REPETITION PRIMING AND THE INFLUENCE OF ENCODING STRATEGIES

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PREFACE

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CHAPTER I

INTRODUCTION

The effect of semantic context on word recognition and other verbal processing has become an area of increasing research in the last decade. Of particular interest in the phenomenon of facilitation of word recognition achieved by priming responses through previously presented words. The typical result is that a word is recognized as a word more quickly when it is preceded by an associated word than when it is preceded by a non-associate. The associated word is assumed to prime the target word representation in lexical memory and thus facilitate recognition. This type of priming involving associated prime and target words is termed "semantic priming". Another type of priming, "repetition priming", occurs when the prime and target words are identical.

Considerable research has focused on the operation of the semantic priming mechanisms but only within the last year have investigators begun to explore the phenomenon of repetition priming. Consequently, most of the models of word recognition concentrate on providing mechanisms for semantic priming, and repetition priming has either been ignored or assumed to be the same phenomenon as semantic priming. That repetition and semantic priming are different phenomena is becoming apparent from research that has indicated significant differences in the magnitude, duration, and locus of operation (in the stages of information processing) of the effects of semantic and repetition priming.

Recent research (Shulman & Davison, 1977) has indicated that encoding strategies influence the magnitude of the semantic priming effect. Presumably, subjects performing a lexical-decision (word-nonword) task will refrain from making semantic encodings of stimulus words when unpronounceable letter strings are used as distractors. The present study attempted to explore the influence of distractor item pronounceability on the repetition priming effect. This information provides an additional comparison of semantic and repetition priming that further defines the differences between the two phenomena.

CHAPTER II

REVIEW OF THE LITERATURE

The following review reports the relevant research concerning word priming. The sections are organized around the major topics pertinent to the present study, namely semantic priming, repetition priming, and theories of word recognition.

Priming is the facilitation of response time (RT) to a word (the target word), by the presentation of another word (the prime word). The presentation of the target and prime may be sequential or simultaneous. When the target and prime are semantically associated words the resulting priming is termed "semantic priming". "Repetition priming" occurs when the target and prime are identical.

Semantic Priming

The semantic priming effect has been the subject of numerous investigations (e.g., Meyer & Schvaneveldt, 1971; Meyer & Ruddy, 1973; Meyer, Schvaneveldt & Ruddy, 1975; Becker & Killion, 1977; Neely, 1977; Shulman & Davison, 1977). The earliest study (Meyer & Schvaneveldt, 1971) investigated semantic priming using two tasks, a same-different task and a lexical-decision task, with word and nonword stimuli. The lexical-decision task required subjects to judge whether or not the presented strings of letters were both English words. The word and nonword stimuli were presented in pairs. Each of the stimulus pairs could consist of two associated words, two unassociated words, two nonwords, or a word-nonword pair. The dependent variable was the subject's reaction time in making the paired lexical decisions. The stimulus pairs were presented simultaneously with one item directly above the other. The same-different task required the subject to judge if the pairs of letter strings were the same (both nonwords or words) or different. The results indicated a significant facilitation of decision RT (on the order of 100 msec.) for associated word pairs on both tasks.

Semantic priming has been demonstrated to interact with the visual quality of the stimulus items (Meyer, Schvaneveldt, & Ruddy, 1972). Meyer et al. (1972) manipulated stimulus quality in an attempt to determine the locus of the semantic priming effect. In this study the subjects made separate lexical decisions on two successive letter strings. The second string in some of the pairs was degraded by a superimposed masking pattern. The results indicated an interaction between semantic priming and stimulus quality. The facilitation of RT due to priming was greater when the stimuli were degraded than when they were intact. In a later study by Meyer, Schvaneveldt, and Ruddy (1975) both a pronunciation task and a lexical-decision task were used in an effort to clarify the results of Meyer et al. (1972). The stimuli, paired letter strings, were presented in both intact and degraded conditions. The results indicated a slightly lower RT for the pronunciation task, however, the effects of semantic priming and stimulus degradation were not significantly different between the two tasks. Meyer et al. (1975) interpreted these results, in the framework of a three stage model of word recognition, as indicating that semantic priming influences the first stage of processing (stimulus encoding) rather than the latter stages (phonemic translation and lexical retrieval). Because priming interacted with stimulus quality then it could be assumed that both factors affect the same stage of word processing. Since the interaction occurred in the pronunciation task which was assumed not to require lexical retrieval (Meyer et al., 1975), then it reasonably followed that the effect of both factors must occur prior to phonemic translation, i.e., in the encoding stage. The interaction of priming and stimulus quality was further confirmed in a study by Becker and Killion (1977) which manipulated stimulus intensity rather than degradation. In the same study Becker and Killion reported results from an additional experiment which demonstrated that the factor of stimulus intensity does not interact with the effect of stimulus word frequency.

Semantic Priming and Control Processes

Previously, semantic priming has been considered to be an automatic process (Meyer et al., 1971). Recently research has been reported (Neely, 1977; Tweedy, Lapinsky, & Schvaneveldt, 1977; Shulman & Davison, 1977) indicating the influence of control processes in semantic priming. Control processes are procedures which a subject may use to control the kinds of information that is encoded during the performance of a task, for example, coding procedures, rehearsal operations, and search strategies are control processes. The appearance of these phenomena depends upon factors such as instructional set, processing task, subject past history, and the demand characteristics within the experiment itself.

Semantic priming (category-exemplar word pairs) has been demonstrated by Neely (1977) to involve two processes that facilitate word recognition. One of the components is a short lived automatic spreading of activation and the second component is the result of selective attention, i.e., strategies of directing a limited-capacity attention mechanism to a particular class of words, on the basis of prime word information. Using a rather complex task Neely (1977) primed selected word trials with a category name (e.g., "Body") which subjects had been instructed would indicate that the target item which followed, if it were a word, would be an exemplar selected from a specified category other than the prime category (e.g., "Building"). But on the trials of interest an exemplar of the prime word followed the prime, contrary to subject's expectations. On these unexpected semantically related trials RT to the target was inhibited rather than facilitated. This indicated that an important component of the facilitation from semantic priming results from control processes that direct the subjects attention to probable target response sets.

