The effect of forced guidance, massed practice, distributed practice and bisensory training on sequential information processing

THE EFFECT OF FORCED GUIDANCE, MASSED PRACTICE, DISTRIBUTED PRACTICE AND BISENSORY TRAINING ON SEQUENTIAL INFORMATION PROCESSING

by

Larry Raymond Decker

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 1

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Larry Decker

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Cecil Rogers — 2/5/71

CECIL ROGERS
Associate Professor of Psychology

Date

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

Sequential information processing was viewed as a difficult and novel task. Practice, forced guidance, and bisensory training were employed in an attempt to train the various information processing mechanisms to process more efficiently. It was found that practice decreased performance, forced guidance appeared to improve performance, and bisensory training had little effect.

INTRODUCTION

A result of a high rate of sequential information presentation is usually a degradation in responding to the individual bits of information. The critical rate of presentation or the rate at which a degradation in performance occurs is around a 200 msec information interval. This degradation has been termed psychological refractoriness (PR). It is demonstrated by a delay in a second reaction time (RT2) relative to a first reaction time (RT1).

There have been several interpretations of this phenomenon. The explanation that has survived most of the experiments done on PR is single-channel theory. This theory is well represented in the works of Welford (1952), Davis (1957, 1959), Adams and Chambers (1962), and Reynolds (1966). The theory states that _S_'s processing the second of two stimulus events (S2) is contingent upon the processing of the first stimulus event (S1). S2 is temporarily stored during the formation of the RT1 thus accounting for the observed degradation of RT2.

The other major interpretations have been the temporal and event uncertainty theory, the expectancy theory, or preparatory-state theory. These theories are well represented by Poulton (1950), Ellithorn and Lawrence

(1955), and Adams (1962). The major statement that these other theories espouse is that when the inter-stimulus-interval (ISI) is selected randomly from a range of values this confounds the length of the interval. When these random ISIs are presented to S along with a varying of S1 and S2 S is uncertain as to the time between S1 and S2 and is uncertain as to which stimulus will be S1 and which stimulus will be S2. The expectancy theorists argue, then, that the delay in RT2 is a result of this temporal and event uncertainty. However, the single-channel theorists argue that there is a definite limit at which man can process information.

A recent study by Bernstein, Blake, and Hughes (1968) has demonstrated that with the same ISI and the same S1-S2 pairings over 10 trials there is still a delay in RT2 at the lower intervals (0, 25, 50, and 75 msec.). This study implies that temporal and event uncertainty act mainly to increase the delay in RT2. The authors take a modified single-channel approach and break down the information processing task into three stages or levels: filtering or detection, processing or recognition (stimulus analysis), and response selection. The mechanisms which operate at each stage are looked upon as separate mechanisms which means that they may process in a serial fashion (Bernstein et al., 1968). Hence, much recent research involves a search for which particular mechanism may be causing the delay, a mechanism with a single-channel limitation. The strategy is to alleviate the load on a particular mechanism and then check for a delay in RT2.

An example of the attempt to remove the load on the response selection stage is to require a response to S2 only (Davis, 1959; Nickerson, 1965). Such studies found a delay still apparent in RT2. Unfortunately, these studies employed random ISIs, thus confounding temporal uncertainty with their results. Another strategy, this time directed at removing the load on the stimulus recognition or the stimulus analyzer stage, is to have S spontaneously elicit RT1 and follow that with a stimulus requiring a second response (Davis, 1959). No delay was found in that situation. However, that approach could also be interpreted as alleviating the load on the response selection stage. Finally, an ingenious experiment by Blake and Fox (1969) employed form-recognition threshold as a means of alleviating the load on the response-selection stage. Using both an auditory-visual and a visual-visual task requiring a RT only to the first stimulus they found that the form-recognition threshold was not impaired even with the required preceding RT. The absence of impairment seemed to indicate that the stimulus analyzer can process in parallel and the single-channel limitation is in the response-selection stage.

However, work done in dichotic listening indicates that if two signals arrive close together, one in each message, then it is unlikely that both will be detected (Shaffer and Hardwick, 1969). When S is presented with varying lists of five-letter words at different ISIs there is another marked decline in performance at the shorter ISIs (Katz, Schoenberg, and Mayzner, 1970). These studies demonstrate that the single-channel limitation still may be in the stimulus analyzer stage. Furthermore, Blake and Fox have not demonstrated a method that is adequate to reduce or eliminate the delay in a strict RT paradigm. Most performance in everyday life is based upon some sort of motor reaction. If one is interested in the actual application of findings and is not content to test at the theoretical level, then one should base his experiments on what is occurring in everyday life. If it were possible to parallel process at each mechanism and each mechanism could process in parallel with other mechanisms, then man's ability for the task involved would be greatly enhanced.

