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Phonemic Priming in the Lexical Decision Task:
Evidence for Graphemic Dependence

by

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requirements for the degree

Master of Arts

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Hillinger (1980) reported that a target word was identified as a real word faster when it was preceded by a phonetically related prime than by a neutral prime. He found that this facilitation occurred even when the prime and target were graphemically dissimilar. On the basis of this he concluded that activation spread automatically from the lexical entry of the prime to phonologically related lexical entries. The series of experiments reported in this thesis were designed to investigate several aspects of Hillinger's experiments. Hillinger's findings were replicated when his design was employed. Further investigations showed that minor variations in this design resulted in very different patterns of facilitation and inhibition. While it was demonstrated that lexical decisions to word targets are facilitated, apparently automatically, when the targets are preceded by graphemically similar-phonemically similar primes, no such facilitation was observed when graphemically dissimilar-graphemically similar primes were used. These results were found even when subjects were required to access the phonology of the primes. It was concluded that phonetic facilitation is the result of a process of structure that is based both on phonology and orthography.
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The mechanisms which allow a reader to understand a printed word have been studied extensively in recent years. These investigations shed light both on the steps involved in going from the printed word to meaning, and on the structure and organization of our knowledge about words. This knowledge is assumed to reside in what is known as the internal lexicon. The internal lexicon is analogous to a dictionary with each word having a separate entry (called a lexical entry). When the lexical entry of a word is located (a process referred to as lexical access) the graphemic, phonemic, and semantic information about that word becomes available to the reader.

A number of experimental paradigms have been used to investigate the processes involved in visual word recognition. Among these are naming latency, word matching, rhyme judgement, and lexical decision tasks. Coltheart (1978) argues that the lexical decision task is best suited for the study of word recognition because it is the only task for which the subject must access the lexical entry for a presented word. The matching task can be performed entirely on the visual characteristics of the stimulus. Correct performance on this task does not necessarily mean that the subject has accessed the long term trace for the word. Likewise, neither the rhyme judgement nor the naming task require lexical access. Both of these tasks can be performed on both words and meaningless word-like letter strings. A subject simply needs to sound out the letters in
the presented item (although some words would be pronounced incorrectly if subjects were using a direct letter to sound mapping strategy).

In a lexical decision experiment the subject is presented with a letter string (simply any combination of letters). The subject is required to indicate whether the presented letter string spells a real word or is a nonword (a nonword is a meaningless string of letters). It is assumed that before a letter string can be correctly identified as a word the subject must locate the lexical entry for the letter string. If an entry is located the subject can respond 'word'. If the letter string is in fact a nonword one of two things may happen, either the subject performs an exhaustive search of memory before responding 'nonword' or searches only until some time limit expires, responding 'nonword' if no entry had yet been found.

The lexical decision task has been used to investigate the effects of the semantic properties of words on lexical access. One of the more significant studies to come out of the lexical decision literature was one by Meyer and Schvaneveldt (1971). In their paper they reported that if a target word (the one about which a lexical decision must be made) was preceded by a semantically related word (referred to as a prime) then the target word was identified as a real word faster than if it was preceded by an unrelated prime (i.e., 'DOCTOR' was identified as a real word faster when it was primed by the word 'NURSE' than by the word 'BUTTER').
The effect, termed semantic facilitation, has been replicated repeatedly in the years since (den Heyer, Briand, & Dannenbring, 1983; Fischler, 1977; Fischler & Goodman, 1978; Henik, Friedrich, & Kellogg, 1983; Kiger & Glass, 1983; Neely, 1976, 1977; Stanovich & Bauer, 1978; Tweedy, Lapinski, & Schvaneveldt, 1977; Tweedy & Lapinski, 1981; Warren, 1977; among others). This effect has lead researchers to assume that memory is organized on the basis of semantic relatedness (Meyer & Schvaneveldt, 1971; Collins & Loftus, 1975; Neely; 1976, 1977). Neely (1977) reasoned that semantic priming resulted from activation of one memory location spreading to nearby (therefore semantically similar) memory locations. These related items then require less additional activation in order for them to become available to the system.