Further support for the role of control processes in semantic priming comes from a study by Tweedy, Lapinski, and Schvaneveldt (1977). Tweedy et al. examined the consequence of varying the proportion of associated prime-target word pairs in a lexical-decision task. It was found that the effect of semantic priming decreased in a linear manner (as much as 43 msec.) as the proportion of associated word pairs was decreased from 7/8 to 1/8.

Recently Shulman and Davison (1977) investigated the influence of pronounceable and unpronounceable nonwords on the facilitation resulting from semantically related items in a lexical-decision task.

Shulman and Davison (1977) hypothesized that semantic encoding was an optional process determined in part by the nature of the nonword stimuli used. They predicted a reduction in the facilitation effect from semantic priming when non-pronounceable letter strings were used as nonwords, relative to trials using more word-like nonwords. Using non-pronounceable letter strings it was argued, would remove the necessity of semantic processing in performing the lexical-decision task (i.e., would make the depth of processing more shallow). Subjects could then base their decisions on a lower level (orthographic or phonemic) encoding. (Stanners, Forbach & Headley, 1971, showed consonant string decision times were faster and reached the same conclusion.) Shulman and Davison (1977) found that facilitation from semantic relatedness, in the orthographically illegal nonword condition, was appreciably smaller (33 msec. facilitation effect) than in the pronounceable nonword condition (106 msec.). The data were interpreted as supporting the hypothesis of a shift in the processing mode with the type of nonword used. However, the facilitation effect did not disappear entirely, even with extended practice (Shulman & Davison, 1977, Expt. 2).

Repetition Priming

The facilitation of lexical-decision RTs through the presentation of prime words prior to target word presentations is not limited to semantic priming. Forbach, Stanners, and Hochhaus (1974) clearly demonstrated a facilitation effect from repeated presentations of the same word items in a lexical-decision task. This repetition priming resulted in many words (as many as 36) being in a primed state simultaneously, and the facilitation was long lived, persisting beyond 10 minutes.

Repetition priming has received relatively little attention from investigators in the area of memory processes. This oversight may be due in part, to a belief that repetition priming is merely semantic priming where the semantic relationship between the prime and target is one of identity, an assumption which still remains to be experimentally established.

Scarborough, Cortese, and Scarborough (1977) conducted a series of five experiments on repetition priming. Analysis of the response latencies, using Sternberg's (1969) additive-factors approach, led the authors to suggest that word repetition effects occur in a memory retrieval stage. 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 translation-response organization). Sternberg argues that factors which exert their influence at the same stage of processing will show an interaction, while the influence of factors occurring in separate stages of processing will be additive. Scarborough _et al_. (1977) found that word frequency interacted with word repetition indicating that both the frequency effect and the effect of word repetition are located in the same stage of processing. Previous research (Becker & Killion, 1977) had indicated that the locus of the word frequency effect was not in the visual encoding stage since frequency effects did not interact with stimulus quality effects.

Scarborough _et al_. (1977, Expt. 3) found that a task variable pronunciation versus lexical-decision) interacted with word repetition.

The repetition effect was less in the pronunciation task than in the lexical-decision task. It was also noted that the word frequency effect all but disappeared in the pronunciation task, indicating that the pronunciation task did not require lexical access. Reasoning from these results, Scarborough et al. (1977) suggested that repetition effects for words occurred in both the memory search stage (due to the interaction with word frequency) and in the encoding stage at a point beyond visual encoding (due to the interaction with task type).

Differences Between Repetition and Semantic Priming

There are some substantial differences between the two types of priming that would suggest that they result from separate processes. For example, the characteristic size of the facilitation effects and rates of decay of the two processes differ widely. The facilitation from repetition priming is reliably greater than 100 msec. (Forbach et al., 1974; Scarborough et al., 1977; Hall, 1978) while RT facilitation from semantic priming is typically in the range of 50-80 msec. (Meyer & Schvaneveldt, 1971; Meyer & Schvaneveldt, 1976). In regard to the rate at which the facilitation decays, the repetition priming effect has been demonstrated to have a decay rate in terms of minutes (Forbach et al., 1974) and a small but significant (26 msec.) facilitation across blocks of trials separated by two days, was reported by Scarborough et al. (1977). However, Meyer, Schvaneveldt, and Ruddy (1972) indicated a fifty percent reduction in the semantic priming effect following a delay of only four seconds between prime and target presentation.

Thorson (1978) reports research that demonstrates that repetition priming does not interact with stimulus quality. This result would also suggest that the effect of repetition priming is not located in the same stage of processing as is the semantic priming effect. It is also of interest that Hall (1978) found that the effect of semantic priming could be diminished through a repetition-semantic satiation procedure but the effect of repetition priming was not reduced by satiation.

In regard to control processes, Scarborough et al. (1977) investigated word and nonword repetition effects in a series of five experiments. In Experiment 2 Scarborough et al. manipulated the relative probability of a word item occurring on any trial. The two levels of word probability (.57 and .78) resulted in significantly different response times, with the high probability condition having the shortest RTs. But, there was no effect of word response probability on the facilitation gained from item repetition. This result seems to suggest that the influence of control processes may differ between repetition and semantic priming. This conclusion is couched in tentative terms because Scarborough et al. did not alter the percent of primed items, as did Tweedy et al. (1977) for semantic priming, and thus no adequate comparison of the results is possible. Additionally, in Experiment 3, Scarborough et al. demonstrated that the type of task the subjects performed (pronunciation or lexical-decision) significantly influenced the amount of RT facilitation from word repetition. The largest facilitation effect occurred in the lexical-decision task. However, Meyer et al. (1975) found no difference in the facilitation effect from semantic priming with lexical-decision and pronunciation tasks. At present no study has been conducted using repetition priming and manipulating nonword distractor type as Shulman and Davison (1977) did with semantic priming. Such a study would provide further information on the locus of the repetition priming effect and thus better define the boundaries separating the processes of semantic and repetition priming.

