AN EXAMINATION OF THE LOCUS OF THE REPETITION EFFECT

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CHAPTER I

INTRODUCTION

The effect of context on word recognition has been increasingly investigated over the last decade. Of particular interest, is the phenomenon of word repetition priming. That is, the facilitation of word recognition, as a result of the prior presentation of the same words. This word repetition effect typically results in a facilitation of word recognition time on the order of 100 msec. (Scarborough, Cortese, & Scarborough, 1977).

Recent research (Scarborough, Gerard, & Cortese, 1979) has been directed at determining the locus of the repetition effect. Based on a sequential stage model of processing (e.g., Sternberg, 1969), the Scarborough et. al. research has indicated that the effects of repetition priming occur in the memory search stage of processing. However, Scarborough et al. (1977; 1979) did not adequately examine the possibility that the effect of word repetition may occur in the stimulus encoding stage of the word recognition process. Hernon, Painton, and Neiser (1979) report results which suggest that the repetition effect may be active in stimulus encoding stages.

The present study sought to further examine the question of the locus of the word repetition effect. It was hoped that the study would aid in the specification of the processing stage or stages which are influenced by the repetition of word items. In addition, the study attempted to incorporate a new and somewhat controversial model of word processing, the cascade model of McClelland (1979), into the data analysis.

CHAPTER II

REVIEW OF THE LITERATURE

The Repetition Effect

The repetition of stimulus items in verbal processing tasks has been demonstrated repeatedly to facilitate task performance (Forbach, Stanners, & Hochhaus, 1974; Hall, 1978; Painton & Hochhaus, 1979; Scarborough, Cortese, & Scarborough, 1977). However, this repetition effect has received relatively little attention since it was first reported by Forbach et al. (1974). The repetition effect is the observed facilitation of a Subject's response time to a stimulus item (target item) as a result of a previous presentation of the same item (prime item).

Forbach et al. (1974) demonstrated the repetition effect from repeated presentations of word items in a lexical-decision task. The lexical-decision task requires Subjects to judge whether or not the individually presented letter strings are English words. The repetition of items resulted in an average (100 msec.) facilitation of target item response time, compared to that for once-presented items. Forbach et al. reported that as many as 36 target items were in a primed state simultaneously and the facilitation was long lived, persisting beyond 10 minutes. An even more dramatic example of the persistance of the repetition effect comes from Scarborough, Cortese, & Scarborough (1977) who reported a small but significant (26 msec.) facilitation across blocks of trials separated by two days. Additionally, the data from Forbach et al. (1974) indicated a trend toward increasing facilitation following the second repetition of word items. Hall (1978), in a study of semantic satiation, confirmed that additional facilitation does result from three presentations of a word in a lexical-decision task, however, the repetition effect does not increase further beyond the two repetitions. Forbach et al. (1974) failed to find an interaction between word frequency and the repetition effect.

Scarborough et al. (1977) investigated word and nonword repetition effects in a series of five experiments. Experiment 1 replicated the findings of Forbach et al. (1974) with the exception of the added facilitation from second repetitions. Additionally, Scarborough et al. found a repetition effect for nonwords (46 msec.) as well as word items (82 msec.) and a reduced error rate for repeated items. The experiment involved three independent variables, item type (word or nonword), prime-target presentation lag and prime-target pair lettercase (same or different) in a lexical-decision task with repeated items. Neither the presentation lag variable nor the letter case variable had significant effects. A post hoc analysis of the data from Experiment 1 demonstrated an interaction between word frequency and the repetition effect. Low frequency word items benefited significantly more from repetition than high frequency items. However, the average response time to high frequency items was not significantly different from that for low frequency items. The authors accounted for this lack of significance as a result of insufficient seperation between frequency levels of the low and high frequency words.

Experiment 2 of Scarborough et al. (1977) replicated the Experiment 1 variables of presentation lag, letter case, and word frequency. In addition, a response bias variable (the items consisted of 57% or 78% words) and a nonword pronounceability variable were introduced into the experiment. The results of Experiment 2 essentially replicated those of Experiment 1. The the interaction of frequency and repetition was significant. No other interactions were significant, however.

The third experiment of Scarborough et al. was a replication of Experiment 1, with the exception that the task was item pronunciation rather than the lexical-decision. Item repetition was the only factor with a significant effect. It is of interest that the repetition effect was appreciably smaller (22 msec.) in the pronunciation task relative to the lexical-decision task. In addition, the frequency effect virtually disappears in the pronunciation task.

Experiment 4 was a repetition of Experiment 1 with the addition of a 48 hour delay treatment. The result of most interest in this experiment was the presence of a 26 msec.

repetition effect across the 48 hour lag between prime and target presentations.

The purpose of the fifth experiment of the series was to explore the relationship of item repetition to episodic memory. The task was not a lexical-decision task, rather, Subjects were required to judge whether the items presented were 'OLD' or 'NEW' items (having been previously presented or not). The results indicated no effect of item frequency. There was little difference between the word & nonword data, and there was a pronounced effect of presentation lag on Subject's performance.

On the basis of the above five experiments, several characteristics of the repetition effect are evident. Experiments 1, 2, and 4 indicated that within a lexical-decision task, which presumably requires memory access, the repetition effect reliably interacts with word frequency. In addition, the presentation lag variable had little effect on the repetition effect, suggesting a relatively slow rate of decay for the phenomenon. Experiment 3 demonstrated that in tasks not requiring lexical access (e.g., item pronunciation) the repetition effect is substantially reduced. This suggested that the repetition effect may be susceptible to control processes (procedures which a Subject may use to control the kinds of information that is encoded during the performance of a task). Experiment 5 indicated to Scarborough et al. that episodic memory is probably not involved in the repetition effect. Scarborough et al. based this conclusion on the results which demonstrated that the word frequency effect virtually disappeared in the old-new task, and that the presentation lag variable, which substantially influenced performance in the old-new task, had a minimal influence on the repetition effect in the lexical-decision task.

An experiment by Painton & Hochhaus (1978) confirmed that the repetition effect is influenced by control processes. In addition, the study provided additional evidence on the lack of episodic memory effects in a lexical-decision task involving item repetitions. The Subjects recieved two blocks of two-item simultaneous lexical-decision trials. The blocks of trials differed in the type of nonwords they contained, either pronounceable nonwords or unpronounceable consonant strings. The Subject's task was to decide whether or not both items presented simultaneously during a trial were words. The results indicated a significantly smaller repetition effect for word items when they were presented in the block containing consonant string nonwords, than in the context of pronounceable nonwords. It was concluded that the presence of consonant string nonwords removed the necessity of lexical access to make the word-nonword decision, consequently, the repetition effect was influenced by Subject control processes. However, when items were presented singly the nonword type by word repetition interaction was no longer significant (Painton & Hochhaus, 1978).

In the first experiment of Painton and Hochhaus the

Subjects were required at the end of all trials to recall as many of the word items as possible. In addition the Subjects were given a list of all the word items used and asked to identify the block of trials and temporal position within the block in which the items appeared. The results indicated that temporal information (item recency information) and item recognition preformance were not above chance expectancy. The failure of item repetition to facilitate temporal information recall, suggests that episodic memory information is not involved in the repetition effect.

Scarborough, Gerard, and Cortese (1979) carried out three experiments which extended the findings of Scarborough et al. (1977) by demonstrating that the repetition effect transfers across tasks but not modalities. In addition, the study provided information on the failure of the word repetition effect in episodic memory tasks. In Experiment 1 the Subjects performed two tasks. Part 1 of the experiment consisted of the Subject pronouncing words and naming pictures which were projected for 1 second. In part 2 the Subjects performed a lexical-decision task in which the stimulus items included the original words and the names of the pictures from part 1. The results indicated that prior pronunciation of a word would facilitate (32 msec.) later lexical decisions on those words. Thus, the repetition effect transfered across tasks. However, there was no evidence of repetition effects transfering across modalities. That is, prior naming of pictures did not facilitate later lexical decisions on the picture names. This result is dificult to interpret due to the confounding of task differences with repetitions. In addition, a frequency effect for words in part 2 was significant, although the word frequency by word repetition interaction was not significant.

Experiment 2 was a replication of Experiment 1, with the exception that the number of Subjects was increased and some of the stimulus items were changed. The results of Experiment 2 were quite similar to those of Experiment 1. The only notable difference was that the frequency by repetition interaction was more pronounced. This trend was significant in one of the two analyses of variance required for the minimum F' analysis (suggested by Clark, 1973), however, the min. F' was not significant.

The design and procedure of Experiment 3 of Scarborough et al. (1979) was identical to that of Experiments 1 and 2, the task in part 2, however, was changed to an old-new task. The results demonstrated the superiority of pictures over words in recognition memory tasks. That is, the Subject's accuracy in recognizing the names of pictures they had seen before, was significantly greater than that for words seen previously. This result agrees with previous research (Scarborough et al., 1977; Painton & Hochhaus, 1978) which suggests a lack of involvement of the word repetition effect in episodic memory tasks.

The discussion to this point has served as a review of the repetition effect. In summary, the repetition of verbal items has been demonstrated to result in approximately 80-100 msec. of response facilitation, for word items, and approximately 30 msec. of facilitation for nonword items, in a lexical-decision task (Forbach et al., 1974; Scarborough et al., 1977). The repetition effect is long lasting, with a decay rate measured in minutes and hours, and it appears to interact with word frequency, although, other research has not supported the frequency by repetition interaction (Forebach et al., 1974; Scarborough et al., 1977). The repetition effect can be influenced by control processes and does not involve recognition memory processing (Painton & Hochhaus, 1978; Scarborough et al., 1977; Scarborough et al., 1979). In addition, the repetition effect transfers across tasks although the type of task performed influences the magnitude of the effect (Scarborough et al., 1977; Scarborough et al., 1979). However, the repetition effect does not transfer across modalities (Scarborough et al., 1979).

Information Processing Models and the Repetition Effect

The present section is devoted to a review of one conceptualization of word recognition that accounts for the repetition effect, the Logogen model (Morton, 1970). Morton proposes a model of word recognition which has as its central structure a set of logogens which function as information registers for individual words. Auditory or visual information collected by feature detectors is incremented in the relevant logogens. Each logogen contains a feature description of the word which it represents. When the feature count is incremented for one of the possible logogens beyond its criterion number of features (its threshold), then the word represented by that logogen becomes available as a response.