Perhaps if one were to look at rapid information processing as a novel and difficult task, then some sort of learning technique could be applied. Initially, practice *per se* was thought of as a training device. Several investigators have noted large practice effects in their PR studies. Reynolds (1966) talks about the difference between "well practiced" and "less well practiced" Ss in relation to temporal uncertainty. He found no PR in Ss that received 100 trials at one ISI with temporal certainty. Yet he did find PR with Ss that received only 20 trials at the same ISI. However, this result was confounded with temporal uncertainty. Davis (1959) mentions that the effect of practice in one situation significantly affects the RT in another situation. Adams (1962) found that the delay in RT1 at the short intervals was less in Ss that had been trained at those intervals than in those Ss trained on longer intervals and then tested at the shorter intervals. Other studies have employed quite a bit of distributed practice. Gottsdanker and Way (1966) employed eight sessions of one hour in length over a period of two weeks. The first two sessions were looked upon as practice, sessions 3 and 8 were controls receiving fixed ISIs, and 4 through 7 were given variable or uncertain ISIs. Unfortunately no comparisons were reported for sessions 3 and 8 or for 1, 2, 3, and 8. Two studies that measured a practice effect were done by Hick (1948) and Herman and McCauley (1969). Hick found that a delay persisted in RT2 even after 100 trials at one interval. However, these trials were randomly spaced over several intervals. Herman and McCauley found a large practice effect but they employed only a short amount of total practice: 128 trials total and 8 trials at each ISI. Most present-day experimenters use well-trained Ss in an attempt to control for a yet unquantified practice effect. Practice would thus seem to be a major variable in PR, yet is recognized mainly for its confounding effects.

The present study has employed practice as one of the main effects. Two types of practice, massed and distributed were employed. Research on massed versus distributed practice is voluminous. Most of the studies have indicated that practice is a performance and not a learning variable. Thus, while there may be no difference in the amount of learning S attains, differential fatigue may be reflected in S's performance in the practice trials. Distributed practice appears to slightly facilitate performance but there is often no substantial observable difference in spaced as opposed to massed practice (Bilodeau and Bilodeau, 1961). The present study was undertaken to see if that "no difference effect" would be replicated in a RT paradigm and to see if practice alone was an adequate training device for rapid information processing.

A recent analysis of PR in terms of signal detection theory has indicated that the delay in RT2 may be due to a decrease in sensitivity (Bernstein, Clark, and Blake, 1970). The authors do not indicate the proposed location of the decrease in sensitivity but it is still conceivable that the decrease could be in the stimulus analyzer stage. If so, a way of increasing the sensitivity of the channel or mechanism might be by pairing a click with a light.

That is, S responded to the light but had a click presented at the approximate time that the light was presented. Several studies have shown that this type of paradigm decreases overall RT. Davis (1959) has stated that "there appears to be some sort of functional convergence of signals arriving from different sense modalities; that the classifying of a signal and the organization of a response to it was performed by the same central system, no matter by what sense modality the information arrived [p. 211]." Other studies (Hershenson, 1962; Morrell, 1968; Bernstein, Clark, and Edelstein, 1969) have shown a facilitation of RT with bisensory stimulation. This facilitation has been attributed to a summation of "reaction tendencies" (Hilgard, 1933), a difference of latencies of neural responses (Morrell, 1968), and a summation of energies dependent on the extent to which both relevant and irrelevant sources arrive in functional synchrony (Bernstein et al., 1969). That is, RT to an auditory event that is simultaneous with a visual event is approximately equal to RT to an auditory event alone. This RT is facilitated in an inverted U-shaped function over increasing ISIs between the auditory and visual event. However, what was of interest in the present study was the RT to a light with the auditory stimulus merely acting as a sensitizor. Thus S was asked to ignore the click and to respond to the lights. It was hoped then that the click might sensitize the central channel and facilitate the processing of both bits of information.

Finally, a method of alleviating the load on the response selection stage and still keep a motor response in the situation was to use forced guidance. Several authors, Holding (1959) in particular, have used forced guidance as aids to training in difficult tasks. The argument for forced guidance is that if an S were trained without any active responding on his part but his relevant muscles were forced to respond at the correct time and in the correct fashion, then when the S was presented with the same situation but without the forced guidance the S might show a marked improvement in responding as compared to those Ss that received comparable amounts of practice but without the forced guidance variable.