Models of Priming

The priming phenomena, particularly semantic priming, have been incorporated into several models of word recognition. The present section is devoted to a review of three of the more prominent models presently in use (the Logogen model, Morton, 1970; the Verification model, Becker & Killion, 1977; and the Limited-capacity Attention model, Posner & Snyder, 1975).

At least one model of word recognition, the Logogen model (Morton, 1970) proposes different mechanisms that account for the facilitation gained from semantic and repetition priming. This model 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 increments in the feature count for one of the possible logogens exceeds its criterion number of features, then the word represented by that logogen becomes available as a response.

In addition to the logogen system, the model proposes a response out-put buffer, which functions as a short-term memory store, and a context system which represents the long-term memory story. Material in the cognitive system is primarily coded in a semantic form. Morton (1970) assumes that a semantic context, through this context system, increments the feature count of word detectors (logogens) which are semantically related to the context. When a logogen has acquired a critical amount of information from visual feature detectors and/or the context system, a word response becomes available. All semantic information and thus semantic priming influences the logogen system indirectly through the context system.

In Morton's model (1970) there is no direct transfer of information among logogens. Information that enters the logogen system is assumed to decay rapidly, with the feature count returning to baseline within seconds. Unlike information levels, the threshold of the logogen following an instance of response availability, does not return to previous levels very quickly. A word repetition occurring during this period of lowered threshold would require less feature count incrementation and thus recognition time would be shortened. Morton's model predicts differences in the span of time over which repetition and semantic priming operate. Noticeably absent from Morton's model, however, is any reference to processing strategies and their potential influence on either semantic or repetition priming.

Becker and Killion (1977) proposed a "Verification" model of word recognition to explain the data of Meyer et al. (1975) and their own results. This model, unlike the Logogen model (Morton, 1970) assumes that the feature analysis and the feature increment process for word detectors is an indeterminant one. The process results in a number of word detectors reaching criterion. This provides a subset of lexical memory items which are plausible words based on the visual feature information. Recognition requires a serial verification process in which each member of this "feature set" is sampled and its predicted features are compared with the stimulus features contained in visual memory until a match is found. In this model, the effect of a word prime is to activate word detectors, semantically related to the prime, and thus provide a "semantic set" which is then used in the verification process for the subsequent presentation. This would allow a bypass of sampling from the feature set when target and prime were related, since verification could begin with the semantic set, while the feature set was being produced. Thus semantic context would facilitate RT when the prime was related, but when the prime is unrelated to the target the semantic set is exhaustively sampled and, if no match is found, then the feature set must be sampled. This suggests that the effect of a semantically related prime would be to facilitate recognition while an unrelated prime would result in an inhibition of recognition, a prediction confirmed in the study by Neely (1977). The verification model (Becker & Killion, 1977) accounts for some of the control process effects in priming, but it fails to provide any mechanism which would account for repetition priming as a different process from semantic priming.

Posner and Snyder (1975) have proposed an attention model of information processing, which incorporates a limited-capacity attentional mechanism and an automatic spreading-activation process in the retrieval of information from memory. Posner and Snyder's model makes use of Morton's (1970) concept of "logogens" as memory representations of words that attain a response threshold (activation) by the incrementation of information from feature dectors. In

Posner and Snyder's model though, there is a transfer of information between logogens. Once a logogen reaches threshold, activation rapidly and automatically spreads from that logogen to other semantically related logogens. RT facilitation occurs for logogens activated in this manner, since less feature information is required to reach threshold. This spreading-activation process comprises the early automatic component of semantic priming that Neely (1977) reported. Response facilitation can also result from the attentional mechanism. For information to be read out from an activated logogen, the limited-capacity attentional mechanism must be directed to it. Furthermore, it is assumed that less time is required to shift attention between semantically related logogens than between unrelated ones. Posner and Snyder (1975) suggest that subjects adopt the strategy of directing their attention to logogens which are semantically related to the prime word. When attention is appropriately directed (i.e., the prime and target are related), response facilitation results, but misdirected attention (when prime and target are unrelated) results in an inhibition effect, as demonstrated by Neely (1977). The limited-capacity attention mechanism of the Posner-Snyder model (1975) is slow acting relative to the spreading activation, but it is much longer lasting. Additionally the attention mechanism requires conscious awareness for its operation. The Posner-Snyder model, presumably, could account for repetition effects in the same manner as Morton (1970) even though that subject is not specifically delt with. The model clearly accounts for attentional control processes and it could conceivably account for the Shulman and Davison (1977) results as the consequence of subjects adopting the strategy of directing attention to a phonemic decision in the presence of non-pronounceable distractor items.

Review Conclusion

The relationship between semantic and repetition priming is presently an open issue. In view of the differences already noted between the two phenomena (e.g., size of facilitation, decay rate, effect of semantic satiation, influence of word frequency, and effect of stimulus quality), it seems reasonable to further investigate other areas to gain more information by which to compare repetition and semantic priming. The area of control processes appears to be of particular interest. Research has been conducted on the influence of nonword structure using semantic priming tasks (Shulman & Davison, 1977) but similar research with repetition priming has not been reported. The results of research in this area would, in conjunction with the results of Scarborough *et al*. (1977) contribute to a clearer picture of the locus and method of operation of repetition priming.

CHAPTER III

STATEMENT OF PURPOSE

The purpose of the present research is to conduct a study similar to Shulman and Davison (1977), incorporating repetition priming in a lexical-decision task, with orthographically illegal nonwords or word-like pseudo-words serving as distractors. Such a study is expected to provide information concerning the influence of control processes (specifically encoding strategies) in repetition priming.

The present study attempted to provide the desired information concerning the effect of distractor type and repetition priming. A within-subjects design was selected for the study in order to gain statistical power. Shulman and Davison (1977), motivated by similar power considerations, combined the data of pairs of subjects into one pseudo-subject score for statistical analysis. In the present research, as in Shulman and Davison (1977), two levels of the independent variable (distractor type) were used, consonant strings and pseudowords. Each subject received two blocks of trials, one block for each distractor type. The distractor items used were created in a manner similar to that used by Shulman and Davison (1977). By keeping the study as similar as possible to the Shulman and Davison (1977) study, it was felt that a clear comparison of the results from the two studies could be made. Due to the within-subjects design, the study contained a second independent variable, the order in which the two blocks of trials containing different distractor types were presented. Each subject received only one order of presentation and thus treatments were factorially crossed with order.