Neely interpreted semantic facilitation in terms of Posner and Snyder's (1975) two process model of information processing. He argued that spreading activation is an 'automatic' process as opposed to a 'controlled' process. Posner and Snyder (1975) have distinguished between these two processes on the basis of several characteristics. Automatic processes occur very quickly (e.g. 250 msec, Neely, 1977; 75 msec, Warren, 1977), are independent of a subject's strategies, decay in a short period of time (as quickly as 750 msec when the subject is employing a competing strategy, Neely; 1977), and only facilitate processing of stimuli. Controlled processes, on the other hand, have onset times
which are longer than automatic processes (400 msec, Neely; 1977), are affected by a subject's strategies, and can contribute either facilitation or inhibition to stimulus processing.

Neely demonstrated this hypothesis with a lexical decision experiment. This experiment was set up so that on most trials a certain type of target was expected based on what type of prime preceded it. Some of these expected trials were semantically related to the prime (i.e., BIRD-SPARROW) while others were unrelated (i.e., BODY-WINDOW). On a small proportion of trials the target that appeared was unexpected. Some of these unexpected targets were related to the prime (i.e., BODY-ARM) while others were not related (i.e., BIRD-WINDOW). Yet another type of trial was a neutral control trial in which a target word was preceded by a string of asterisks ('*****'). The neutral control trials were used to determine subjects' base rate for a lexical decision without the aid of facilitation nor the deleterious effects of inhibition. In addition to these manipulations Neely varied the stimulus onset asynchrony (SOA) between 250 msec and 2000 msec (the SOA is the time between the onset of the prime and the onset of the target).

The results of this experiment concur with the predictions made by the Posner and Snyder two process model. First, considering the results obtained at short SOAs, when the target was related to the prime, RTs were facilitated relative to the neutral control condition. This facilita-
tion occurred regardless of whether the target was an expected target or an unexpected target and demonstrated the strategy independent nature of automatic processing. When the target was unrelated to the prime and unexpected, neither facilitation nor inhibition relative to the neutral control was found. Automatic processes, although fast, do not produce inhibition.

At the long SOAs a different pattern of results was found. When the target was expected but unrelated, facilitation was found. This facilitation was due to strategic (or controlled) processes which take longer to become apparent than the automatic processes. And finally, when the target was unexpected yet related to the prime, RTs were inhibited. This demonstrates that, if given enough time, controlled processes come into play and are capable of producing inhibition as well as facilitation.

A number of models which have been proposed to describe the access of word information from the internal lexicon can account for the semantic facilitation effect. These models can be roughly separated into direct lexical access models and search models. Two of the more widely cited models will be briefly considered in this paper (for a more thorough discussion of these models the reader is encouraged to read the original articles). These are the Logogen model, a direct access model, and the Forster multiple access file model, a search model.

John Morton (1969) argued that when a word is per-
ceived, the features of the word are extracted. These features then act to increment feature counters which he called logogens (from the Latin words 'logo' for word and 'genus' for birth). Each logogen is postulated to be associated with the lexical entry for a word. Since many words have similar features, words which were not presented but are similar to the target will also have their logogens incremented. However, the logogen for the word presented will increment faster and to a greater extent than logogens for non-presented words.

When the logogen for a word increments beyond some critical value the lexical entry for the associated word becomes available (this critical value, called the threshold, is specific to each logogen and can increase or decrease on the basis of the frequency with which the word is perceived). Within the logogen model, semantic priming is the result of a contextual system which comes into operation when a word is perceived. When a lexical entry becomes available the contextual system increments the logogens for all words which are semantically related to the available entry.

The attribute that makes the Logogen model a direct access model is that the process of recognition occurs in parallel. Many logogens are incremented by the perception of a single word (assuming that the word does not have entirely unique features). The word that becomes available to the reader is the one that is incremented the most.
Alternatively, search models of lexical access assume that a subject must check, one by one, a set of entries in the internal lexicon before an identification can be made. While a few models assume that all lexical entries are checked every time a new word is perceived, most models postulate that some subset of entries is searched. One such model is Forster's multiple access file model (Forster, 1976).

Forster uses the term Master file to refer to the internal lexicon. His model assumes that, with one exception, a lexical entry in the Master file cannot be accessed directly but rather must be accessed through a peripheral access file (the exception to this assumption is discussed below). The model assumes that there are three of these access files, one is ordered on the basis of graphemic attributes, another on the basis of phonemic attributes, and the final access file ordered according to semantic similarity. Forster choose these dimensions on logical grounds. The graphemically related file would be necessary for comprehension of written words, the semantic for production, and the phonemic for understanding speech.