In addition to the system of logogens, the model proposes a response output buffer which functions as a short-term memory store and a context system which represents the long-term memory store. Material in the context system is primarily coded in a semantic form. In Morton's model there is no direct transfer of information among logogens. All semantic information influences the logogen system indirectly through the context system. Morton (1970) assumes that semantic information, through this context system, increments the feature count of word detectors (logogens) which are semantically related to the information context. Logogens with incremented feature counts require less sensory feature information to reach threshold. Consequently words related to the context may be recognized more quickly. However, information that enters the logogen system is assumed to decay rapidly, with the feature count of logogens returning to baseline within seconds.

The threshold (criterion number of features) of the logogens varies with the frequency and recency of the word represented by the logogen. Logogens representing high frequency words will have lower thresholds than logogens representing lower frequency words. Consequently, the logogens representing high frequency words will reach threshold more quickly. Following the availability of a response, the threshold of the logogen is assumed to be lowered. Unlike information levels, the threshold does not return to previous levels very quickly. Consequently, a word repetition occurring during this period of lowered threshold would require less feature count incrementation, thus, recognition time would be shortened. With the provision for the influence of recency, the Logogen model is able to predict the occurrence of the repetition effect. In addition, since the Logogen model postulates that both the frequency and repetition factors affect the threshold value required for activation of a logogen, then the model can account for the interaction of word frequency and the repetition effect. If it is assumed that threshold reduction effects are not linear, but rather a negatively accelerating function of frequency, then the degree of threshold reduction resulting from an item repetition would be less for higher frequency items than low frequency ones.

The Locus of the Repetition Effect

The following section provides a review of the literature which relates to the locus of the repetition effect. Initially, the conceptualization of reaction time tasks as consisting of four discrete stages (Sternberg, 1969) is briefly discussed. Sternberg (1969) has proposed that information processing in reaction time tasks occurs in a series of four relatively independent stages; stimulus encoding, memory search, binary decision, and response organization. Sternberg argues that factors will show an interaction when the locus of their effects reside in the same processing stage. However, factors which exert their influence in separate stages of processing will be additive. Using variables which are assumed to selectively influence particular stages of processing, the additive-factors approach allows an experimenter to locate the stage or stages in which the factor of interest is active.

In their series of five experiments, Scarborough et al. (1977) used the additive factors approach in an attempt to pinpoint the locus of the repetition effect. The strong interaction of the repetition effect with word frequency, observed in Experiments 1, 2, 3, and 4 suggested that the effect of word repetition occurs in the memory search stage of processing. However, it must be noted that Forbach et al. (1974) reported additive effects for frequency and repetition, though an interaction trend was apparent. In addition, in Scarborough et al. (1977) the repetition effect was significant, though decreased in magnitude, in the pronunciation task (Experiment 3). If the pronunciation task eliminates the memory retrieval stage, as Scarborough et al. concluded, then repetition effects must also occur in the encoding stage. However, Scarborough et al. failed to find a significant effect of letter case on word repetition, which was interpreted as placing constraints on an encoding stage locus. Because the effects of response probability (Experiment 2) were additive with the repetition effect, the response stage was disregarded as a possible locus of the effect of repetition. The possibility of repetition effects at the decision stage could not be eliminated. However, Scarborough et al. (1977) suggest that the lack of a response probability by repetition interaction can be interpreted as arguing against a decision stage locus.

Additional information on the locus of the repetition effect comes from an unpublished study by Hernon, Painton, and Neiser (1979). The data of Hernon et al. indicate a significant interaction of item repetition with stimulus quality. The Subjects performed a lexical-decision task on both visually degraded and non-degraded stimulus items which were repeated within the experimental session. The data suggest that at least part of the repetition effect is located in the perceptual encoding stage of the reaction time process.

The stimulus materials consisted of 40 medium frequency words (frequency range 18 to 42) from Kucera and Francis (1967) and 40 pronounceable nonwords taken from Coltheart and Davelar (1977). All stimulus items were repeated. Consequently, 160 stimulus items, or 80 prime-target item pairs, were presented to the Subjects. In the Hernon et al. (1979) study, the term 'prime' designated an initial presentation of an item, while the repetition of the same item was refered to as the 'target' of that item pair. The 80 prime-target pairs were divided equally among four different degradation conditions in a random manner with the constraint that equal numbers of word and nonword pairs were assigned to each condition. The four degradation conditions were (1) prime only degraded, (2) target only degraded, (3) both prime and target degraded, and (4) neither prime nor target degraded. The degradation of items consisted of superimposing a random dot matrix over the 35 mm. slide of the item.

The results of the Hernon et al. study revealed significant effects of item repetition, item visual quality, and the quality by repetition interaction on lexical-decision response latencies. Furthermore, these results were true for the nonword as well as the word data. However, the repetition effect for nonwords was appreciably smaller (30 msec.) than that for the word items (100 msec.). The significant interaction of repetition with stimulus quality found by Hernon et al., suggests a locus of the effect of word repetition earlier in the stimulus encoding stage than the locus suggested by the results of Scarborough et al. (1977). However, this agrees with the general conclusion of Scarborough et al., that the effect of repetition is active in both the encoding and memory search stages.

Meyer, Schvaneveldt, and Ruddy (1975) propose a revised stage model, suggesting that the stimulus encoding stage consists of two components; graphemic encoding and phonemic transformation. The pattern of results from Experiments 1, 2, and 3 of Scarborough et al. (1977) would indicate the later phonemic transformation process as the locus, since a change in letter case, presumably effective in the graphemic encoding component, did not affect the repetition effect. However, the stimulus quality interaction from Hernon et al. (1979) would indicate the early graphemic component as the locus. The two results need not be incompatible. There was a slight trend in the Scarborough et al. (1977) data toward an interaction of the letter case manipulation with item repetition. Perhaps the study lacked sufficient power to yield a significant result.

On the other hand, it may be that the Hernon et al. (1979) results do not indicate a locus in an early graphemic encoding stage. Becker and Killion (1977) argue that stimulus degradation may influence processing at a stage later than early graphemic encoding, perhaps even the memory search stage. The principal evidence for locating the effect of stimulus degradation in the encoding stage comes from research by Sternberg (1967) which indicates that stimulus degradation is additive with stimulus set size in a memory scanning task. This task requires Subjects to decide as rapidly as possible whether a test digit is a member of a previously memorized set of 1-6 digits. It is assumed that set size affects memory search. An additive relationship between set size and stimulus degradation would suggest that the degradation manipulation is influencing processes prior to memory search. However, as Becker and Killion (1977) point out, this additive result occurred only on the second day of the Sternberg study. An interaction was apparent on the first day of the experiment. Consequently, Becker and Killion argue that the upper boundary for the degradation effect is not specified.

The results from a study by Stanners, Jastrzemsski, and Westbrook (1975) place some bounds on the degradation effect. Stanners et al. demonstrated that stimulus degradation and word frequency are additive factors in a lexical-decision task. Given that word frequency influences a memory search stage, an assumption supported by the lack of a word frequency effect in a pronunciation task (Scarborough et al., 1977), the Stanners et al. result would appear to restrict the stimulus degradation effect to the encoding stage. Consequently, there seems to be relatively reliable evidence (Scarborough et al., 1977, Hernon et al., 1979) indicating that the word repetition effect is active in both the encoding and memory search stages of processing, based on applications of additive factors logic. However, the validity of present applications of additive factors logic has been jepordized as a result of a recent article by McClelland (1979). McClelland suggests that the discrete stage model of information processing is not the only plausable model appropriate for the analysis of reaction time data. McClelland proposes a cascade process model as an additional possibility.

The Cascade Model

The cascade model proposed by McClelland (1979) assumes, as does the discrete stage model, that performance in a reaction time task involves an underlying system of processing levels. The reaction time data measure only the processing time for the last response level of processing. In the cascade model, each of the processing levels reflects the activities of a number of processing units, e.g., feature detectors at the perceptual level or decision units at higher cognitive levels. All units are assumed to accumulate information, in the form of positive or negative activation, up to an asymptotic level, provided that processing time is unlimited. Furthermore, at each processing level, all units are assumed to use a weighted sum of the outputs from selected units of the preceding level as inputs (with the exception of the first level). Consequently, the initiation of processing in each successive level is contingent upon information coming from the preceding level. However, but parallel in the cascade model, as information is accumulated in the preceding level it is passed on to the next level. Therefore, processing at a succeeding level need not wait for the completion of all processing in the preceding level, as is the case in the discrete stage model.

The cascade model assumes that a unit's rate of activation is dependent upon the magnitude of the difference between the current degree of activation of the unit and the assumptotic level of activation its inputs are driving it to. The cascade model entails a cascade equation. The cascade equation is an expression of the rate assumption, describing how the summed activations of processing units will vary for a given level of processing, as a function of the time since the onset of a stimulus. This equation has three parameters, rate of activation, asymptotic activation, and an intercept (the level of activation at time zero). For convenience of analysis, a speed-accuracy tradeoff function (Wickelgren's equation, Wickelgren, 1977) may be substituted for the cascade equation. Graphically, the cascade function is expressed as a negatively accelerated exponential curve of unit activation ploted over time. The shape of the activation function will change as a result of changes of either the rate coefficient or the asymptotic value of the cascade equation.

In a reaction time task, experimental manipulations which alter task performance time are assumed, by the cascade model, to do so via alteration of either the rate or asymptote parameters of one of the processing levels. Rate affecting and asymptote affecting treatments do not differ in their main effects; however, their patterns of interaction with other treatments are markedly different.