The purpose of the present study was two-fold, the first intent was to gain information about the influence of encoding strategies on repetition priming and the second purpose was to gain information that would contribute to an understanding of the relationship between repetition priming and semantic priming. An understanding of the relationship between the two types of priming will have important consequences for models of human information processing. Any serious model must reflect that relationship by providing mechanisms which would account for all differences between repetition and semantic priming.

In the present study three hypotheses were proposed. First, the order of the two blocks of distractor trials was not expected to have a significant effect on the subject's responses. Secondly, based on the results of Shulman and Davison (1977) the effect of distractor type on repetition priming was expected to be significant. Specifically, it was expected that the facilitation from priming would be greater in blocks of trials containing pseudowords than in blocks of trials containing consonant strings as distractors.

However, in consideration of the results from Scarborough et al. (1977), which suggested a locus of effect for repetition priming in the memory retrieval and late-encoding stages (stages beyond early visual feature encoding), a null effect of distractor type on repetition priming was a distinct possibility. Additionally, the previously noted differences apparent between repetition priming and semantic priming effects contribute support for a null effect hypothesis.

CHAPTER IV

METHOD

Subjects

Twenty-two Oklahoma State University undergraduates (11 males and 11 females) enrolled in an introductory psychology course served as subjects. These students received partial grade credit for participation as subjects. All subjects were native English speakers, ranging in age from 17 to 20 years. The subjects were assigned to one of two experimental groups in a random fashion, with the exception that each group contained an approximately equal number of subjects of each sex.

Materials

The subjects performed a lexical-decision task on sequentially presented word and nonword stimuli. The word stimuli consisted of thirty, four, five, and six letter words (ten of each) which served as test items, and an additional ten such words which were used in practice trials. The word items were made up of medium frequency words (range, 30-49 per million) from the Thorndike-Lorge (1944) word count. The nonword items used were of two varieties, "pseudowords" and consonant strings". Eighty orthographically legal, pronounceable, nonwords were created by substituting vowels in four, five, and six letter words, so as to produce word-like pseudowords (e.g., wird). By substituting consonants for vowels in the pseudowords, eighty orthographically illegal, unpronounceable nonword consonant strings were produced (e.g., wsrd). All stimulus items were presented in lowercase letters on a Cathode Ray Tube (CRT) display.

Design

The stimulus items were presented in two blocks of eighty trials. In each block the first twenty trials were practice items and the remaining sixty trials were test items. Each block of trials had a distinct set of word items and counterbalanced distractor items, randomly assigned to trials within the block. Within each block, all of the word items (15 in each block) received one repeated presentation at a variable lag of 5, 10, or 15 items (e.g., with a lag of 5 a word would be repeated on the 6th trial following its initial presentation). The presentation order of the two blocks was fixed for word items, but the nonword items appeared in a counterbalanced order between subjects. The study was a 2 X (2) mixed design (i.e., split-plot) with repeated measures on one factor (Keppel, 1973). The within-subjects variable, type of nonword, consisted of two levels, pseudowords (PW) and consonant strings (CS). The between-subjects variable, order of nonword type also had two levels, PW-CS and CS-PW, which represented the assignment of PW and CS nonwords to blocks one and two. Each subject received one of the two possible orders, a block of trials containing PW items followed by a block containing CS items, or the reverse CS-PW order.

The dependent variable was the facilitation of response latency for target word (repeated) items, due to repetition priming (i.e., the response latency for the first presentation minus that for the second presentation of the word).

Procedure

The stimulus item presentation and data collection was automatically performed by an ADS 1800 Minicomputer. The subject was seated at a table in front of a cathode-ray tube (CRT). Recessed into the table, in front of the subject, were two appropriately labeled decision keys which were used to signal the word or nonword decision. The left-right position of the decision keys was counterbalanced between-subjects. Tape recorded instructions (see Appendix A) explaining the experimental task and procedure were played for the subject, and any questions pertaining to the instructions were answered by the experimenter. Following the instructions, the first block of eighty trials began and was followed in turn by the second block of eighty trials. A short break intervened between the two block of trials to allow for data print-out. During the break the subject remained seated at the table.

All trials followed the same general procedure. The beginning of a new trial was signaled by the appearance of the word "READY" on the CRT. This ready signal stayed on until the subject depressed both the word and nonword keys. The stimulus item appeared 1.50 sec. 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 1.50 sec.) concerning the accuracy of his/her decision. At termination of the feedback interval a time-out period of 1.50 sec. commenced, during which the CRT screen was blank. After the time-out period the ready signal immediately appeared, initiating a new trial.

At the end of the last block of trials the subjects were requested to perform an incidental recall of all word items used in both blocks of trials, and to identify the block and position within the block in which the item occurred. This auxillary task was included in the present study to provide an independent measure of the depth to which subjects were encoding the items. For a more complete description of the recall task and a discussion of the results of this task, see Appendix B. Following the recall task all subjects were debriefed concerning the purpose and experimental importance of the study. Each experimental session including the debriefing and the recall task lasted approximately fifty min.