METHOD

Subjects

Sixteen Ss were run, with four in each of four groups. There were nine females and seven males. All were students at The University of Arizona. No S had any previous experience with RT experiments.

Apparatus and Stimuli

The stimulus display was modeled after an apparatus used in a study by Reynolds (1966). Facing S at a distance of 72 in. was a vertical panel 26 by 24 in. Three holes, 1-1/2 in. square were cut such that a horizontal line bisecting their centers would be 12 in. above the table top on which the panel rested. Centers of these holes were 7 in. apart. The three holes were each covered from the front with a white plexiglass square. The center hole was also covered with a red cellophane square. This center hole provided the fixation point and the signal of the foreperiod. The targets were lit from the rear by small neon bulbs. The luminance, measured at the source, of each target was approximately 40 ft. lamberts. Each visual target subtended an approximate visual angle of 1.5°, this provided a fixation angle of 5.5°, and a total display angle of about 11°. Each stimulus light was exposed for 90 msec.

The response panel consisted of two pairs of response keys, with their centers 9-1/2 in. apart. One pair was two microswitches with a dowling stick response surface. The other pair was the same dowling stick surface attached to two solenoids. Attached to the dowling surface was a strap of leather. This leather strap, with the aid of foam rubber padding held S's first digit on each hand to the dowling surface. These latter response keys were used solely for the forced guidance group. The solenoids pulled the dowling and S's finger down a distance of 1/2 in. while S had to depress the microswitches .01 in. before contact was made.

For another group there was a set of earphones which, when plugged into the response panel, would deliver a set of clicks at approximately the same time and in synchrony with the occurrence of the stimulus lights. The clicks were well above threshold. The group that received the clicks constituted the bisensory training group.

Hunter decade interval timers delivered the fore-period, the ISIs, and the inter-trial-interval (ITI). RT was measured by S's depression of one of the microswitches which halted one of two Hunter Klockcounters. The resulting RT was then recorded by hand by E. The Klockcounters were both started by the cessation of a warning signal.

The initial presentation, or trial one, of the stimuli was made by E. However, the RT2 by S started the ITI timer. The ITI was a constant of 20 sec. for all groups at all intervals. Upon cessation of the ITI timer the foreperiod timer began which delivered the warning signal. The warning signal had a constant duration of 500 msec for all groups at all intervals. The cessation of the warning signal started the Klockcounters and started the foreperiod. The foreperiod was a dark interval of from 1 to 5 seconds in 200 msec steps, in a random order, and in a rectangular distribution. This randomization of the foreperiod intervals was in an attempt to control for any anticipatory responding to S1. When S1 began it also initiated the start of the ISI. The warning signal was the occurrence of the red light. S1 was the occurrence of one of the white lights and S2 was the occurrence of the other white light.

The stimuli, response panel, and S were all in a dimly lit anechoic chamber. E and all of the timers and relays were in a room immediately outside the chamber. A small intercom was used to communicate with S. This separation was necessary due to the loudness of the Hunter timers.

Procedure

Forced guidance (FG-D) consisted of the depression of one of two solenoids in synchrony with the occurrence of S1 and S2. That is, when S1 came on one solenoid was activated and when S2 came on the other corresponding solenoid was activated. The right solenoid always responded to the right light and the left solenoid to the left light. The activation of the solenoids was as nearly synchronous as possible with the occurrence of the lights. FG-D was instructed to remain passive during the first three blocks of trials. They were further instructed to "attempt to see the relationship between the depression of the keys and the occurrence of the lights."

Bisensory training (BT-D) received a treatment identical to FG-D except that BT-D received clicks in synchrony with the lights and RTs were recorded for this group on all of the trials. BT-D was told to respond as quickly and accurately as possible and to respond to the lights. Further instructions stated that they were to ignore the clicks. This was an attempt to keep the lights as the focal stimuli for all groups.

The distributed-practice group (VG-D) did not have either of stimuli or responses augmented in any way. Ss in this group received the same instructions as BT-D without the click instructions. The massed-practice group (VG-M) was identical to VG-D except that VG-M received all of the trials on one day. Table 1 diagrams the exact ordering of blocks across days and groups.