For each word in a peripheral access file there is a pointer which points to the word's lexical entry in the master file. In order to access a words entry in the access file, the file must be searched until the entry is found. When the entry in the access file has been located, the reader follows the pointer from the access file's entry to
the entry in the Master file. Forster argued that readers do not need to search every entry in an access file. He assumed that the reader could quickly scan an access file until a set of possible matching entries was found. Because the access files are ordered on the basis of a specific attribute, entries in the access file which are similar are likely to be found in close proximity. It is this subset within an access file which is searched entry by entry.

In order to account for semantic facilitation Forster postulated that lexical entries in the Master file are connected by an associative network. When one Master file entry is accessed other associatively related entries could be accessed faster through the network than through one of the peripheral access files. However, Forster's description of this process is vague because it does not specify when or why a subject chooses to use the associative lexical access route instead of the peripheral access file route.

While the lexical decision task has been used extensively to study the semantic facilitation effect, it has been used to study other phenomenon as well. In recent years the lexical decision task has been used to investigate the effects of phonological properties of words on lexical access. Michael Hillinger (1980) reported that a target word was identified as a word faster when it was preceded by a phonetically related word prime than by a neutral control. This facilitation occurred even when the prime and target were graphemically dissimilar (i.e., EIGHT-MATE). Hillinger
concluded that activation spread automatically from the lexical entry for the prime to phonemically related items. The activation would then facilitate lexical decisions when the target was phonemically related to the prime.

Hillinger's findings have important implications. New assumptions about the structure of the internal lexicon would have to be made if activation spreads automatically to phonetically as well as semantically related items. First, it may be that the lexicon is organized both semantically and phonetically. If this is the case, then semantic and phonemic spreading activation would seem to occur in parallel.

Alternatively, it could be the case that semantic information and phonetic information are available to the system at different stages. One hypothesis that makes such a prediction is the grapheme to phoneme conversion hypothesis (Meyer, Schvaneveldt, & Ruddy, 1973). This hypothesis postulates that graphemes (abstract units which represent the letters that make up a word) are translated into phonemes (abstract units which represent the sound of a word). If a phonemic code is needed for lexical access then phonemic information would be available to the system earlier than semantic information. The spread of activation to phonemically related entries would occur at the phonemic processing stage, while the activation spreading to semantically related entries could occur only after lexical access had occurred.
It is possible to account for phonetic facilitation within the framework of the Logogen model. As a word which has been perceived visually becomes available, through the process discussed earlier, all aspects of the word become available to the system. As the phonetic information becomes available it may be that this information increments the counters for words that share those particular phonetic features. When a new but phonetically related target word is perceived, less additional information would be necessary before the counter for the perceived target word surpasses the identification threshold. The result would be that semantic and phonetic facilitation would appear to occur in parallel because both require lexical access to be achieved before the activation can spread.

If the assumption is made that the phonetic code is available prior to lexical access then a different prediction is made by the Logogen model. If subjects have access to the phonetic code prior to the availability of the lexical entry for the word then the phonetic features themselves would increment the logogen counter for the word perceived as well as those for all phonetically related words. The result would be that the onset of phonetic facilitation would occur prior to the onset of semantic facilitation.

Hillinger argued that the Forster model was an appropriate vehicle for explaining phonetic facilitation. Assuming that subjects typically recode a perceived word into a phonetic code, he reasoned that the master file entry for
the prime is accessed via the phonologically ordered peripheral access file. Within this access file phonetically similar entries are located in close proximity. Hillinger argued that the access of the prime results in a spread of activation to the phonetically related entries located in the same region. This activation makes these related entries temporarily more sensitive to additional activation. When the subject accesses an item that was phonetically similar to a previously presented item the recently activated region is located faster. Because the time necessary for scanning the access file to find an acceptable subset of entries to search is reduced the subject can access the target word faster than if it had not been phonetically primed.

Given these assumptions about the Forster model, it is not clear whether semantic facilitation would occur earlier than phonetic facilitation. What is made explicit from these assumptions is that phonetic and semantic facilitation result from different processes and are therefore not likely to have identical onset times.

It is apparent from the above discussion that the relative location of phonological access in visual word recognition is a current and much debated topic. Many have argued that readers recode the visually presented word into a phonetic code prior to lexical access (Hillinger, 1980; Meyer, Schvaneveldt, and Ruddy, 1973; Parkinson & Underwood, 1983; Rubenstein, Lewis, & Rubenstein, 1971; Underwood & Thwaites, 1982). Others argue that phonological encoding proceeds in
parallel with direct visual access but that lexical access through phonological recoding is a slower process (Coltheart, Davelaar, Jonasson, & Benser, 1977; Coltheart, 1980; and Stanovich & Bauer, 1978, to a lesser extent). Finally, there is also evidence that phonemic information is made available as a result of lexical access in the typical reader (Evett & Humphries, 1981; Humphries, Evett, & Taylor, 1982; Martin, 1982; Taft, 1982; Tanenhaus, Flanigan, & Seidenberg, 1980).