It is this difference between rate and asymptote effects that is the source of McClelland's (1979) criticism of additive factors logic. Table I (see appendix) presents the logical inferences possible under the cascade model. In the case of rate influencing treatments, the discrete stage model and the cascade model make the same inferences, and additive factors logic applies. When both of the treatments in a study influence the rate parameter of different processing levels, then their effects will be additive. If both treatments influence the rate of the same level, then their effects will interact. However, if one or both of the experimental manipulations influences the asymptote of a process, then the discrete stage model and the cascade model no longer lead to the same inferences, and additive factors logic is no longer applicable. Two factors influencing different processes will have interactive effects if both factors influence the asymptote, or one influences the asymptote and the other influences the rate of the slowest process in the system. On the other hand, if one factor influences the asymptote and the other factor influences the rate of a relatively fast process, then the effects will be additive. Consequently, under the cascade model it is imperative to determine whether the factors in question affect rates or asymptotes, prior to making inferences based on additive factors logic. McClelland (1979) suggests the use of speed-accuracy trade-off fucntions to determine whether a variable affects the rate or asymptote of a process.

If the cascade model is adopted as the most appropriate representation of processing in reaction time tasks, then the previous studies on the locus of the Repetition Effect (Scarborough et al., 1977; Scarborough et al., 1979; & Hernon et al., 1979) are ambiguous. However, there is nothing presented by McClelland (1979) that would discredit the discrete stage model. All that McClelland argues is that the cascade model is a plausable alternative to the discrete stage model. The answer to the question of which model is appropriate, awaits empirical investigations. On the other hand, application of the cascade model analysis might prove useful in evaluating results concerning the locus of the repetition effect. For example, is the repetition effect truely active in both the encoding and memory search stages, or are at least one of the interactions attributable to a factor that influences the asymptote of some process?

It seems that the results concerning the locus of the repetition effect are not unequivocal. First, the frequency by repetition interaction was reported by Scarborough et al. (1977) but not by Forbach et al. (1974). Secondly, the results which locate the repetition effect in the encoding stage (Scarborough et al., 1977) and (Hernon et al., 1979) are in conflict over how early in encoding the effect is functioning. In addition, the locus of the degradation by repetition interaction is made somewhat ambiguous by the Becker and Killion (1977) argument. Finally, with the introduction of the cascade model, it may be possible to question the entire set of results concerning the locus of the repetition effect. What appears to be called for, is a study directed at verifying the locus of the repetition effect, and incorporating the cascade model into the analysis of the results. The following section will propose just such a study.

CHAPTER III

STATEMENT OF PURPOSE

The present section reviews the purpose and hypotheses of the study. In general, the purpose of the experiment was to clarify some of the previously mentioned problems concerning the locus of the repetition effect, and to attempt an application of the cascade model analysis to the data.

It seemed reasonable that the locus of the repetition effect, in both encoding and memory search stages, could be investigated by the joint manipulation of word frequency and item quality in combination with word repetition in a lexical-decision task. To avoid the issue of the locus boundary of item degradation (Becker & Killion, 1977), an intensity manipulation served as the stimulus quality variable. In order to allow application of the cascade model analysis, in addition to the discrete stage model additive factors logic, speed-accuracy trade-off fucntions were individually determined for the intensity, frequency, and repetition factors prior to the execution of the multi-factor experiment.

In association with the multi-factor (intensity X frequency X repetition) experiment, several hypotheses were proposed concerning the possible pattern of results. The individual variables of intensity, frequency, and item repetition were all expected to influence the Subject's response time (RT) in making the lexical decisions. A decrease in item presentation intensity or word frequency was expected to increase overall RT (for both word and nonword items in the case of intensity and only for word items in the case of frequency). The repetition of items, it was hypothesized, would decrease overall RT, however, word items were expected to benefit more from repetition. It was also hypothesized that the intensity by repetition interaction and the frequency by repetition interaction would be significant. The factors of presentation intensity and word frequency were not expected to interact. It is possible that some other pattern of results could emerge, however, these do not appear probable in light of the past research (Forbach et al., 1974; Hernon et al., 1979; Scarborough et al., 1977).

Only three hypotheses were associated with each of the three single factor studies. The null hypothesis suggests that in each case the factor will not influence RT. As alternative hypotheses, it was proposed that each factor would influence either the rate, the asymptote, or both parameters of the speed-accuracy trade-off function.

CHAPTER IV

EXPERIMENT I

The following section discusses the three single factor studies, which were intended to provide information on whether the factors of presentation intensity, item repetition, and word frequency, exert their effects on RT by influencing the rate constant or the asymptote of the activation function.

As was noted previously, McClelland (1979) recommended the use of speed-accuracy trade-off (SAT) curves to obtain measures of the slope and asymptote of the relative activation function. There are several methods which could have been used to obtain the SAT curves. Wickelgren (1977) discusses six methods of deriving SAT curves payoffs, deadlines, time bands, response signals, partitioning reaction times, and instructions. The payoff method manipulates the speed-accuracy criterion that the Subject adopts, by varying the relative payoffs for speed and accuracy across trials. In the deadline method, the Subject is required to respond as accurately as possible, but faster than a pre-set time limit. It is possible to combine the payoff method with a deadline. A variant of the deadline method, refered to as time bands, uses both an upper time limit (deadline) and a lower time limit to constrain the Subject's response times, within a set reaction time band. Response signals, which follow the stimulus presentation at some pre-determined interval, have been used as a method of manipulating response time. With this <u>response signal method</u>, the Subject is required to respond as soon as the signal occurs. Wickelgren argues that the response signal method has a major advantage over all other methods in that it does not require the Subject to know the time condition which is in affect prior to the presentation of the stimulus. Thus it is assumed that the Subjects are less likely to alter their response strategies with the change in time constraints.

The partitioning of reaction times is a post-hoc method of determining SAT functions. With this method, the Subject's response times are sorted into three or more discrete time intervals. These intervals, along with their respective accuracy measures, are then used to derive the SAT function. In general, Wickelgren suggests that partitioning is not a satisfactory method, because the range of the Subjects' response times is truncated at the shorter intervals.

The final method of manipulating response times, is through the <u>use of different instruction sets</u>, emphasizing speed or accuracy differentially. A disadvantage of this approach is that it is generally a weaker manipulation, affording less control over the Subjects' response times. That is, it allows greater variability in the decision times, both within and between Subjects. However, for the present study, there was an additional concern that led to the adoption of the instruction set methodology. The present study was concerned with the generalizability of the SAT study results, to aid interpretation of the reaction time results from Experiment 2. Because it does not introduce any additional factors, not involved in the methodology of Experiment 2, it was belived that the instruction set method was least likely to alter the underlying processing involved in the task performance. Consequently, the instruction set method was used in Experiment 1 to derive the SAT data. A complete SAT curve required that a Subject perform the RT task under three instruction sets stressing (1) speed of performance, (2) accuracy of performance, and (3) both speed and accuracy, respectively.

Each of the single factor studies differed with respect to the stimuli used. However, other aspects of the method, procedure, design, and results analysis were consistent across all three studies.

Method

Subjects

In all, 18 Subjects participated in experiment I. In each of the three SAT studies, the Subjects consisted of six (3 male & 3 female) undergraduate students enrolled in psychology courses at Oklahoma State University. All Subjects were native English speaking individuals, with visual acuity equal to or better than 20/20 (or correctable to

20/20). The Subjects received extra credit toward their course grade for participation in the experiment.

Materials

The stimulus materials used in all three of the sat studies consisted of 312 letter strings of 4, 5, 6, or 7 upper case letters in length. Half of the letter strings (156 items) were composed of noun words, selected from the Kucera and Francis (1967) word frequency analysis. The words used in the intensity and repetition SAT studies ranged in frequency from 1 to 9, with an average frequency of (approximately) 5 occurrences per million words. In the frequency SAT study the 156 word items were made up of 78 low frequency nouns, drawn from the nouns used in the intensity SAT study, and 78 higher frequency nouns. The high frequency words ranged in frequency from 60 to 120 occurrences per million words. The other 156 letter strings were graphemically legal nonwords (e.g., JATED). All of the nonwords were pronounceable, however, none were homophonic with a word. The same pool of stimulus items were used in the repetition SAT study as were used in the intensity SAT study. Half of the word items (78) and half of the nonword items (78) were randomly selected (with frequency and word length controled) from the 312 items of the intensity SAT study. The selected set of 156 items were duplicated, to produce a total of 312 items, 156 primes (1st presentation) and 156 targets (2nd presentation). In the intensity SAT study half of the nonword and word items were presented at a reduced intensity of illumination. The other half of the intensity SAT items, and all items in the other two SAT studies, were presented at a standard (high) level of illumination. The standard illumination, as measured by a Minolta Auto Meter II (ASA 100), was set at an exposure value (EV) of 3. The intensities were selected prior to the experiment, by adjusting the low intensity level to a point which appeared to substantially increase the time required by pilot Subjects to accurately perform the item recognition task.

Procedure

Prior to presentation of instructions or trials, the visual acuity of the Subject was tested for pattern resolution. The Subjects were required to detect the orientation of a gap (subtending 1 minute of visual angle) in a circle figure. The stimulus presentation and data collection were programed on an ADS 1800E minicomputer. The Subjects performed a lexical-decision task which required that they decide as quickly as possible, given the speed-accuracy criterion in effect, whether the presented item was or was not a word. Each Subject received a total of 312 trials, spread over 3 blocks of 104 trials each. The first 24 trials of each block were practice items, and the remaining 80 trials were test items. All items were presented via an oscilloscope (Tektronix 604) monitor. The 4, 5, 6, and 7 letter items resulted in a vertical visual angle of .57 degrees and horizontal visual angles of; 2.52, 3.21, 3.89, and 4.58 degrees, respectively, for the four letter length conditions.

The Subjects were seated at a table in front of the monitor. Recessed into the table, in front of the Subject, were two appropriately labled (word, nonword) decision keys, which were used to indicate the word or nonword decision. The left-right position of the response keys was balanced between Subjects. Tape recorded instructions, explaining in detail the experimental purpose, task, and procedure, were played to the Subject. The instructions stressed the importance of adopting the designated speed-accuracy criterion. A sign was placed in full view of the Subject, emphasizing the desired speed-accuracy criterion during all trials of a block.

At the start of each block of trials the Subject received a different set of instructions with regard to the speed-accuracy criterion in effect for that block of trials. For the successive three blocks of trials the Subjects were instructed to adopt one of the following attitudes, (1) emphasize speed and accuracy, (2) emphasize speed at the expense of accuracy, or (3) emphasize accuracy at the expense of speed. The order of assignment of speed-accuracy instructions to blocks of trials was counterbalanced to control for possible fatigue or practice effects between blocks.