Table 1. Blocks of Trials by Groups and Days

Groups	Day 1	Day 2	Day 3
VG-M	All blocks 2 min. rest between each block		
VG-D	B-1	B-2	B-3 2 min. rest B-4
FG-D	B-1	B-2	B-3 2 min. rest B-4 (no FG)
BT-D	B-1	B-2	B-3 2 min. rest B-4 (no BT)

Each block of trials for all of the groups consisted of 20 trials at each of five ISIs. The five ISIs were 50, 100, 150, 200, and 250 msec intervals. The presentation of these ISIs was counterbalanced in ascending and descending order over blocks and over Ss. The blocks were all conducted on consecutive days for FG-D, BT-D, and VG-D. VG-M received all of the blocks of trials on one day, as has been previously mentioned. There were four blocks of trials total with the last two being presented on the third day for FG-D, BT-D, and VG-D. Each block of trials took approximately 45 minutes to run off. On the third day, when the two blocks were run, the first block consisted of further forced guidance for FG-D and further bisensory stimulation for BT-D. However, the fourth block or the second block on the third day resulted in all of the groups receiving equal conditions. That is, the forced guidance was removed for FG-D and the auditory stimulation was removed for BT-D. Both of these groups then received the identical instructions that VG-D and VG-M had received. The first three blocks may be looked upon as learning for all of the groups and the final fourth block may be looked at as the testing situation. There was a two-minute resting period between all of the blocks for VG-M and for blocks three and four for FG-D, BT-D, and VG-D.

All of the groups received "catch trials." That is either S1 or S2 would not come on. All of the <u>S</u>s were informed of the presence of these catch trials before the blocks of trials were begun. All of the <u>S</u>s received immediate feedback regarding their performance on the catch trials. The feedback consisted of "Perfect!" when they correctly failed to respond to the absence of the light and "Please respond only when the light comes on!" when they would incorrectly respond to the light's absence. These catch trials constituted 20% of each run of 20 trials.

All of the groups had the first 10 trials at each ISI with a sequence of stimuli going from left to right. The Ss were then informed of a change in sequence (via the intercom) and the stimuli were presented in a right to left order. Ss were not informed of the change in the ISI but were only informed of the new change in sequence. As the first 10 trials of each ISI were from left to right it soon became apparent that the change from right to left to left to right also indicated a change in ISI. Questioning of Ss at the conclusion of the experiment validated this assumption.

Before each block of trials Ss were given four warm-up trials. These warm-up trials were half left to right and half right to left. All of the Ss had a total of 400 trials over the four blocks and 80 trials at each ISI over the four blocks.

RESULTS

RT2-RT1 difference scores were used as the main response measure. Most PR studies employ the same <u>S</u>s in all of the groups. However, this would have confounded the practice variable which was a principal variable in this study. That also meant that a direct comparison of RT1 and RT2 across groups was not a true indicator of group differences. That is, there are some individuals that are faster responders than other individuals irregardless of other variables. What was of primary interest in this study was the effect on RT2 of RT1 and not the overall speed of the RTs. The groups could be significantly different in terms of actual speed of the individual responses, yet the relationship of RT2 to RT1 might not show any significant degree of difference. Difference scores seemed to better reflect overall information processing.

Difference scores were derived by a subtraction of RT1 from RT2. Any significant difference found in the comparison of difference scores may have been due solely to the RT1 component. Thus, when a significant group difference was found a further analysis of RT1 was carried out for those groups that showed significance. If the RT1 comparison was not significant a post-hoc test was conducted to find where the group significance lay.

There were nine separate analyses of variance (ANOVA) performed. The summary F values for each comparison are presented in Tables 2, 3, 4, and 5. A separate two-way ANOVA for each block of trials of S mean difference scores between VG-M and VG-D was carried out in order to assess the amount of difference, if any, between massed and distributed practice. The row variable in all of the ANOVAs was the ISI. Thus the statistical design for most of the comparisons was a 5 by 2 factorial.

Table 2. Summary F Values for the Block by Block Comparison of S Mean Difference Scores

Analysis Effect	B-1 (F)	B-2 (F)	B-3 (F)	B-4 (F)
VG-D vs. VG-M	2.576	2.619	4.586*	2.141
Interval (ISI)	4.782***	7.989***	6.356***	2.119
Interaction	< 1	< 1	< 1	< 1

*p < .05.