CHAPTER V

RESULTS

The first analysis of the data consisted of an assessment of the effect attributable to the between-subjects independent variable, the order in which the subjects received the two blocks of trials. The analysis resulted in two between-subjects t-statistics, each pertinent to the effect of order on PW and CS distractors, respectively. A change score (priming score) was defined as the difference in reaction time (msec.) between the first and second presentation of each word. (Positive change scores reflect positive priming.) The mean priming score for each subject in each block was determined. For PW distractors, the mean priming scores were 163.5 and 143.9 for blocks 1 and 2, respectively; the difference is not significant, $t\ (20) = .56$, $p > .05$. For CS distractors, block 1 and block 2 means were 128.0 and 130.2, respectively. (See Table I, Appendix C.) The effect of order on the CS condition priming is also not significant, $t\ (20) = -.80$, $p > .05$. Therefore, the data were collapsed over the factor of order resulting in scores analyzable by a single factor, repeated measures design. A 2 X 22 (treatment X subjects) analysis of variance (BMD; Biomedical Computer Programs, Dixon, 1977) was computed on the collapsed data. The results (see Table II, Appendix C for AOV summary) indicated a nonsignificant main effect for treatment (distractor type), $F\ (1, 21) = 1.70$, $p > .05$, signifying that the factor of distractor type did not influence the facilitation of response time due to priming. The mean facilitation (priming score) for the PW condition was equal to 153.7 msec. while the mean facilitation under the CS condition was equal to 128.1 msec. That the effect of priming did result in significant overall facilitation of response time (RT), was indicated by two matched t-tests of the mean difference between RTs for the first and second presentations of items on both the PW and CS treatment levels, (PW: $\underline{t}$ (21) = 10.26, $\underline{p} < .001$ & CS: $\underline{t}$ (21) = 7.57, $\underline{p} < .001$). Please refer to Table I, Appendix C for means and standard deviations involved in these tests.

In general, subjects took longer to respond under the PW than the CS condition. The two levels of the distractor type, the PW and CS conditions, resulted in mean RTs for the first presentations of words, of 936.4 msec. and 810.7 msec., respectively. A matched t-test was computed on the difference between these two means, verifying that the PW distractors significantly increased RT in comparison to performance under CS distractors, $\underline{t}$ (21) = 3.97, $\underline{p} < .001$. Table I in Appendix C presents the means and standard deviations of the RT scores to the first and second presentations of word items and the facilitation scores for word items, in both nonword conditions and both presentation orders. The two distractor conditions also resulted in different error rates in the blocks of trials in which they were in effect. Table III in Appendix C contains the means and standard deviations for errors under each distractor condition in both presentation orders I and II, and collapsed over order. The mean number of errors per subject, per block of PW trials, was 4.1 while 1.2 errors per subject was the rate for comparable blocks of CS trials. A matched t-test indicated the difference in mean error rates is significant, $t\ (21) = 11.25$, $p < .001$. The direction of difference in error rates suggests that the RT difference in PW and CS blocks of trials is not due to a trade-off between accuracy and speed.

CHAPTER VI

DISCUSSION

The principal question that this study sought to answer, concerned the nature of the relationship between repetition priming and a control process, namely, encoding strategy. The study by Shulman and Davison (1977) addressed the same question with respect to semantic priming, and showed a significant effect of nonword distractor type. To the extent that both repetition and semantic priming effects are similar processes, one then might have expected similar results in the present study. But in view of the ample evidence (Scarborough et al., 1966; Thorson, 1978) suggesting that repetition priming is a different process from semantic priming (e.g., differences in magnitude, decay rate, and probable locus of the effect) qualitative and quantitative differences between the present study and that of Shulman and Davison (1977) seemed clearly possible.

The question now becomes one of, why the present study failed to find a significant effect of nonword structure on repetition priming. In general, two possible explanations of the data must be considered. First, it is possible that the absence of significant results was due to a lack of power in the present study which prevented the detection of the effect of distractor type. Secondly, it is also possible that the distractor type effect was not significant because of differences between repetition and semantic priming or because of methodological differences between this study and the one by Shulman and Davison (1977).

Lack of Test Sensitivity

If the effect of nonword type on repetition priming did occur, but the study failed to detect it, then the F-test may not have been powerful enough. In the present results, the F-test which compares the effects of PW and CS nonword type only reaches significance when the alpha-level is adjusted to the 0.25 probability level. However, the present study detected the effects of repetition and nonword type, both at the 0.001 level, suggesting a power level comparable to that of Shulman and Davison (1977) had been achieved. It is worth noting, that Shulman and Davison's (1977) calculated $F'(1, 2) = 71.19$ approaches significance at the 0.01 level ($F = 98.5$), and since it was a "Quasi F" it was a less sensitive test than a conventional F-test (Clark, 1973). Thus it seems that the effect observed by Shulman and Davison (1977) was robust and that any such effect that may have occurred in the present study certainly was not very large. Still, a small tendency in the data toward the hypothesized outcome is evident, and the possibility of a Type II error exists, though the author believes it to be small.

Null Effect of Nonword Type

It is important to note that the present study and the original by Shulman and Davison (1977) used different stimulus presentation procedures. Shulman and Davison (1977) presented their stimuli in pairs. The subjects were to decide if both the simultaneously presented letter strings were words. Thus, the prime and target items were processed in the same lexical-decision trial. In the present study the prime and target items were presented individually on separate trials. Target (repetitions of the prime item) presentations were separated from prime presentations by 5, 10, or 15 trials. The difference between the present results and those of Shulman and Davison (1977) may involve the different presentation methods employed. The validity of this explanation, however, depends on how one views the effect of the nonword manipulation.

Explanation of the results of the present study hinges critically upon interpretation of the effect of the nonword manipulation. The CS nonwords may affect the memory retrieval stage of processing by allowing a bypass of the memory search altogether or it may be that the CS condition results in shallow memory access. Either interpretation of the effect of the CS condition encounters difficulties in accounting for differences between the present results and those of Shulman and Davison (1977).

If the effect of the CS condition is to allow subjects to respond on the basis of a phonemic or orthographic encoding without accessing lexical memory then priming (both semantic and repetition) should be eliminated. Why then did the nonword manipulation have no apparent influence on repetition priming in the present study? Part of the answer may come from Shulman and Davison's (1977) explanation of why semantic priming was not reduced to zero in their study. They suggest that semantic, phonemic, and orthographic coding occur in parallel with randomly determined completion times. In the CS condition a response required only a phonemic encoding, but on some occasions the semantic code became available first. On those occasions semantic priming occurred, resulting in the non-zero effects of semantic relatedness. This seems to suggest that semantic processing could continue automatically into lexical access following a phonemic based response. In the present study such post-trial processing could have resulted in the failure of the CS condition to reduce the repetition effect. Post-trial processing, however, could not have affected the data of the Shulman and Davison (1977) study because the simultaneous presentation of the prime and target would prohibit subjects from benefiting from the automatic lexical access. The subjects were processing the target words before lexical access of the prime occurred.

