Officer
Service School Command
U. S. Naval Training Center
San Diego, California 92133

3 Commanding Officer
Naval Personnel & Training Research Laboratory
San Diego, California 92152

1 Officer in Charge
Naval Medical Neuropsychiatric Research Unit
San Diego, California 92152

NAVY

1 Commanding Officer
Naval Air Technical Training Center
Jacksonville, Florida 32213

1 Dr. James J. Regan
Naval Training Device Center
Orlando, Florida 32813

1 Chief
Aviation Psychology Division
Naval Aerospace Medical Institute
Naval Aerospace Medical Center
Pensacola, Florida 32512

1 Chief
Naval Air Reserve Training
Naval Air Station
Box 1
Glenview, Illinois 60026

1 Technical Library
U. S. Naval Weapons Laboratory
Dahlgren, Virginia 22448

1 Chairman
Leadership/Management Committee
Naval Sciences Department
U. S. Naval Academy
Annapolis, Maryland 21402

1 Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
(Code AX)
Washington, D. C. 20380

1 Technical Services Division
National Library of Medicine
8600 Rockville Pike
Bethesda, Maryland 20014

1 Behavioral Sciences Department
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Commanding Officer
Naval Medical Field Research Laboratory
Camp Lejeune, North Carolina 28542

1 Director
Aerospace Crew Equipment Department
Naval Air Development Center, Johnsville
Warminster, Pennsylvania 18974

1 Chief
Naval Air Technical Training
Naval Air Station
Memphis, Tennessee 38115

1 Technical Library
Naval Training Device Center
Orlando, Florida 32813

1 Technical Library
Naval Ship Systems Command
Main Navy Building, Rm. 1532
Washington, D. C. 20360

1 Technical Library
Naval Ordnance Station
Indian Head, Maryland 20640

1 Naval Ship Engineering Center
Philadelphia Division
Technical Library
Philadelphia, Pennsylvania 19112

1 Library, Code 0212
Naval Postgraduate School
Monterey, California 93940

NAVY

1 Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Technical Library
Naval Ordnance Station
Louisville, Kentucky 40214

1 Library
Naval Electronics
Laboratory Center
San Diego, California 92152

1 Technical Library
Naval Undersea Warfare Center
3202 E. Foothill Boulevard
Pasadena, California 91107

1 AFHRL (HRTT/Dr. Ross L. Morgan)
Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL (HRO/Dr. Meyer)
Brooks Air Force Base
Texas 78235

1 Mr. Michael Macdonald-Ross
Instructional Systems Associates
West One
49 Welbeck Street
London W1M 7HE
England

1 Commanding Officer
U. S. Naval Schools Command
Mare Island
Vallejo, California 94592

1 Dr. Don C. Coombs
Assistant Director
ERIC Clearinghouse
Stanford University
Palo Alto, California 94305

1 Scientific Advisory Team (Code 71)
Staff, COMASWFORLANT
Norfolk, Virginia 23511

1 ERIC Clearinghouse
Educational Media and Technology
Stanford University
Stanford, California

1 ERIC Clearinghouse
Vocational and Technical Education
Ohio State University
Columbus, Ohio 43212

1 Education & Training Developments Staff
Personnel Research & Development Lab.
Building 200, Washington Navy Yard
Washington, D. C. 20390

1 Director
Education & Training Sciences Dept.
Naval Medical Research Institute
Building 142
National Naval Medical Center
Bethesda, Maryland 20014

1 LCDR J. C. Meredith, USM (Ret.)
Institute of Library Research
University of California, Berkeley
Berkeley, California 94720

1 Mr. Joseph B. Blankenheim
NAVELEX 0474
Munitions Building, Rm. 3721
Washington, D. C. 20360

NAVY

1 Commander
Operational Test &
Evaluation Force
U. S. Naval Base
Norfolk, Virginia 23511

1 Office of Civilian
Manpower Management
Department of the Navy
Washington, D. C. 20350
Attn: Code 023

1 Chief of Naval Operations, Op-07TL
Department of the Navy
Washington, D. C. 20350

1 Chief of Naval Material
(MAT 031M)
Room 1323, Main Navy Bldg.
Washington, D. C. 20360

1 Naval Ship Systems Command
Code 03H
Department of the Navy
Main Navy Building
Washington, D. C. 20360

1 Chief
Bureau of Medicine and Surgery
Code 513
Washington, D. C. 20390

1 Technical Library
Bureau of Naval Personnel
(Pers-11b)
Department of the Navy
Washington, D. C. 20370

1 Director
Personnel Research &
Development Laboratory
Washington Navy Yard, Building 200
Washington, D. C. 20390

1 Commander, Naval Air Systems Command
Navy Department, AIR-4133
Washington, D. C. 20360

1 Commandant of the Marine Corps
Headquarters, U. S. Marine Corps
Code A01B
Washington, D. C. 20380

ARMY

1 Human Resources Research Office
Division #6, Aviation
Post Office Box 428
Fort Rucker, Alabama 36360

1 Human Resources Research Office
Division #3, Recruit Training
Post Office Box 5787
Presidio of Monterey, California 93940
Attn: Library