***p < .01.

Table 3. Summary F Values for the S Mean Difference Score Comparison and the S Mean RT1 Comparison

Analysis Effect	Difference Score (F)	RT1 (F)
FG-D vs. BT-D vs. VG-D	4.62**	< 1
Interval (ISI)	5.48***	1.00
Interaction	< 1	< 1

**p < .025.

***p < .01.

Table 4. Summary F Values for the Total Block Comparison of S Mean Difference Score

Analysis Effect	Difference Score (F)
VG-D vs. BT-D	1.381
Interval (ISI)	4.426***
Interaction	< 1

***p < .01.

Table 5. Summary F Value for the Error Block Four Comparison

Analysis Effect	Error (F)
FG-D vs. VG-D vs. VG-M vs. BT-D	1.479

The test for a practice effect was made by a two-way ANOVA comparing the S mean difference scores of block one with block four of VG-D and another two-way ANOVA which compared S mean difference scores of block one and block four of VG-M.

The forced guidance and bisensory effect was tested for by another two-way ANOVA of S mean difference scores of FG-D, BT-D, and VG-D. A significant group difference was found here so a further two-way ANOVA was carried out on S mean RT1 scores. That comparison showed no significance so a Scheffé test was carried out on the data of the original ANOVA.

The final two-way ANOVA was used for the overall comparison of S mean difference scores of blocks one through three of BT-D and VG-D.

The final comparison made was a one-way ANOVA of the error scores. The error scores were measurements of the number of times that S responded incorrectly during the catch trials.

In the massed versus distributed effect no group differences were found until a small difference ($p < .05$) was found in the third block of trials. The ISI effect was significant at the .01 level on all of the blocks except for block four where no significant effects were found for any of the comparisons.

No practice effect was found in the VG-D comparison. However, a highly significant practice effect ($p < .01$) was found in the VG-M comparison. This effect was in the direction opposite to that which was expected and will be discussed in detail below.

A significant group difference was found in the test for forced guidance and bisensory training. As the RT1 comparison was nonsignificant, a Scheffé test was carried out. The Scheffé test showed that FG-D was significantly different from both BT-D and VG-D. However, no difference was found to exist between VG-D and BT-D. This lack of a bisensory effect was further substantiated by the no difference finding of the three block comparison of VG-D and BT-D.

A no difference effect between groups was found in the analysis of the error scores.

All of the cell means for each comparison have been graphed. The means for the VG-D and VG-M comparison and the VG-D, FG-D, and BT-D comparison (blocks one through four) are found in Figure 1. The cell means for the RT1 analysis of VG-D, FG-D, and BT-D are in Figure 2. The practice effect means are Figure 4, the VG-D and BT-D comparison is in Figure 5, and the error means are graphed in a histogram, Figure 3.