This post-trial explanation of the results from the present study encounters a number of problems. First, it conflicts with the results of Scarborough et al. (1977), which demonstrated a reduction in the repetition effect in a pronunciation task. Presumably, a pronunciation task does not require lexical access. However, if post trial processing occurs, then the repetition effect should have been unaffected by the nonword manipulation (as was the case in the present study).

Secondly, a post-trial explanation would place the locus of the repetition effect in the encoding or response stage rather than the memory retrieval stage of processing. If the effect of the CS condition is to eliminate memory retrieval, then for priming from post-trial processing to facilitate responding equivalently in the CS and PW conditions the locus of the effect must be in other than the memory retrieval stage. This conclusion, however, is inconsistent with the results of Scarborough et al. (1977) and Thorson (1978) which suggest that the locus of the repetition effect is predominantly in the memory retrieval stage.

The explanation of the present results in terms of post-trial processing could be tested experimentally. A study replicating the present study but incorporating simultaneous presentations of the stimuli would appear appropriate. Such a procedure might show that under the CS condition the repetition effect is reduced considerably. If under simultaneous presentation the repetition effect remained constant, then some other explanation would seem necessary.

Alternatively, it could be argued that the effect of the CS condition is not to eliminate memory search but rather that (under CS conditions) memory is accessed with a phonemic or orthographic encoding and memory search occurs at a phonemic level of processing. According to the memory access view, if the letter string is a CS nonword then (1) no phonemic coding is available, (2) memory is not accessed, and (3) a "NO" response may be executed. In the case of a word item (in the context of CS nonwords) a phonemic code is available and, presumably, processing continues until memory access occurs, then a "YES" response is executed. It may be that the "word" response in the lexical-decision task always involves some degree of lexical access. If word processing occurs at a phonemic level in the CS condition, semantic information may seldom be accessed. Presumably, activation does not spread among semantically related memory representations until items are processed at a semantic level. However, accessing a memory representation at any level of processing may result in repetition priming because the repetition effect (like the word frequency effect) may be a product of access frequency, rather than a result of semantic activation.

Some support for proposing that subjects process words differently from nonwords in the CS condition comes from the results of Shulman and Davison (1977). Under the CS condition their subjects' RTs were reliably slower for stimulus pairs including a word and nonword than for pairs constructed of two nonwords. If subjects were making a decision on the basis of a pronounceable-unpronounceable dichotomy alone then it would seem that RT for words should have been equal to the RT for nonwords. However, that the word RTs were longer suggests that additional processing was involved with the word stimuli.

General Conclusions

The results from this study are not definitive. They are disturbing in that they do not easily merge with the results from previous research concerned with repetition and semantic priming. The author prefers to interpret the results as suggesting that repetition and semantic priming are different phenomena, each with a different locus of effect. However, such an interpretation requires more substantial support that is provided by the present study. It is hoped that the present research will assist in the development of a more thorough understanding of the repetition priming effect.

CHAPTER VII

SUMMARY

While semantic priming has been the focal point of frequent investigations, the phenomenon of repetition priming has received relatively little attention from reaction time researchers. Priming is the facilitation of response time (RT) to a word (the target), by the presentation of another word (the prime word). While semantic priming occurs when the prime and target are semantically associated words, repetition priming results from the repeated presentation of the same word. In general, existing models of memory processing view both processes as aspects of one underlying mechanism. Recent research, however, has indicated significant differences between the two types of priming, in their magnitude, duration, and locus of operation (within the stages of information processing).

Shulman and Davison (1977) manipulated the structure of the nonword distractors used in a lexical-decision (word-nonword) task. The distractors were either work-like pronounceable nonwords (pseudo-words) or unpronounceable consonant strings. The consonant string distractors are assumed by Shulman and Davison (1977) to allow subjects to take advantage of an encoding strategy of using less effortful phonemic encodings rather than semantic encodings to perform the lexical-decision task. Based on the additive-factors logic of Sternberg (1969), factors that are active in common stages of will interact, while factors in separate stages will have an additive effect. Consequently the locus of the effect of semantic priming has been identified with the early encoding stage of processing because it interacts with stimulus quality and nonword structure. Research by Scarborough, Cortese, and Scarborough (1977) has suggested that the locus of the repetition priming effect is in the memory retrieval stage and to a lesser extent, late in the encoding stage (based on interactions with word frequency and processing task, respectively).

The present study examined the influence of the structure (pronounceability) of the nonword distractors, on the repetition priming effect in a lexical-decision task (in a manner similar to Shulman & Davison). It was intended that the results should provide additional information by which to compare repetition and semantic priming.

Twenty-two English-speaking college students served as subjects in the study. The subjects performed a lexical decision (word-nonword) task in two blocks of 80 trials each. On each trial subjects were presented with a letter string of four to six characters, which they identified as a word or nonword. Half of the 80 letter strings presented in each block were nonwords. The other half of the trials consisted of the first and second presentations of 20 word items. Both word and nonword items were presented in a random order within each block. The two blocks of trials differed in the type of nonwords they contained. One block was assigned "pseudowords" (e.g., chaer) while in the other block the nonwords were consonant strings (e.g., chlpr). The design of the study was a 2 X (2) split-plot (order of the blocks of trials X nonword type) with repeated measured on the dependent variable of the repetition priming effect.

Analysis of the data indicated that the effect of nonword pronounceability did not influence the repetition priming effect. However, the type of nonword used did have an effect upon over-all RT, subjects RTs were reliably slower (125 msec.) in blocks of trials containing pseudoword distractors.

In general no clear explanation of the results was available. However, two possible explanations of these results were suggested which differed principally in the interpretation they placed on the effect of the CS condition on word processing. The first explanation assumed that in the CS condition lexical memory access is not required for the word-nonword decision. It was suggested that the repetition effect occurred because of post-trial processing of word items. However, it was noted that this explanation would prohibit locating the effect of repetition priming in the memory retrieval stage (contrary to Scarborough et al., 1977). The second explanation assumed that in the CS condition, if a phonemic code was available (as was the case for word items), then lexical memory would be accessed and the repetition effect could occur. It was suggested, however, that lexical access under the CS condition was at a phonemic level and consequently semantic information was not involved (accounting for the results of Shulman & Davison, 1977).