Regardless of the speed-accuracy condition, all trials followed the same procedure. The beginning of a trial was signaled by the appearance of the word 'READY' on the monitor screen. This ready signal stayed on until the Subject depressed both the word and nonword decision keys. The stimulus item appeared 0.5 seconds after the ready signal terminated, and stayed on until the Subject responded by releasing either of the decision keys. Immediately following the response, the Subject received visual feedback (lasting .3 sec.) concerning the accuracy of their decision. At the termination of the feedback interval a time-out period of .3 seconds commenced, during which the monitor screen was blank. Following the time-out period, the ready signal immediately appeared, signaling a new trial. At the end of all three blocks of trials the Subjects were debriefed and any questions pertaining to the study were answered.

Design

The same 2 X 3 repeated measures design (Winer, 1971) was used for all three of the SAT studies in Experiment I. The independent variables were different in each of the SAT studies. The main independent variable was either item intensity, item repetition, or word frequency. Each variable employed two levels. The secondary variable was the speed-accuracy instruction set, at three levels (neutral set, speed set, and accuracy set). Each Subject received one of three instruction conditions. The items were nested within blocks of trials, but randomized within the blocks for each Subject. The main variables were counterbalanced across items, within blocks of trials. The two dependent variables consisted of the Subject's response time and accuracy, within each block of trials.

Experiment-I Results

The data from each of the three SAT studies in Experiment 1 were analysed in an identical manner. The analysis consisted of a series of operations using the response times and error rate data from each of the treatment conditions to produce three points of an SAT curve for each of the two levels of the three main variables (intensity, repetition, and word frequency).

Each Subject's data were separated into six blocks, on the basis of the combination of the main variable (2 levels of intensity, frequency, or repetition) and the secondary variable of instruction set (3 levels) in effect for that block of trials. The mean response time (RT) and an estimate of accuracy (d') were calculated for each group of items. In order to calculate the d' values the hit rate (the proportion of correctly identified word items) and the false alarm rate (the proportion of errors in identifying the nonwords) were computed from the data in each block of trials. From each pair of hit rate and false alarm rate, d' was computed using a table of d' values from Hochhaus (1972). For every Subject, the above procedure resulted in three pairs of RT and d' values for each of the 2 levels of the main variables in the 3 SAT studies. However, the d' and RT values for individual Subjects were quite irregular. Consequently, the d' and RT values under each level of the main variable for each SAT study were summed across Subjects within the levels of the instruction set blocks. The analysis then proceeded by computing mean estimates of d' and RT.

By plotting the mean d' estimates with the mean RT estimates for each of the three levels of instruction set within a level of the main variable, three points of an SAT curve were produced for each level of the three main variables. Next, the three parameters of the Wickelgren equation; intercept (i), rate (r), and asumptote (a, expressed in d' units) were estimated by a least squares fit of the data to Wickelgren's (1977) equation for SAT functions. This equation ($d'=a[1-e^{-r(t-i)}]$) represents an SAT function having an exponential approach to an asymptote of accuracy over time. The Subject's accuracy is expressed as a d' measure from signal detection theory (Swets, 1964). The asymptote parameter (a) represents the level of accuracy that would be attained given unlimited processing time. The rate parameter (r) represents the rate of increase in accuracy as a function of processing time. The stimulus presentation time is represented by the parameter t. The intercept parameter (i) is the time required for accuracy to rise above a chance level.

The parameter estimation was accomplished by an iterative least squares curve fitting program run on an APPLE microcomputer. This resulted in 2 SAT functions (one at each level of the main variable) for each SAT study. The values of the 3 parameters for each of the six Wickelgren SAT functions are presented in Table II (see appendix). The SAT curves from the studies on intensity, repetition, and frequency are presented in Figures 1, 2, and 3 respectively (see appendix). Following the determination of the SAT function parameters, the asymptotic d' values of each pair of SAT curves from the SAT studies were analysed in three G-tests for significant differences (Gourevitch & Galanter, 1967). Neither the intensity, repetition, nor frequency treatments resulted in conventionally significant asymptotic d' differences at the .05 level of probability. The G values for intensity, repetition and frequency were G=.199, p=.421; G=1.37, p=.086; and G=.382, p=.352, respectively.

A visual inspection of the SAT functions and Table II reveals that the stimulus intensity variable affected both the intercept and rate paramenters of the activation curve. It appears that the asymptote parameter is not affected by the intensity variable. The word frequency variable appears to have slightly affected both rate and intercept parameters, the rate change being most apparent. Likewise, the variable of item repetition appears to have had the greatest influence on the intercept parameter of the SAT function. However, the above differences were not capable of being submitted to any precise statistical tests, and should be accepted with appropriate caution.

Experiment-I Discussion

Because the individual SAT curves from which the final SAT functions were derived were quite irregular, the reliability of the results is questionable. Consequently, any interpretation of the results of the SAT studies is rather speculative. It is not clear what contributed to the large variability among the individual SAT curves. Possibly different response strategies were adopted by different Subjects within the same set of experimental conditions. For example, in the neutral condition some Subjects may have stressed accuracy while others placed greater stress on speed. In addition, Subjects might have utilized different processing strategies to deal with the different treatment contexts. This might partially explain why the frequency SAT function asymptote for low frequency words is different (although not significantly) from the repetition SAT function asymptote for prime items. This result was unexpected since the items in both studies were the same low frequency words and the same nonwords. The same is true for the observed difference between the rate and intercept parameters from the intensity SAT function for high intensity items and the rate and intensity parameters from the two previously mentioned SAT functions. Finally, some of the Subjects apparently failed to adopt the appropriate speed-accuracy set for a given block of trials. This failure to adopt the response criterion designated for a block of trials would explain the occurrence of accuracy blocks of trials with a faster mean response time than that for the same Subject's speed block. Such reversed orderings of response times were observed in one Subject in each of the SAT studies. More frequently (6 out of 18 Subjects) the speed and neutral or the accuracy and neutral block response times were reversed in order. In general it does not appear that the instruction set method is able to produce consistent SAT curves across Subjects.

Bearing in mind the speculative nature of any conclusions from the data, some tentative interpretations of the final SAT functions can be suggested. It appears from an examinaton of the intensity SAT functions (Figure 1) that the intensity variable is most strongly influencing the rate of processing element. Though not as clearly, the SAT function from the frequency SAT study suggests that the variable of word frequency influences the rate of a process. Although not significant, an asymptote change is apparent in both the Wickelgren function (Table II) and the SAT curves (Fig. 3). However, the direction of the change is counter-intuitive. It does not seem plausable that the effect of increasing the word frequency should reduce the asymptote parameter value. This is quite perplexing and resists explanation. An examination of the SAT curves (Fig. 3) reveals that for each block of trials (speed, neutral, and accuracy) a frequency effect occurred. That is, the high frequency words were responded to more quickly than the low frequency words. It seems then, that the assymptote difference is not due to the failure of the Subjects to respond to the word frequency differences. Since over-all response time decreased with high frequency words, it seems likely that the asymptote difference is erroneous.

The repetition SAT functions appear to have divergent asymptotes and rates. Though the asymptote difference was not significant, the apparent magnitude of the asymptote difference (see Fig. 2) suggests that item repetition may influence the asymptote of some information process in the task. However, this asymptote effect is not apparent if the repetition SAT function for target words is compared to the SAT function for low frequency items. As noted above, the low frequency SAT function would be expected to be quite similar to the SAT function for prime items. A glance at Table 2 shows that in fact the parameters for the two functions are quite similar except for the asymptote values. If it is assumed that the asymptote of the prime SAT function should approximate the 3.88 value of the low frequency SAT function, then the asymptote effect drops out and the repetition variable appears to only influence the rate of the SAT function. However, there is another possible way to adjust the frequency asymptote parameters. The low frequency SAT curve asymptote could be decreased to the level of the high frequency asymptote. This would resolve the problem of a counter-intuitive asymptote change and at the same time bring the asymptote value of the repetition SAT function for prime items into agreement with the low frequency SAT function value. Such a change would not resolve the existence of both rate and asymptote effects in the repetition SAT data.

However, if the asymptotes of the low frequency and prime SAT functions were set at the low value (3.39) then the asymptote of the high intensity SAT function would be out of agreement. Adjustment of the high intensity asymptote to lower levels would increase the asymptote difference between the intensity SAT functions, in the counter-intuitive direction. It seems that the earlier suggested asymptote adjustments would be more parsimonious and therefore are the prefered interpretations.

If the existence of both rate and asymptote changes in the data were not due to measurement artifact, then the data would suggest that the intensity variable affects only the rate of one process while the repetition and frequency variables influence both the rate and asymptotes of some process. However, it appears most probable from the data of experiment 1, that neither the intensity, frequency, nor the repetition variables resulted in SAT asymptote effects.

CHAPTER V

EXPERIMENT II

Experiment 2 was concerned with a specification of the locus of the repetition effect through a factorial combination of item repetition with item presentation intensity and word frequency. Experiment 2 served a twofold purpose. First, the locus of the repetition effect was more clearly defined through its relationship to the stimulus intensity factor. Second, the interpretative logic of the Cascade model could be compared to the discrete stage model additive factors logic in interpreting the results of the study.

Method

Subjects

The Subjects consisted of 20 undergraduate students enrolled in introductory psychology courses at Oklahoma State University. The Subject selection criteria ensured that an equal number or males and females participated, and that all Subjects were native English speaking individuals with a visual acuity of 20/20 or better (corrected or uncorrected). All Subjects received partial credit toward their course grade for participation in the study.

Materials

The stimulus items consisted of 170 different letter strings of 4, 5, 6, and 7 letters in length. Half of the items were English words and the other 85 items consisted of pronounceable nonwords. All of the items were duplicated to produce a total set of 340 items. All of the 85 nonword items were selected from the nonwords used in the Experiment 1 studies. The 85 word items consisted of 42 high frequency nouns and 43 low frequency nouns, selected from the word items used in the word frequency SAT study of Experiment 1.