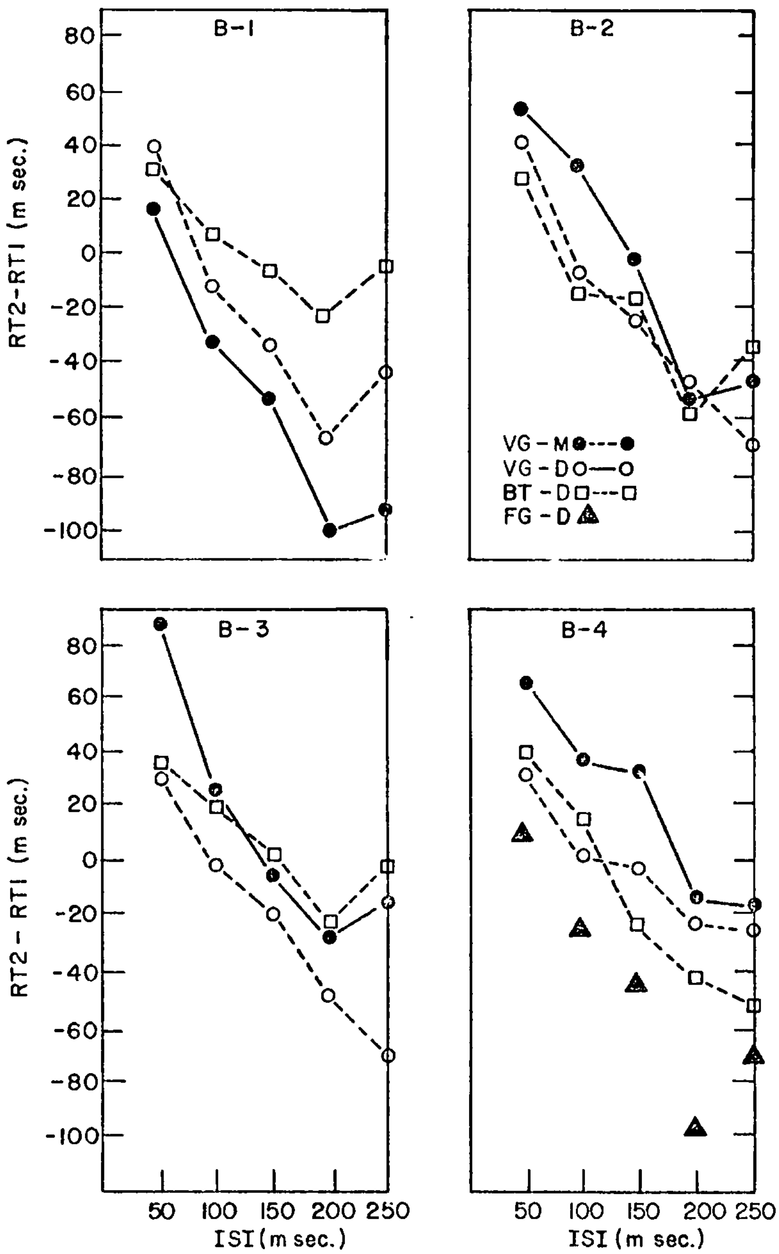

Figure 1. Mean Difference Scores of Blocks One Through Four

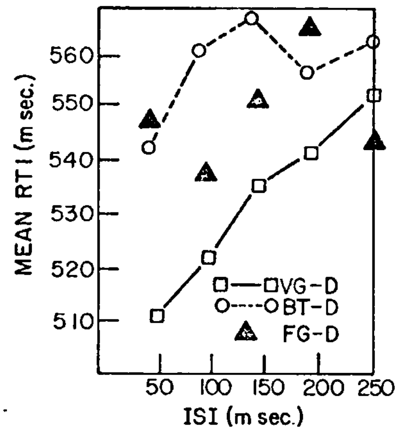

Figure 2. Mean RT1 Scores of Block 4: VG-D, BT-D, and FG-D

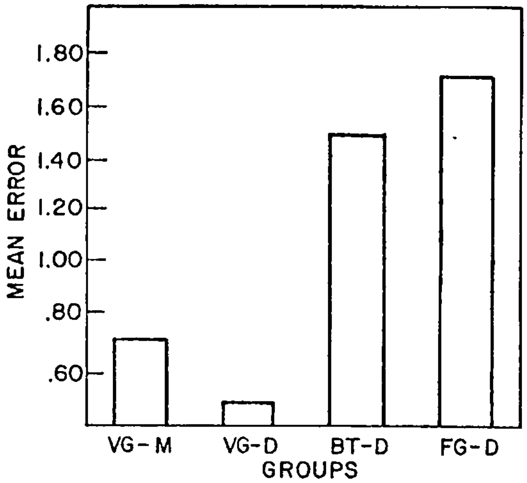

Figure 3. Mean Error Scores of Block 4: All Groups

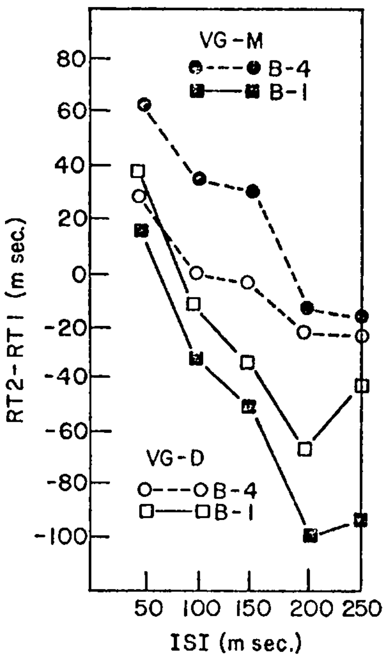

Figure 4. Mean Difference Scores of Block 1 and Block 4: VG-M and VG-D

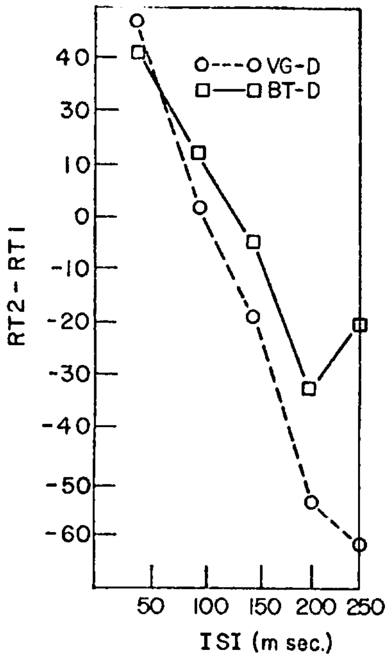

Figure 5. Mean Difference Scores Over all Blocks for VG-D and BT-D

DISCUSSION

The results show that there was little difference between the effects of massed and distributed practice on sequential information processing. The difference that was found on block three was probably due to the extended delay of RT2 at the 50 msec ISI of VG-M. The Ss in VG-M exhibited the effects of a boring and fatiguing task by elevating their RT2 scores over the blocks. This elevation of RT2 scores was also present in VG-D and accounted for the no difference effect between the groups on the three blocks out of four.