1 Human Resources Research Office
Division #4, Infantry
Post Office Box 2086
Fort Benning, Georgia 31905

1 Department of the Army
U. S. Army Adjutant General School
Fort Benjamin Harrison, Ind. 46216
Attn: AGCS-EA

ARMY

1 Director of Research
U. S. Army Armor
Human Research Unit
Fort Knox, Kentucky 40121
Attn: Library

1 Research Analysis Corporation
McLean, Virginia 22101
Attn: Library

1 Human Resources Research Office
Division #5, Air Defense
Post Office Box 6021
Fort Bliss, Texas 79916

1 Human Resources Research Office
Division #1, Systems Operations
300 North Washington Street
Alexandria, Virginia 22314

1 Director
Human Resources Research Office
The George Washington University
300 North Washington Street
Alexandria, Virginia 22314

1 Armed Forces Staff College
Norfolk, Virginia 23511
Attn: Library

1 Chief
Training and Development Division
Office of Civilian Personnel
Department of the Army
Washington, D. C. 20310

1 U. S. Army Behavioral Science
Research Laboratory
Washington, D. C. 20315

1 Walter Reed Army Institute of Research
Walter Reed Army Medical Center
Washington, D. C. 20012

1 Behavioral Sciences Division
Office of Chief of Research
and Development
Department of the Army
Washington, D. C. 20310

1 Dr. George S. Harker
Director, Experimental Psychology Div.
U. S. Army Medical Research Laboratory
Fort Knox, Kentucky 40121

AIR FORCE

1 Director
Air University Library
Maxwell Air Force Base
Alabama 36112
Attn: AUL-8110

1 Cadet Registrar
U. S. Air Force Academy
Colorado 80840

1 Headquarters, ESD
ESVPT
L. G. Hanscom Field
Bedford, Massachusetts 01731
Attn: Dr. Mayer

1 AFHRL (HRT/Dr. G. A. Eckstrand)
Wright-Patterson Air Force Base
Ohio 45433

AIR FORCE

1 Commandant
U. S. Air Force School of
Aerospace Medicine
Brooks Air Force Base, Texas 78235
Attn: Aeromedical Library
(SMSDL)

1 6570th Personnel Research Laboratory
Aerospace Medical Division
Lackland Air Force Base
San Antonio, Texas 78236

1 AFOSR (SRLB)
1400 Wilson Boulevard
Arlington, Virginia 22209

1 Research Psychologist
SCBB, Headquarters
Air Force Systems Command
Andrews Air Force Base
Washington, D. C. 20331

1 Headquarters, U. S. Air Force
Chief, Analysis Division (AFPDPL)
Washington, D. C. 20330

1 Headquarters, U. S. Air Force
Washington, D. C. 20330
Attn: AFPTRTB

1 Headquarters, U. S. Air Force
AFRDDG
Room 1D373, The Pentagon
Washington, D. C. 20330

1 Headquarters, USAF (AFPTRD)
Training Devices and Instructional
Technology Division
Washington, D. C. 20330

MISCELLANEOUS

1 Dr. Alvin E. Goins, Executive Secretary
Personality & Cognition Research
Review Committee
Behavioral Sciences Research Branch
National Institute of Mental Health
5454 Wisconsin Avenue, Room 10A11
Chevy Chase, Maryland 20203

1 Dr. Mats Bjorkman
University of Umea
Department of Psychology
Umea 6, Sweden

1 Technical Information Exchange
Center for Computer Sciences
and Technology
National Bureau of Standards
Washington, D. C. 20234

1 Director
Defense Atomic Support Agency
Washington, D. C. 20305
Attn: Technical Library

1 Executive Secretariat
Interagency Committee on
Manpower Research
Room 515
1738 "M" Street, N. W.
Washington, D. C. 20036
(Attn: Mrs. Ruth Relyea)

1 Mr. Joseph J. Cowan
Chief, Personnel Research Branch
U. S. Coast Guard Headquarters
PO-1, Station 3-12
1300 "E" Street, N. W.
Washington, D. C. 20226