One argument in favor of phonetic coding prior to lexical access is that beginning readers are accomplished listeners. When they are first learning to read they do so by transforming the written language into a phonetic code. But while this may be how beginning readers understand written words, experienced readers may use a different method. Nonetheless, experienced readers will often report the subjective impression of 'hearing' what they read. But this does not necessarily mean that skilled readers phonologically recode a word before being able to achieve lexical access. It may be that readers do 'hear' what they read but the phonetic information actually becomes available as a result of lexical access rather than being a precursor of it.

The phoneme to grapheme conversion hypothesis mentioned earlier assumes that a phonetic code is available prior to lexical access. However, a basic problem with this hypothesis is that many words in the English language have an
irregular spelling, that is, they do not conform to standard rules of grapheme to phoneme mapping (e.g., 'sword'). These irregular words constitute somewhere between 5% and 20% of all English words (Coltheart, 1978). If most lexical access results from the recoding of graphemes to phonemes then we would expect irregular words to be processed slower because some other procedure would be necessary for phonological encoding to take place (this would not be the case, however, if a word's phonology is accessed on a whole word basis rather than grapheme by grapheme). In fact, Coltheart, Besner, Jonasson, and Davelaar (1979) reported that average lexical decision latencies for regular words were no different than for irregular English words.

Stanovich and Bauer (1978) also tested this hypothesis and found that subjects did require more time to make lexical decisions to irregular words. However, in the same paper they reported that if a response deadline was employed (forcing the subjects to respond quickly) lexical decisions to both regular and irregular words were just as accurate. They concluded that while phonological recoding can occur, it is either post-lexical or occurs in parallel with a visual lexical access route, but is a slower process.

Underwood and Thwaites (1982), on the other hand, reported experimental results which are consistent with a pre-lexical phonological access. It had been shown previously that lexical decisions were inhibited when a target word was accompanied by an unattended yet semantically
related word. That is, the lexical decision to 'RUBBISH' would be inhibited if the word 'WASTE' was presented peripherally (note: this effect should not be confused with semantic facilitation which occurs when a target is preceded, or accompanied, by a semantically related item which is attended to). In a clever manipulation, Underwood and Thwaites demonstrated that 'RUBBISH' would also be inhibited when it was accompanied by the unattended word 'WAIST', the homophone of a related word. They assumed that the phonetic code for the unattended word was automatically accessed, but that the semantic code was not. The result was that all lexical entries which shared that particular phonetic code were activated. Activation then spread from each of the activated lexical entries to entries which were semantically related to them. Their results were a bit odd, however, because 'WAIST' inhibited responses to 'RUBBISH' more than 'WASTE'. At best we would expect the two homophones to result in the same amount of inhibition. In any case, the results do support a pre-lexical access phonological code.

Additional experimental evidence for the phonological recoding hypothesis comes from the pseudohomophone effect. A pseudohomophone is a nonword which has the same phonology as a real English word (e.g., 'BRANE' is a pseudohomophone of 'BRAIN'). Rubenstein, Lewis, and Rubenstein (1971) reported that when a target was a pseudohomophone it took subjects a significantly longer time to indicate that it was a nonword than if the nonword target was not a pseudohomo-
phone. Coltheart, Davelaar, Jonasson, and Besner (1977) reviewed the Rubenstein et. al. experiment and concluded that the nonword controls, against which the RTs to the pseudohomophones were compared, were not as visually similar to real English words as were the pseudohomophones. Coltheart et.al. replicated the original experiment, this time controlling for the visual similarity of the nonwords. They did this by changing one letter in the pseudohomophones to produce the nonword controls. The pseudohomophones and the nonwords were then divided into two groups such that no subject saw both the pseudohomophone and the nonword control created from it. Even so, Coltheart et. al. still found the pseudohomophone effect.