Procedure

The Subjects performed a lexical-decision task identical to the Experiment 1 task. All Subjects received 20 practice trials and 320 test trials. The stimulus presentation and data collection involved the same ADS-1800E minicomputer that was used in the Experiment 1 SAT studies. In general, the experimental procedure was quite similar to the Experiment 1 procedure. However, all Subjects received the same set of instructions, stressing speed and accuracy. In addition, all trials were presented in only one block. Otherwise, the sequence and timing of events occurring in a single trial were identical to the Experiment 1 procedure.

Design

Experiment 2 used a 2 X 2 X 2 within Subjects repeated measures design (Winer, 1971). The independent variables were presentation intensity, word frequency, and item repetition. The dependent variable was the Subject's RT on each trial. The two levels of the intensity variable (high & low) were the same as those used in Experiment 1. All items were repeated with an average lag of 15 trials (range 5-25 trials) between the first and second presentations. Within the repetition trials of an item, the first presentation of the item was designated as the 'prime' and the second presentation as the 'target' of the item pair. For each prime-target item pair, four combinations of presentation intensity were possible, i.e., both presented at high intensity (H-H), the prime presented at high and the target presented at low intensity (H-L), the prime low and the target high (L-H), and both prime and target presented at low intensity (L-L). The item pairs were assigned equally among the four intensity conditions. Consequently, four sets of prime-target presentation intensities existed for each of the three types of items used, high frequency words (HFW), low frequency words (LFW), and nonwords (NW), resulting in twelve combinations of item type and prime-target intensity. Within each of the three types of items (HFW, LFW, and NW), the assignment of prime-target pairs to intensity conditions was counterbalanced across Subjects.

Experiment-II Results

The data consisted of each Subject's RT scores for each correct trial. Error trials (3% of all trials) were excluded from the data. However, error rates under each treatment level were tabulated and evaluated for evidence of speed-accuracy trade-offs. The total errors ranged from 2 to 20 errors per Subject, with a mean of 10.2 errors. The mean number of errors for word trials (5.2) was not significantly different from the nonword trial error rate mean (5.0), $t(19)=0.19$, $p>.05$. Within the word data, the mean error rate for high intensity words (2.4) was not significantly different from that for low intensity words (2.8), $t(19) = 0.89$, $p>.05$. The mean error rate for high frequency word trials (1.65) was significantly less ($t(19)=3.64$, $p<.005$), than the mean number of errors (3.6) for low frequency word trials. For words, the prime trial mean error rate (4.1) was significantly greater, $t(19)=5.67$, $p<.005$, than the mean error rate on target trials (1.1). However, for nonwords, the repetition variable did not result in significant mean error rate differences, $t(19)=0.96$, $p>.05$, between prime (2.7) and target (2.3) nonword trials. The mean error rate (2.0) on high intensity nonword trials was significantly smaller, $t(19)=2.96$, $p<.005$, than that for low intensity nonword trials (3.0). The pattern of errors indicated that the results were not attributable to a trade-off of accuracy for speed. Within each treatment the level which resulted in the slowest response times also resulted in the highest error rate for both word and nonword items.

The response times were summed over Subjects to produce grand means for each of the levels of word item; frequency, repetition, and intensity, and nonword repetition and intensity. The results indicated a faster (80 msec.)average response time to high frequency words (659 msec.) than to low frequency words (739 msec.). The average response time to the first presentation of a word (prime) item was 755 msec. while the average response time to the second presentation of word (target) items was 650 msec., resulting in an average repetition effect of 105 msec. The average repetition effect for nonword items, prime nonwords (841 msec.) vs target nonwords (774 msec.) was 67 msec. High intensity words were responded to more rapidly (667 msec.) than were low intensity words (739 msec.). The same was true of the Subject's average response time to nonwords presented at a high intensity (753 msec.) compared to that for low intensity nonwords (863 msec.).

Separate analyses were conducted for the word and nonword data. Table III (in the appendix) presents a summary of the F values from the analysis of variance of the word data. The word data were analyzed in a 3-way within-Subjects analysis of variance (intensity by frequency by repetition by Subjects AOV) for designs involving repeated measures (Winer, 1971). This analysis resulted in F values for each of the main effects intensity (I), frequency (F), and repetition (R) all of which were significant at the .0001 probability level. The pattern of interactions among the three variables (displayed in Figures 4-6 in the appendix) was varied. The RxF interaction (Fig. 4) was significant

($F(1,19) = 29.9$, $p < .0001$) as was the RxI interaction (Fig. 6) ($F(1,19) = 7.9$, $p < .01$). However, neither the IxF (Fig. 5) nor the IxFxR interactions were significant at the .1 level of probability.

A second analysis of the word data was performed with items collapsed over Subjects in a 3 way split-plot AOV (IxFxRxItems [nested in Freq]). The results of this analysis (in Table III) were essentially the same as the by Subjects analysis. The results from both the by Subjects and the by items analyses were combined to calculate minimum F's, as is recommended by Clark (1973), so that the results may be generalized to both Subject and word item populations. The results of the min F' computations are also displayed in Table III. The main effects of word intensity ($F'(1,56) = 22.5$, $p < .001$), word repetition ($F'(1,28) = 64.0$, $p < .001$), and word frequency ($F'(1,41) = 36.3$, $p < .001$) were significant. Among the interaction terms evaluated, only the RxF interaction was significant ($F'(1,41) = 19.7$, $p < .001$). However, the RxI interaction approached significance at the .1 level of probability ($F'(1,85) = 2.76$, $p < .105$).

The nonword data were subjected to a 2-way within Subjects analysis of variance (IxRx Subjects AOV). The results of the analysis appear in Table IV in the appendix. The main effects of item repetition and item intensity were significant ($F(1,19) = 13.91$), $p < .0014$) and ($F(1,19) = 29.8$, $p < .0001$), respectively. The interaction of repetition and intensity (Figure 7 in the appendix) was not significant.

Next, the nonword data were summed across Subjects and submitted to a second 2-way AOV (IxRxItems). The results of this analysis essentially replicated the by-Subjects results, both main effects (I and R) were significant at the .001 level and the interaction was not significant. As in the case of the word data, the results from the nonword by-Subjects and by-items analyses were combined to compute minimum F's for the effects which were significant in both the by-Subjects and the by-items analyses. Both the main effects of nonword repetition ($F'(1,25)=12.06$, $p<.003$) and nonword intensity ($F'(1,32)=22.47$, $p<.001$) were significant.

Discussion

The results of Experiment 2 supported the hypothesis concerning the word frequency effect, the effect of item presentation intensity, and the repetition effect. High frequency words produced faster response times than low frequency words. The items presented at the standard high intensity illumination were responded to more rapidly than were items presented at the low intensity illumination. The repetition of items resulted in a facilitation of response time and the facilitation was greater for word items (105 msec.) than for nonword items (67 msec.). The observed repetition effect for nonwords is somewhat larger than any previously reported nonword repetition effect. There was nothing obvious about the nonword items used in the experiment which would account for the size of this effect.

With regard to the interactions among the three variables, the results support the experimental hypotheses. The variable of item repetition interacted with word frequency and item presentation intensity. As was hypothesized, word frequency did not interact with intensity of presentation and the three way interaction of repetition, intensity, and word frequency did not occur. The repetition by intensity interaction was not as substantial as the author would have liked it to have been. However, the by-Subjects and by-items analyses were robust enough to support the conclusion that the nonsignificant min F' was a type II error. This conclusion is also supported by the results of Hernon et al. (1979); although the interaction was not as strong in the present study the same pattern of results emerged. This difference may be attributable to the different methods used to manipulate the stimulus quality variable in the two studies. It is possible that the random dot degradation used by Hernon et al. disrupts stimulus processing much more than does the illumination intensity manipuulation used in the present study. The former manipulation would break up the letter pattern of the items while the latter manipulation leaves the item intact. The fact that the mean response time to degraded high frequency prime words was 940 msec. in the Hernon et al. study, while it was only 726 msec. in the present study, lends support to this supposition.

The results from Experiment 2 are in partial agreement with those of Scarborough et al. (1977). There was a strong interaction of repetition with word frequency as in the Scarborough study. However, the interaction of repetition with intensity does not agree entirely with the stage model conclusions of Scarborough et al. based on their failure to obtain an interaction of word repetition and the letter case variable. This will be discussed in the general conclusions section to follow.

The results from the analysis of the nonword data are something of a puzzle. The failure to find a repetition by intensity interaction does not agree with the experimental hypothesis nor the results of Hernon et al., who reported a large repetition by degradation interaction for nonwords. The difference may in part be attributable to the differential effects of random dot degradation and illumination intensity as the means of manipulating stimulus quality. In addition, it should be noted that the nonword data were more variable than the word data. The over-all standard deviation of the nonword data (305 msec.) was 66 msec., or 28% larger than that for the word data (239 msec.). It seems possible that because of the variability, the F test lacked sufficient power to detect a significant repetition by intensity interaction.

General Conclusions

The primary purpose of the present research was to obtain additional information on the locus of the repetition effect. The relevance of the results from Experiment 2 in resolving this question is dependent upon the processing model that is applied to the data, and the interpretation of the results from Experiment 1. If the cascade model is chosen as the appropriate model for interpreting the data from Experiment 2, then the results from Experiment 1 must be applied to the interpretation. Three possible interpretations of the Experiment 1 results were proposed, (1) that the intensity variable affects the rate while the repetition and frequency variables affect both rate and asymptote. (2) that the intensity variable and the frequency variable affect rate while the repetition variable affects both rate and asymptote, and (3) that all three variables affect only the rate parameter of processes. The results from Experiment 1 suggested that none of the variables influenced the asymptotes of the SAT curves. This leaves only the third interpretation of the Experiment 1 results for consideration. However, if the Experiment 1 results are interpreted as indicating that all three variables, intensity, repetition, and frequency, are only altering the rates of different process, then the interpretation of the Experiment 2 results under the cascade model will be identical to that under the discrete stage model.

In the discrete stage model, additive factors logic is applicable. An interaction between two variables indicates that both variables have their effect in the same stage of processing. The interaction of repetition with word frequency indicates a locus of the repetition effect in a common stage, presumably the memory search stage. However, the interaction of repetition and intensity indicates that the repetition effect is also active in the encoding stage of processing. The lack of an intensity by frequency interaction lends support to this interpretation, verifying once again that the word frequency and item intensity variables exert their effects in two different stages of processing. This interpretation agrees with the conclusions of Scarborough et al. (1977). It appears that the effect of word repetition is at two stages of processing, the memory search stage and the stimulus encoding stage. In addition the present interpretation agrees with the Hernon et al. (1979) results indicating an effect of word repetition earlier in the encoding stage than was suggested by Scarborough et al. (1977).