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APPENDIXES

APPENDIX A

LEXICAL-DECISION TASK INSTRUCTIONS

This is an experiment concerned with simple judgments about verbal materials. It is not an intelligence test or any other kind of test and should not be interpreted as such. Also, there is no electric shock nor any other unpleasant stimulus involved. Although the task may seem to be a very simple one, our research indicates that it can provide important information about language behavior. We feel that your participation and cooperation in the experiment are very important. If for any reason during the course of the experiment you feel that you cannot fully cooperate, please let the experimenter know.

When the word, "ready", is on the screen, a trial can be started by pressing down on both response buttons. A very short time later a string of letters will appear on the screen. Your job is to decide as quickly and accurately as possible whether or not the item on the screen is a word in your vocabulary. If you decide the item is a word, immediately let up on the "word" button. If you decide the item is a nonword, immediately let up on the "nonword" button. After each decision the word "correct" or "wrong" will appear on the screen to tell you whether or not your decision was accurate. Try to respond as quickly as possible without making too many mistakes.

A short time after you have let up on both buttons the word "ready" will again appear on the screen. You can then start another trial by pressing down on both buttons. Make sure that when you start the trial that you are paying careful attention to the screen and that you are ready to release the appropriate button. This will increase the speed and accuracy of your decisions. After you have made your choice you can then let up on the other button and wait for the ready signal. You do not have to start another trial as soon as the ready signal appears. If you want to take a short break, that is all right. When the first block of trials are over the word "finish" will appear but please remain in your seat. There will be a short delay of a few minutes to allow the recording of your data, before the next block of trials begins. The procedure will be the same for the second block of trials as it was for the first block. When the second block of trials is over you may then come out into the other room. If you have any questions about the experiment at that time, the experimenter will be glad to try to answer them. Do you have any questions about your task in the experiment?

APPENDIX B

RECALL-TEMPORAL INFORMATION TASK

The following sections of this appendix are devoted to an explication of the purpose, design, method, procedure and results of a secondary task performed by the subjects in the present study. This task was of a secondary nature in the sense that it evaluated issues independent of those raised by the repetition priming task.

The Task

The task consisted of an incidental recall of the word item appearing in the two blocks of priming trials. In addition to the recall task the subjects were asked to identify the block and position within the block in which the word items appeared. The task is therefore called a recall-temporal information task.

Purpose

The present task was instituted in an effort to gain information about the influence of the factor of nonword type on the memory of the word items used in the lexical-decision trials. This information was intended to provide an independent measure of differences in the depth of encoding which subjects employed for word items under the different nonword conditions. Presumably, deeper processing would result in better recall and temporal information performance. Two kinds of information were of interest; first, the number of words which subjects could recall from each block of trials, and secondly, the amount of access to temporal information that subjects had for all words from each block of trials. The temporal information refers to whether the subjects could correctly identify the block and serial position within the block (e.g., first, second, last) in which the item appeared. This temporal information has been suggested by Bower (1967) to depend upon encoded time tags, which allow the subjects to differentiate the more recently presented item from earlier presented ones. Several investigators (e.g., Fozard & Yntema, 1966; Morton, 1968; Hinrichs, 1970) have proposed theories to explain the nature of the time tags presumed to be involved in judgments of item recency. In general, they all assume that recency is judged on the basis of the present strength of a decaying memory representation, that was established when the item was initially encountered. This explanation of temporal information, termed the "Strength Hypothesis", is presently the dominant theory in the area of temporal information.

If temporal information is dependent upon the strength of memory representations, then manipulations which affect memory trace strength should influence the accessability of temporal information. Deeper (semantic) processing tasks have been demonstrated, by Craik and Tulving (1975) to result in better recall performance than that achieved with shallower (structural) tasks. The depth of processing manipulation appears to alter the availability of memory representations. To the extent that availability may be interpreted as the strength of those representations, then the depth of processing of the stimulus items can be expected to result in different temporal information recall performance, as well as different word recall performance.

Design and Hypotheses

Two independent variables were considered in this task, the type of nonword distractor used in each block of trials (two levels, pseudowords (PW) and consonant strings (CS)), and the order in which the block of trials accurred (two levels, first (block-1) and second (block-2)), resulting in four possible combinations; PW-1st, CS-1st, PW-2nd and CS-2nd. The dependent variables in the task were the recall of word items and the recall of temporal information about those items. There were two varieties of temporal information, namely the block in which the item occurred and the serial position of the item within the block.

Several hypotheses were proposed concerning the recall-temporal information task. It was hypothesized that word recall performance would reflect the influence of serial position (order) of the block in which the words occurred and would reflect the influence of the type of non-word distractors used in the block. Better recall performance was expected for items occurring in the most recent block of trials. In regard to the recall of temporal information it was hypothesized that temporal recall performance would, like word recall, be better under the pseudoword condition and within the most recent block of trials.

Method

Following each subject's performance of the two blocks of lexical-decision trials, they were informed that there was an additional task involved in the study. The subjects were then taken to a room, adjacent to the room containing the CRT, where they were given the following instructions:

"The task you are to perform now consists of two parts. For the first part, I would like you to attempt to recall as many as you can, of the word items used in the two block of trials that you just finished. To the side of each word you recall, you are to indicate whether it occurred in the first or the second block of trials and approximately in what position it occurred in that block of trials, either in the first, middle, or last of the block. After you have recalled as many words as you can then you may go to the second part of the task. For the second part, I will give you a list of all the word items that appeared in the trials. You are to indicate beside each word the block and position within the block in which you think the word occurred. Please do not leave any items blank, if you don't know the information, then guess. Are there any questions concerning either part of this task?"

The subjects were then provided with pencil and paper and left alone in the room with the door closed. The experimenter periodically checked on the subject's progress on part one of the task. When the subject finished part one, the experimenter gave them the word list for completion of part two of the task. Each subject received the same randomly ordered list of the thirty word items that had appeared in the experimental trials.