However, this elevation of RT2 was much greater from block one to block four in VG-M than in VG-D. No practice effect was found in VG-D, yet a large effect was found in VG-M. One might say that Ss were learning to delay RT2 in order to optimize their performance on the catch trials. VG-D demonstrates this explanation as the amount of errors decreased from a mean of 1.25 in block one to a mean of .50 in block four. VG-M, however, increased the amount of errors from a mean of zero in block one to a mean of .75 in block four. VG-M then was exhibiting more of a boredom or fatigue factor than an optimizing of performance. When experimenters sum their results over several blocks of trials and average them, a delay that may not have been in earlier trials, but is very strong in later trials, may be evident. The summing and averaging weights the data towards a PR interpretation as the difference between RT1 and RT2 decreases. Indeed, in Figure 5 the small delay at the 100 msec ISI in VG-D is evident. Yet this delay appeared only in block four. Ss apparently learned to delay RT2 in order to increase their performance on catch trials. Most PR studies also employ large amounts of distributed practice before the data-gathering trials even begin. Thus, even if experimenters do not average over blocks of trials but do use pre-experimental practice the results are still biased towards a PR interpretation. That is, most of the delay in RT2 seems to have been the result of extended practice which resulted in an increase in boredom and fatigue and an optimizing of performance on catch trials.

The FG-D effect may have indicated a true alleviation of the response-selection stage and this alleviation may have enabled that mechanism to process information more efficiently. That is, if a single-channel limitation theory is ignored for the present, then it may be possible to train the mechanism that is causing the delay in processing to operate more efficiently. Forced guidance may be the first step towards the training of this mechanism. However, further testing would have to be carried out on FG-D. That is, FG-D would have to continue to receive distributed practice without the forced guidance. If forced guidance were truly effective in the training then Ss might show a complete erasure of any delay of RT2 without any increase in errors; but if the forced guidance effect was only temporary, then the group would show a tendency to delay RT2. Forced guidance may also be looked at as doing away with feedback, both error and kinesthetic. However, doing away with feedback may be the same thing as the alleviation of the load on the response-selection mechanism.

The lack of any BT-D effect may have been due to an inefficient procedure for administering the BT-D variables. That is, the purpose of BT-D was a sensitization of the stimulus analysis stage. It might have been more effective to have paired the click with S2 only. This might have increased the effect of the click on the stimulus analysis mechanism. If that particular type of experiment were done it should also include a signal detection analysis to check on the sensitivity variable. While the RT to a visual-auditory simultaneous pairing is supposed to be equivalent to the RT to an auditory event alone (Bernstein et al., 1969) and PR studies employing the use of visual-auditory sequences have still found evidence for PR (Davis, 1959), there is still reason to believe that combining these paradigms would result in something different from those paradigms taken separately.

The actual mean RTs for each group were excessively large. VG-D had a mean RT1 of over 700 msec in block one at the 150 msec ISI. The size of these RTs has in the past been taken as evidence for the grouping phenomenon (Welford, 1952). Grouping implies that stimuli presented simultaneously or in close sequence can be responded to as single units. Ss wait after the arrival of a stimulus and make their reaction conditional upon the arrival of another stimulus. Thus the two stimuli are responded to as one stimulus. However, this also usually results in RT2 being much faster than RT1 at all the intervals and RT1 showing a large decrease in speed over the intervals with this decrease in direct proportion to the size of the interval. RT2 was considerably slower than RT1 at the 50 msec ISI in all of the groups, except for FG-D. This delay extends out to the 100 msec ISI in BT-D and VG-M and out to the 150 msec ISI in VG-M. These delays are reflected in the positive difference scores in Figures 2 through 5. RT1 did show a small increase in latency but it was not in proportion to the amount of increase in the ISI. That increase in RT1 was 102 msec, at the largest, from the 50 msec ISI to the 250 msec ISI. An alternative explanation of these large RTs is that they were due to the instructions and the variable foreperiod. The instructions stated "while speed is important accuracy is more important." Both the instructions and the foreperiod were directed towards the reduction of anticipatory responding. They were effective as the error rate was extremely low. The highest number of errors were found in S #14 in BT-D to be a total of 15 across blocks. This was more than three times as many for any other single S. That S's data also showed that she was the only S in all of the groups who did not show any delay in RT2 at any of the intervals. This would indicate that the error data reflected anticipatory responding.