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APPENDIX

TABLES & FIGURES

TABLE I

INFERENCES DERIVED FROM THE CASCADE MODEL

Experimental Result	Cascade Model Interpretation
If Factors Interact	They affect the rate of the same process. or They both affect relative asymptotic activation of the same or different processes. or One affects the rate of the rate-limiting process (the slowest), the other affects the asymptotic activation.
If Factors Are Additive	They affect the rates of different processes. or One affects the rate of a fast process and the other affects the asymptote.

TABLE II

SAT FUNCTION PARAMETERS FROM EXPERIMENT-I

SAT Variable	Intercept	Parameter Asymptote	Rate
High Frequency	466	3.30	68
Low Frequency	505	3.88	15
2nd Presentation	468	3.98	31
1st Presentation	495	3.39	15
High Intensity	614	3.96	205
Low Intensity	780	3.77	4

TABLE III

SUMMARY TABLE OF THE EXPERIMENT-II AOV
RESULTS FOR WORD ITEMS

Source	F-Test Type	F Value	df	p<
Repetition	by-subjects	78.53	1,19	.0001
	by-items	346.30	1,78	.0001
	minimum F'	64.0	1,28	.001
Frequency	by-subjects	63.22	1,19	.0001
	by-items	85.35	1,78	.0001
	minimum F'	36.3	1,51	.001
Intensity	by-subjects	42.10	1,19	.0001
	by-items	48.45	1,78	.0001
	minimum F'	22.5	1,56	.001
Repetition	by-Subjects	29.90	1,19	.0001
by	by-items	57.62	1,78	.0001
Frequency	minimum F'	19.7	1,41	.001
Repetition	by-Subjects	7.94	1,19	.0110
by	by-items	4.22	1,78	.0433
Intensity	minimum F'	2.8	1,85	.105
Frequency	by-Subjects	2.74	1,19	.1144
by	by-items	2.20	1,78	.1420
Intensity	minimum F'	*	*	*
RxFxI	by-Subjects	0.94	1,19	.343
	by-items	0.63	1,78	.429
	minimum F'	*	*	*

* test was not computed due to nonsignificance of the component F tests.

TABLE IV

SUMMARY TABLE OF THE EXPERIMENT-II AOV RESULTS FOR NONWORDS

Source	F-Test Type	F Value	df	p<
Repetition	by-Subjects	13.91	1,19	.0014
	by-items	90.97	1,78	.0001
	minimum F'	12.1	1,28	.003
Intensity	by-Subjects	29.80	1,19	.0001
	by-items	91.41	1,78	.0001
	minimum F'	22.5	1,32	.001
Repetition by Intensity	by-Subjects	1.22	1,19	.2827
	by-items	2.19	1,78	.1430
	minimum F'	*	*	*

* test was not computed due to nonsignificance of the component F tests.