MISCELLANEOUS

1 Executive Officer
American Psychological Association
1200 Seventeenth Street, N. W.
Washington, D. C. 20036

1 Mr. Edmund C. Berkeley
Information International, Inc.
545 Technology Square
Cambridge, Massachusetts 02139

1 Dr. Donald L. Bitzer
Computer-Based Education Research
Laboratory
University of Illinois
Urbana, Illinois 61801

1 Dr. C. Victor Bunderson
Computer Assisted Instruction Lab.
University of Texas
Austin, Texas 78712

1 Dr. F. J. DiVesta
Education & Psychology Center
Pennsylvania State University
University Park, Pennsylvania 16802

1 Dr. Phillip H. DuBois
Department of Psychology
Washington University
Lindell & Skinker Boulevards
St. Louis, Missouri 63130

1 Dr. Wallace Feurzeig
Bolt, Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

1 Dr. Carl E. Helm
Department of Educational
Psychology
Graduate Center
City University of New York
33 West 42nd Street
New York, New York 10036

1 Dr. Bert Green
Department of Psychology
John Hopkins University
Baltimore, Maryland 21218

1 Dr. J. P. Guilford
University of Southern California
3551 University Avenue
Los Angeles, California 90007

1 Dr. Harold Gulliksen
Department of Psychology
Princeton University
Princeton, New Jersey 08540

1 Dr. Duncan N. Hansen
Center for Computer Assisted Instruction
Florida State University
Tallahassee, Florida 32306

1 Dr. Albert E. Hickey
Entelek, Incorporated
42 Pleasant Street
Newburyport, Massachusetts 01950

1 Dr. Howard H. Kendler
Department of Psychology
University of California
Santa Barbara, California 93106

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Park
Goleta, California 93107

1 S. Fisher, Research Associate
Computer Facility
Graduate Center
City University of New York
33 West 42nd Street
New York, New York 10036

MISCELLANEOUS

1 Dr. Henry S. Odbert
National Science Foundation
1800 "G" Street, N. W.
Washington, D. C. 20550

1 Dr. Gabriel D. Ofiesh
Center for Educational Technology
Catholic University
4001 Harewood Road, N. E.
Washington, D. C. 20017

1 Dr. Joseph W. Rigney
Electronics Personnel Research Group
University of Southern California
University Park
Los Angeles, California 90007

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

1 Dr. Arthur W. Staats
Department of Psychology
University of Hawaii
Honolulu, Hawaii 96822

1 Dr. Lawrence M. Stolurow
Harvard Computing Center
6 Appian Way
Cambridge, Massachusetts 02138

1 Dr. Ledyard R. Tucker
Department of Psychology
University of Illinois
Urbana, Illinois 61801

1 Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

1 Dr. Joseph A. Van Campen
Institute for Math Studies in the
Social Sciences
Stanford University
Stanford, California 94305

1 Dr. John Annett
Department of Psychology
Hull University
Yorkshire
England

1 Dr. M. C. Shelesnyak
Interdisciplinary Communications Program
Smithsonian Institution
1025 Fifteenth Street, N. W.
Suite 700
Washington, D. C. 20005

1 Dr. Lee J. Cronbach
School of Education
Stanford University
Stanford, California 94305

1 Dr. John C. Flanagan
Applied Institutes for Research
P. O. Box 1113
Palo Alto, California 94302

1 Dr. M. D. Havron
Human Sciences Research, Inc.
Westgate Industrial Park
7710 Old Springhouse Road
McLean, Virginia 22101

1 Dr. Roger A. Kaufman
Department of Education
Institute of Instructional System
Technology & Research
Chapman College
Orange, California 92666

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Learning Research and Development Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
Variability of Response Latency in Paired Associate Learning as a Function of Training Procedure

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Technical Report

5. AUTHOR(S) *(First name, middle initial, last name)*
Wilson A. Judd and Robert Glaser

6. REPORT DATE
March 1970

7a. TOTAL NO. OF PAGES
33

7b. NO. OF REFS
10

8a. CONTRACT OR GRANT NO.
Nonr-624(18)

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
LRDC Technical Report 9

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited. Reproduction in whole or in part is permitted for any purpose of the U. S. Government.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Personnel and Training Branch
Psychological Sciences Division
Office of Naval Research

13. ABSTRACT

Two procedures were investigated in an attempt to decrease the variability of overlearning response latencies in a study-test paradigm, paired-associate task matching CVC's with response keys: (a) self-pacing the task by presenting test-trial stimuli whenever the subject pressed a "home" key, and (b) instructing and shaping subjects to keep the home key depressed until they selected a response key and measuring the period of home-key depression as the latency of response onset. Self-pacing was found to decrease the variability of S-R latency, but only during the early stages of overlearning drill. There was no apparent utility in timing response onset as opposed to the complete S-R response.

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Response latency						
Paired-Associate List Learning						
Overlearning						
Variability						

DD FORM 1 NOV 65 1473 (BACK)
S/N 0101-807-6821

Unclassified
Security Classification