Overall RT scores also showed that BT-D had faster RTs than any other group. That speed disappeared when the auditory stimulation was removed.

The data presented here have indicated that PR may be enlarged by the summing and averaging over blocks of trials and the use of pre-experimental practice. This enlargement of PR appears to have been due to a combination of boredom, fatigue, and the optimization of performance on catch trials. This increase in PR may be circumvented by some sort of stimulus or response augmentation. Future research might be directed towards a more extended testing of the forced guidance effect and a signal detection analysis of bisensory training on S2 only.

REFERENCES

Adams, J. A. Test of the hypothesis of the psychological refractory period. Journal of Experimental Psychology, 1962, 64, 280-287.

Adams, J. A., and Chambers, R. W. Response to simultaneous stimulation of two senses. Journal of Experimental Psychology, 1962, 63, 198-206.

Bernstein, I. H., Blake, R. R., and Hughes, M. H. The effects of time and event uncertainty on sequential information processing. Perception and Psychophysics, 1968, 3, 177-184.

Bernstein, I. H., Clark, M. H., and Blake, R. R. Sensitivity and decisional factors in the psychological refractory period. Perception and Psychophysics, 1970, 7, 33-37.

Bernstein, I. H., Clark, M. H., and Edelstein, B. A. Effects of an auditory signal on visual reaction time. Journal of Experimental Psychology, 1969, 80, 567-569.

Bilodeau, I., and Bilodeau, E. Motor skills learning. Annual Review of Psychology, 1961, 243-271.

Blake, R. R., and Fox, R. Visual form recognition threshold and the psychological refractory period. Perception and Psychophysics, 1969, 5, 46-48.

Davis, R. The human operator as a single channel operator. Quarterly Journal of Experimental Psychology, 1957, 9, 119-129.

Davis, R. The role of attention in the psychological refractory period. Quarterly Journal of Experimental Psychology, 1959, 11, 211-220.

Ellithorn, A., and Lawrence, C. Central inhibition: Some refractory observations. Quarterly Journal of Experimental Psychology, 1955, 7, 116-127.

Herman, L. M., and McCauley, M. E. Delay in responding to the first stimulus in the "Psychological Refractory Period" experiment. Journal of Experimental Psychology, 1969, 81, 344-350.

Hershenson, M. Reaction time as a measure of intersensory facilitation. Journal of Experimental Psychology, 1962, 63, 289-293.

Hick, W. E. The discontinuous functioning of the human operator in pursuit tasks. Quarterly Journal of Experimental Psychology, 1948, 1, 36-44.

Hilgard, E. R. Reinforcement and inhibition of eyelid reflexes. Journal of General Psychology, 1933, 8, 85-113.

Holding, D. H. Guidance in pursuit tracking. Journal of Experimental Psychology, 1959, 57, 362-366.

Gottsdanker, R., and Way, T. C. Varied and constant intervals in psychological refractoriness. Journal of Experimental Psychology, 1966, 72, 792-803.

Katz, M., Schoenberg, K. M., and Mayzner, M. S. Visual information processing of sequentially presented inputs: II. Effects of list length and inter-stimulus interval values on subspan storage and retrieval mechanisms. Perception and Psychophysics, 1970, 7, 149-151.

Morrell, L. K. Cross-modality effects upon choice reaction time. Psychonomic Science, 1968, 2, 129-130.

Nickerson, R. S. The reaction time to the second of two successive signals. Perception and Motor Skills, 1965, 21, 3-10.

Poulton, E. C. Perceptual anticipation and reaction time. Quarterly Journal of Experimental Psychology, 1950, 2, 99-112.

Reynolds, D. Time and event uncertainty in unisensory reaction time. Journal of Experimental Psychology, 1966, 71, 286-293.

Shaffer, L. H., and Hardwick, J. Monitoring simultaneous auditory messages. Perception and Psychophysics, 1969, 6, 401-404.

Welford, A. T. The "Psychological Refractory Period" and the timing of high-speed performance: A review and a theory. _British Journal of Psychology_, 1952, 11, 193-210.