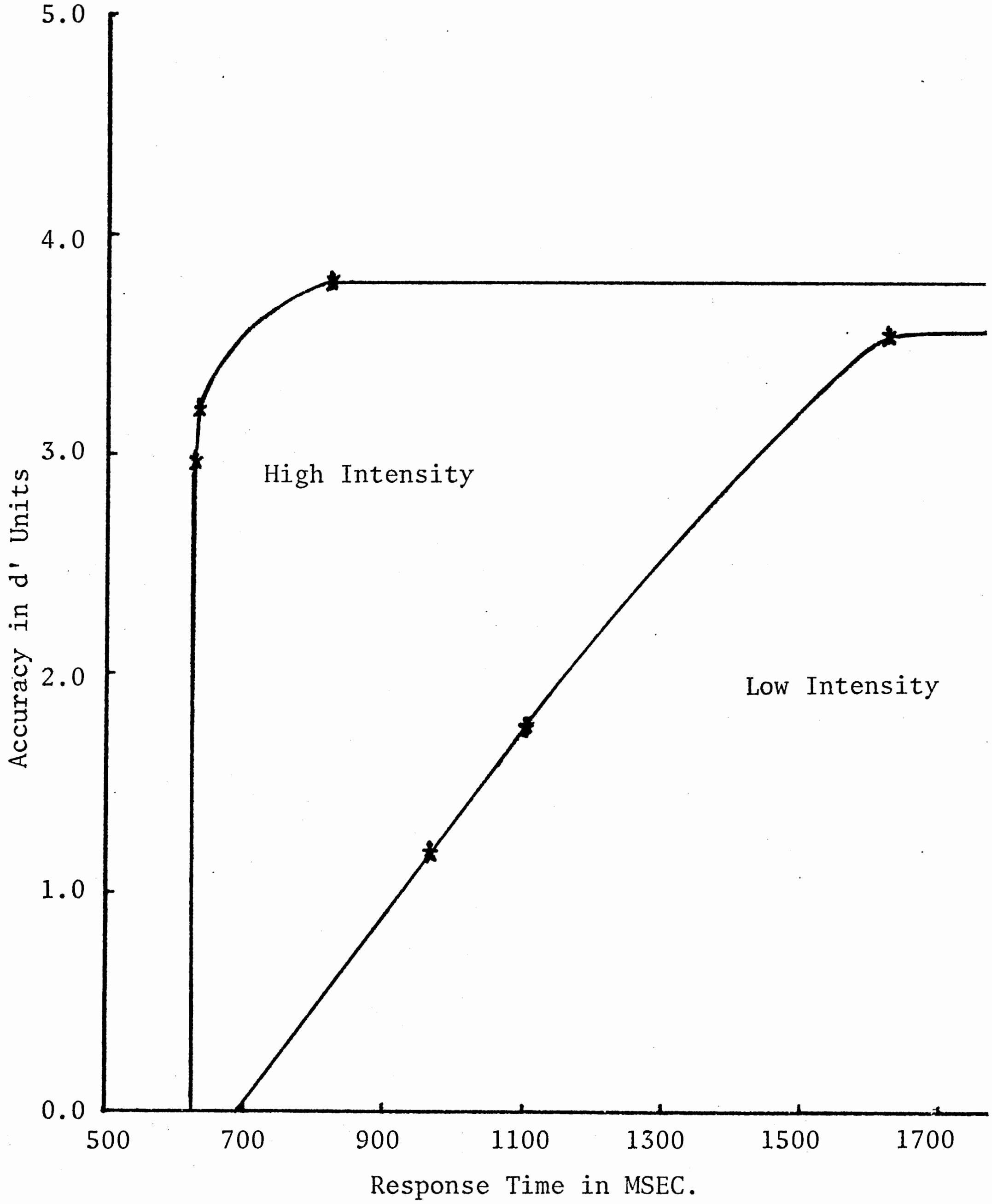

Figure 1. SAT Curves from the Intensity Study of Experiment 1

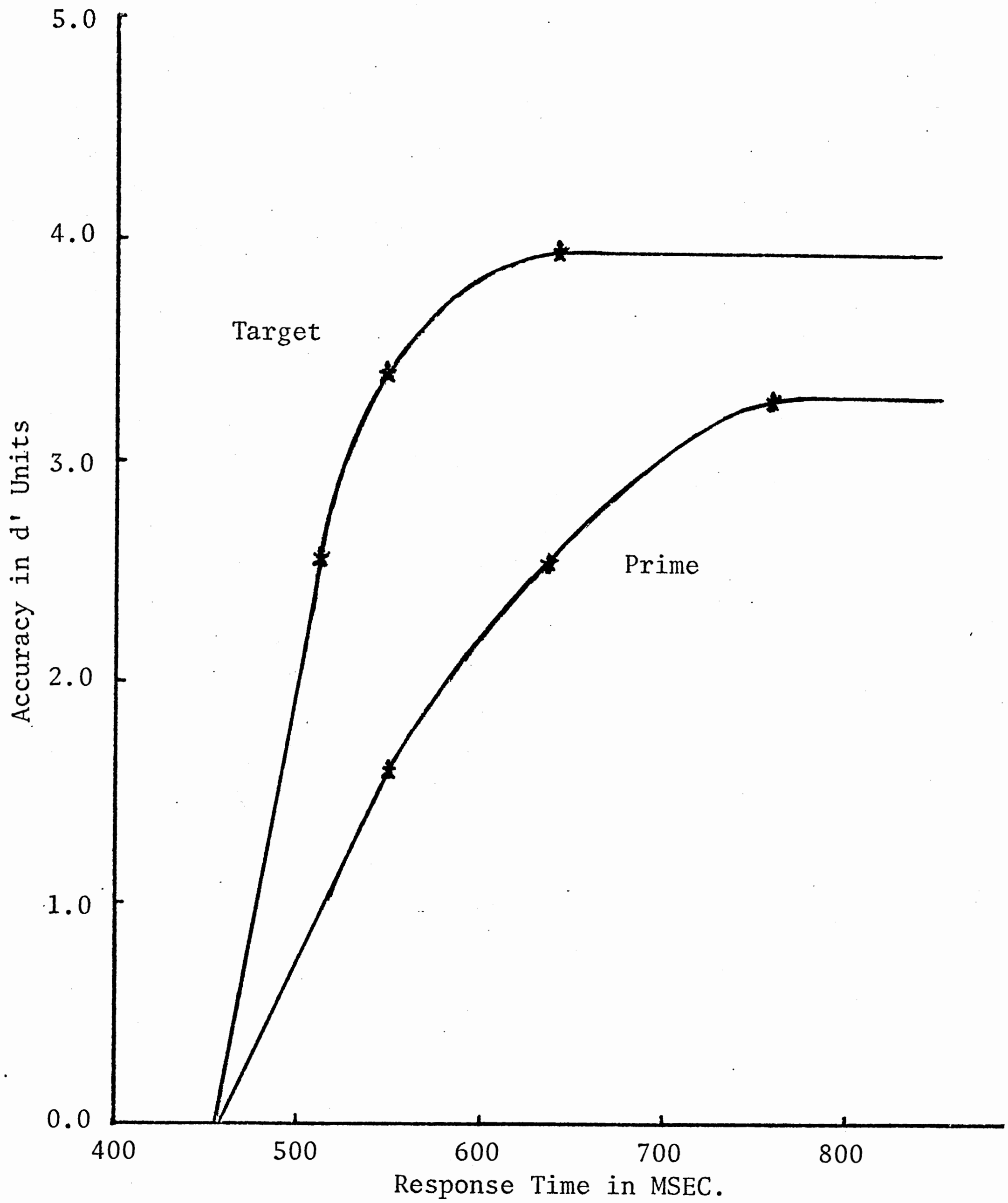

Figure 2. SAT Curves from the Repetition Study of Experiment 1

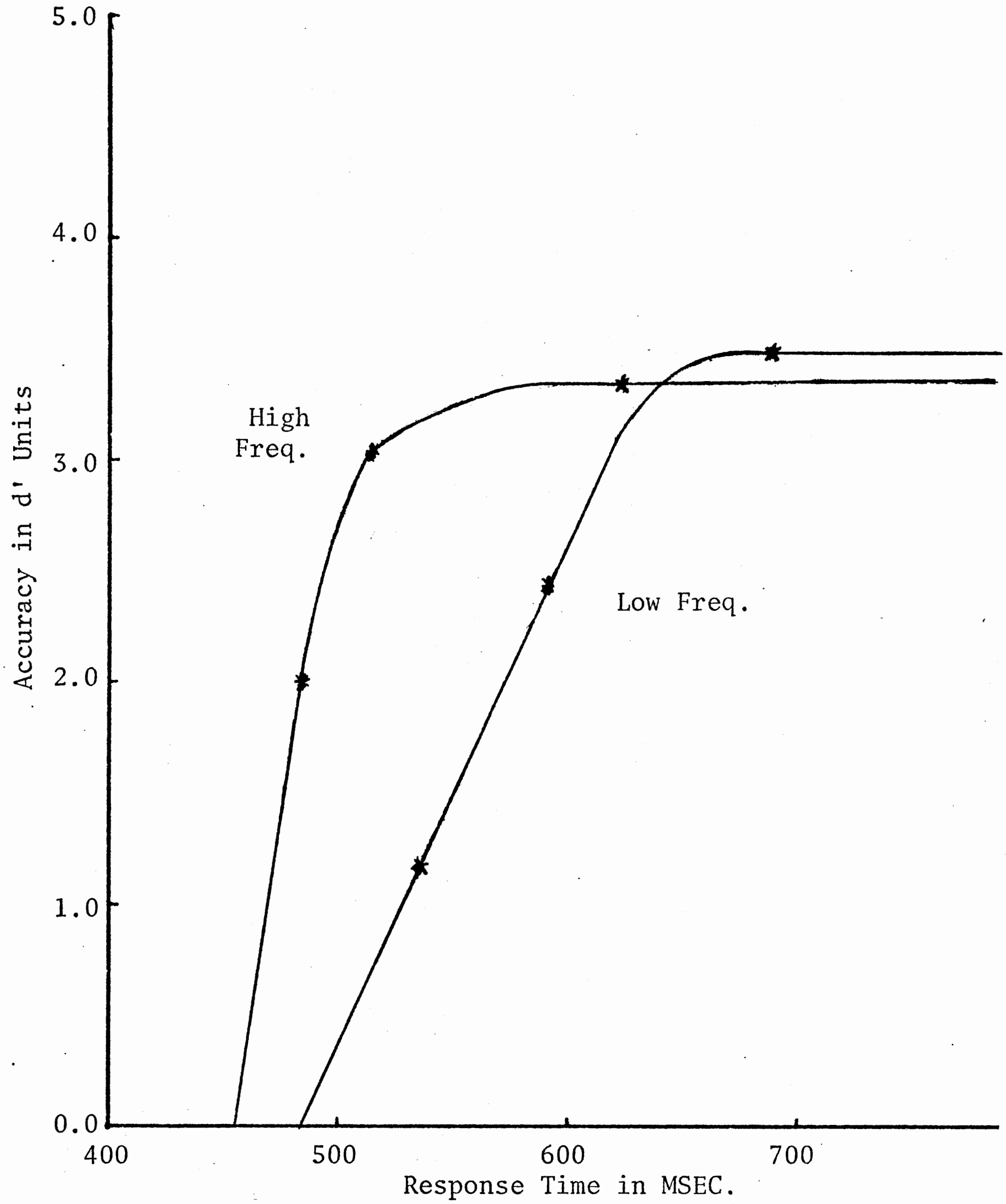

Figure 3. SAT Curves from the Frequency Study of Experiment 1

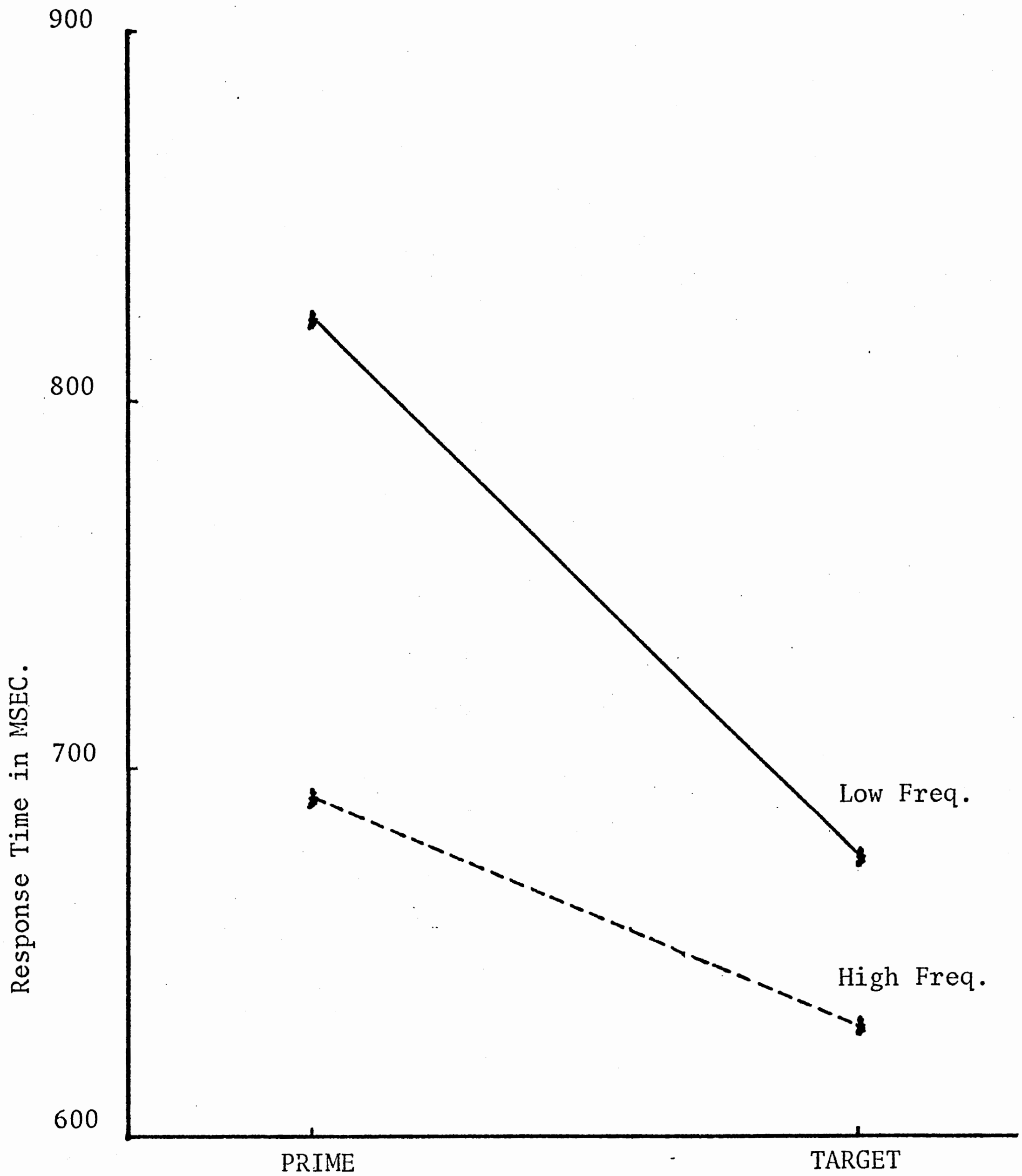

Figure 4. Repetition Effect on Response Time to High and Low Frequency Words

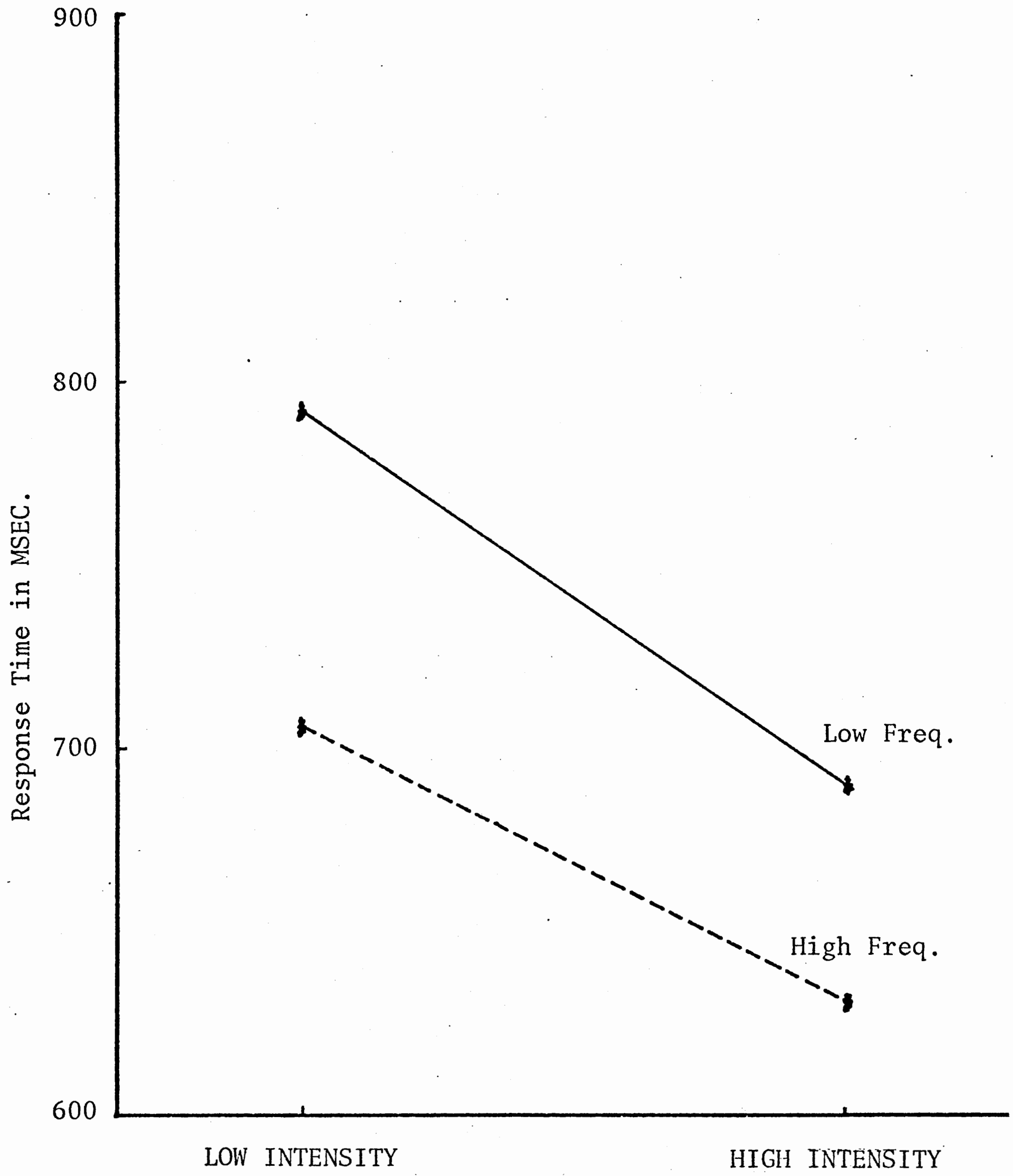