Results and Discussion

The results from the first and second parts of the recall-temporal information task will be discussed separately. The data from each part were analyzed by several paired comparison t-tests. The serial position data were tabulated only when subjects correctly identified the block in which the item occurred. In general, the data from the second part of the task proved nonsignificant on all pair-wise comparisons. Two t-tests were computed on the block identification data considering the effect of nonword type, with block order held constant, which both resulted in nonsignificance (PW-1st 1.9 correct vs CS-1st 2.6, t (14) = 0.681, $p > .05$ and PW-2nd 3.6 vs CS-2nd 4.9, t (14) = -1.091, $p > .05$). A matched t-test was computed on the effect of order of the block of trials, collapsed over the factor of nonword type, resulting in a nonsignificant test, t (15) = 1.232, $p > .05$ (The means for the 1st and 2nd order were 8.88 and 7.75 items correctly assigned to blocks, respectively.) Analysis of the data from subjects' identification of the position of items within the block resulted in similar nonsignificance for the factor of nonword type, and block order. Computed t-tests for the two factors, resulted in t (15) = -0.704, $p > .05$, (the means were PW: 3.38 & CS: 3.81 items correctly identified) for the effect of nonword type collapsed over block order, and for the effect of block order collapsed over the factor of nonword type, (mean number of items assigned correct position were 1st block 3.69, 2nd block 3.50) the resulting statistic was t (15) = 0.305, $p > .05$.

Analysis of the data from the first part of the recall-temporal information task yielded a different pattern of results. This data included recall results as well as temporal information. The effect of nonword type did not have a significant effect on word recall, block identification, or serial position identification in the present task. Three t-tests of the PW versus CS conditions yielded for recall, block, and serial position data, nonsignificant tests. For the recall comparisons between the mean number of words recalled under the PW condition (2.8) and that for the CS condition (3.8) the test resulted in t (15) = -0.392, $p > .05$. The test between the mean number of words correctly assigned to blocks in the PW condition (1.94) and the CS condition (2.44) yielded t (15) = -0.746, $p > .05$. The number of items correctly identified as to their position within the block under the PW condition (1.12) versus that under the CS condition (1.19) resulted in t (15) = -0.392, $p > .05$. In all comparisons the results were not only not significant, but they were in a direction contrary to predictions based on the strength theory. On the other hand, analysis of the data for the effect of block order proved quite significant. All comparisons for the effect of block were collapsed over the factor of nonword type. For the free recall results a comparison of the mean number of words recalled from block-2 (4.3 words per subject) with the mean of block-1 (2.3 words per subject) resulted in a highly significant matched t-test (t (15) = 3.038, $p < .01$). Similarly for the block identification data, a comparison of the mean number of words correctly identified as having occurred in block-2 (2.8 per subject) with the mean for block-1 (1.5 per subject) resulted in a significant matched t-test (t (15) = 2.201, $p < .05$. The effect of block order was also significant (t (15) = 3.084, $p < .01$) in the comparison of the serial position data from block-2 (1.68 words per subject) with that from block-1 (0.62 words per subject).

The interpretation of these results seems rather clear. First, contrary to what was hypothesized, the variable of nonword type had no effect upon the recall of items or the accessibility of temporal information about those items. This does not mean that the hypothesis that different levels of processing results in different performance in the recall of temporal information is incorrect. What the results do indicate, is that the type of nonword did not affect performance in the present specialized task. The present manipulation was not even effective in producing a difference in recall, an effect previously demonstrated with different processing depths (Craik & Tulving, 1975). The one significant finding from the present task was that the recall of both items and temporal information about those items was influenced by the recency of the block of trials in which the items occurred. The more recent block of trials resulted in better recall performance.

It should be noted though that the present results may be a reflection of the nature of the task the subjects were performing during the blocks of trials. The lexical-decision task does not seem to be well suited for a study of incidental recall, since only a minimum of semantic processing is required for task performance and the interval between item exposure and recall ranged between 1 min. and 40 min. depending upon the block and position of the item. Considering these obstacles in the accessibility of information about the items it is not surprising that an average of 3.25 items per subject were recalled, out of a possible 30 items.

APPENDIX C

STATISTICAL TABLES

TABLE I

MEAN REACTION TIMES, DIFFERENCE SCORES, AND STANDARD DEVIATIONS FOR WORD ITEMS IN ORDERS I AND II AND COLLAPSED OVER ORDER

	PW CONDITION		CS CONDITION		nonword type
	1st	2nd	1st	2nd	presentation
BLOCK ORDER I (PW-CS)	974.2	810.7	818.1	690.1	mean RT score
	229.4	299.5	184.0	137.1	SD
	163.5		128.0		mean difference score
	74.3		81.6		SD
	PW CONDITION		CS CONDITION		nonword type
	1st	2nd	1st	2nd	presentation
BLOCK ORDER II (CS-PW)	898.6	754.7	803.3	673.1	mean RT score
	159.9	137.9	142.5	118.4	SD
	143.9		130.2		mean difference score
	78.0		60.1		SD
	PW CONDITION		CS CONDITION		nonword type
PW-CS COLLAPSED OVER ORDER	153.7		129.1		mean difference score
	74.8		70.4		SD

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE FOR INFLUENCE OF DISTRACTOR TYPE ON REPETITION PRIMING

Source	df	MS	*F*	*p* <
Mean	1	873918.100		
Subjects (S)	21	6751.715		
Treatment (T)	1	7255.113	1.7005	ns .05
Error (SxT)	21	4226.500		

The data are based on change scores.

TABLE III

MEAN ERROR RATE PER NONWORD CONDITION WITHIN BLOCK ORDER AND COLLAPSED OVER ORDER

NONWORD	PW CONDITION		CS CONDITION	
BLOCK ORDER	I	II	I	II
MEAN ERRORS	4.6	3.6	1.1	1.3
STANDARD DEVIATION	2.4	2.2	1.2	1.3

NONWORD TYPE COLLAPSED OVER ORDER	PW CONDITION	CS CONDITION
ERRORS	4.1	1.2
STANDARD DEVIATION	2.3	1.3

2

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