Figure 5. The Effect of Presentation Intensity on Response Time to Low and High Frequency Words

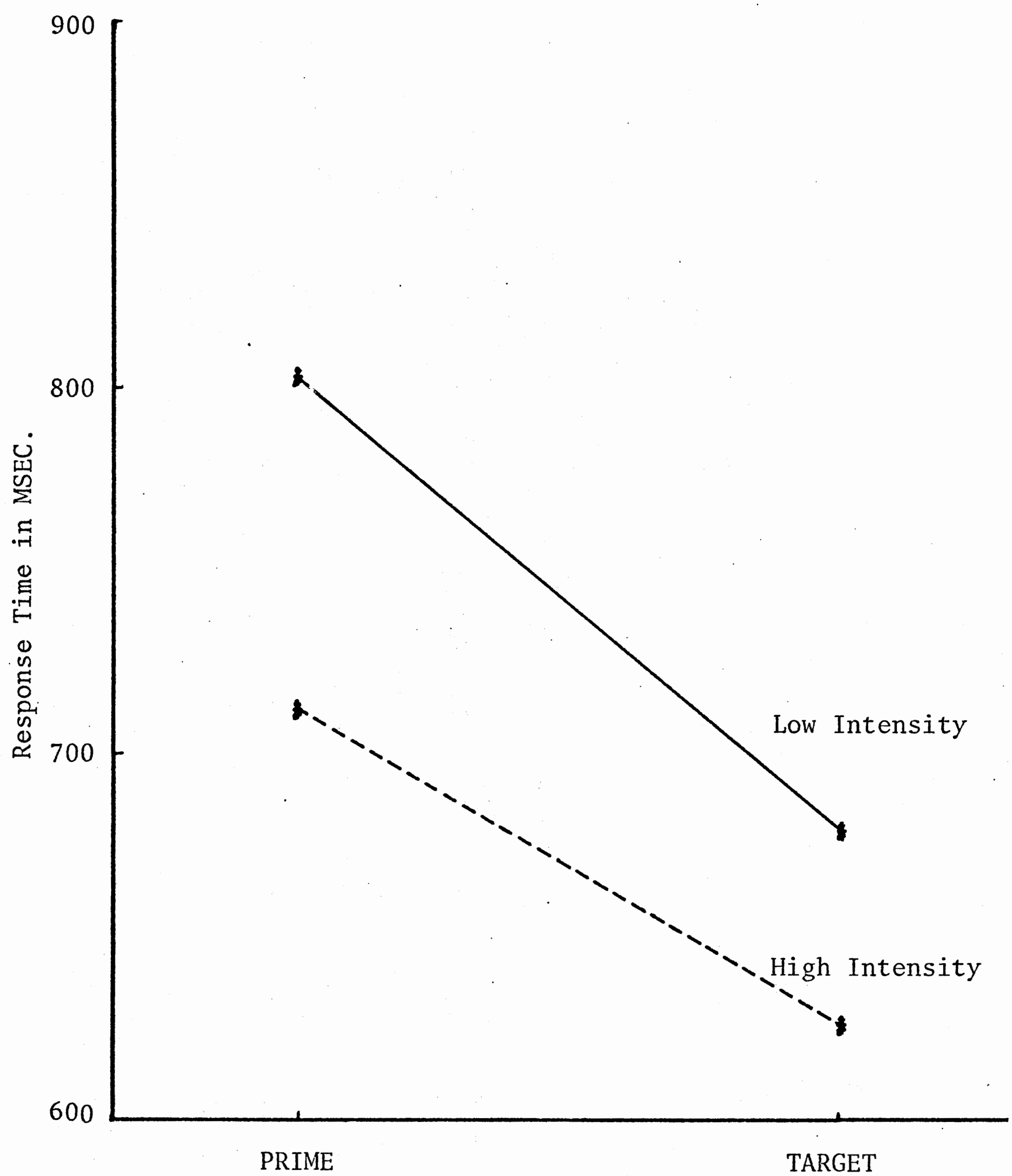

Figure 6. The Effect of Repetition on Reaction Time to High and Low Intensity Words

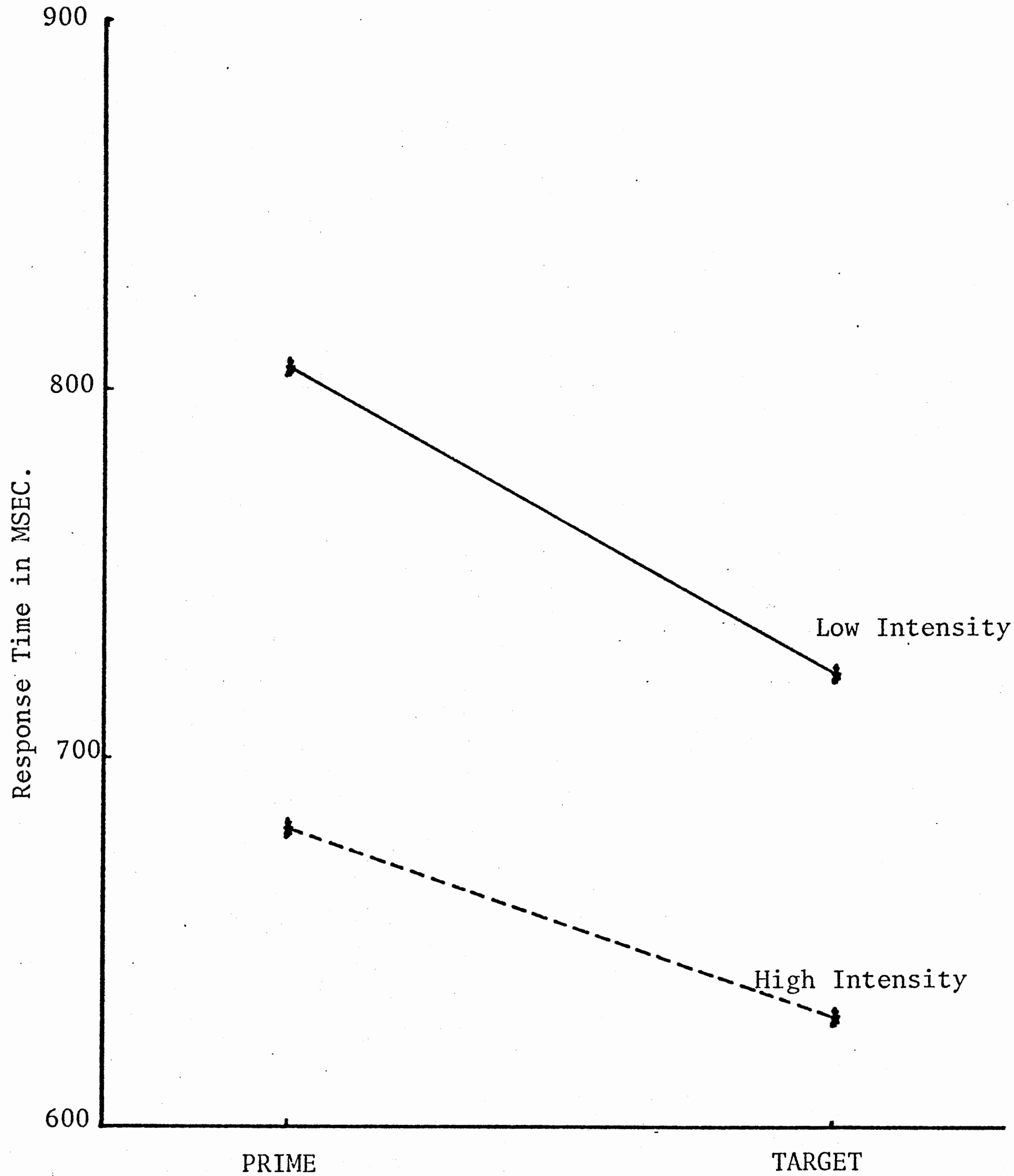

Figure 7. The Effect of Repetition on Reaction Time to High and Low Intensity Nonwords

VITA

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Doctor of Philosophy

Thesis: AN EXAMINATION OF THE LOCUS OF THE REPETITION EFFECT

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