However, Martin (1982) and Taft (1982) both argued that the nonword target controls that Coltheart et. al. used were still less visually similar to real words than the pseudohomophones. This is because the Coltheart et. al. controls differed visually from real English words by one letter more than the pseudohomophones, due to the way the controls were created. To rectify this Martin created a set of controls which were better controlled for visual similarity. This was done by using a measure introduced by Coltheart called an N count. The N count of a nonword is the number of English words which can be constructed from a given nonword by changing a single letter. When pseudohomophones and nonwords were balanced with respect to N count the pseudohomophone effect disappeared. Even more impres-
sive is the fact that Martin demonstrated the pseudohomophone effect, using the Coltheart et. al. stimuli, with aphasic patients who were incapable of accessing the phonology of nonwords. That she found the effect with subjects who were incapable of phonologically recoding nonwords is powerful evidence that the pseudohomophone effect is not phonologically based. In fact, Martin's evidence suggests that the pseudohomophone effect is simply an artifact of the amount of visual similarity that pseudohomophones share with real words.

Other cited evidence for pre-lexical phonemic access comes from an effect first demonstrated by Meyer, Schvaneveldt, and Ruddy (1973). Meyer et. al. presented two letter strings and the subjects were required to make a lexical decision about both of them. When the words were graphemically similar yet had incompatible phonologies (e.g., LEMON-DEMOn) the decision to the target letter string was significantly inhibited when compared to unrelated prime-target pairs. Meyer et. al. argued that subjects were biased toward encoding the target word with a phonological code similar to that of the prime because of their graphemic similarity. When the subjects did so the resulting phonemic code did not match that of any real English word. To achieve correct lexical access, subjects had to recode the target a second time, resulting in a long RT. However, a series of experiments by Bradshaw and Nettleton (1974) designed to investigate this effect found that it was not
easy to reproduce and may have simply been due to the characteristics of the task used by Meyer et. al.. Likewise, Becker, Schvaneveldt, and Gomez (1973, cited by Coltheart; 1978) did not find longer RTs for the 'LEMON-DEMON' type word pairs with a stimulus set different from the one that Meyer et. al. used.

Shulman, Hornack, and Sanders (1978) also investigated the LEMON-DEMON effect in a series of experiments. In each experiment they manipulated the type of nonword foils used. In some cases the nonwords were orthographically legal (i.e., conforming to the rules of English pronunciation; such as 'PLINT') while in other cases orthographically illegal nonwords were employed (e.g., 'GLHFE'). Inhibition for LEMON-DEMON type word pairs was observed in the orthographically legal nonword condition, but not when the nonwords were orthographically illegal. This lead them to conclude that the use of phonological recoding is a voluntary and not an obligatory process. Two other findings from this series of experiments are important to note. First, facilitation was observed for phonologically similar-graphemically similar prime-target pairs regardless of the legality of the nonword foils. Also, in Experiment 3, semantic facilitation was observed even when the nonwords were orthographically illegal. This suggests that subjects were indeed achieving lexical access even though phonological recoding seemed to be absent.

Finally, Humphries, Evett, & Taylor (1983) reported
results which do not support pre-lexical phonological recoding. Subjects were sequentially presented with a pattern mask, a prime, a target, and another pattern mask. In this series, the prime was presented for only 40 msec in most cases. Although subjects were told to identify all words presented in a trial, only on a very small percentage of trials was the prime identified (only 1.3% in one of the experiments). Humphries et al. found that a prime which was a homophone of the target facilitated target identification whether or not the prime and target were graphemically similar. However, nonword homophone primes of word targets did not facilitate identification of those targets. They concluded that the phonological information is obtained, but only through lexical access (however, their results do not dispute the parallel-but-slower arguments of Coltheart et al.) Humphries et al. argued that if phonological recoding is pre-lexical then nonwords would be recoded as well as words. But when a target is preceded by a phonologically related nonword in an identification task no facilitation is obtained. If these nonword primes were recoded phonologically we would expect to see facilitation similar to that caused by the graphemically dissimilar homophone primes.

As is evident from the preceding discussion, the temporal location of phonological access, and its role in visual word recognition, is still an unresolved controversy. While much of the evidence disputes the existence of a pre-lexical phonological code, the finding by Hillinger that a word
prime facilitates lexical decisions to phonemically related
target words suggests some underlying phonemic structure in
lexical access (Hillinger, 1980). If we can locate this
structure in the chain of events that lead to, or result
from, visual word recognition then the location of phonemic
access can be assumed. This could easily be done by compar¬
ing the onset time for semantic facilitation with that of
phonemic facilitation.

The models presented earlier assume that activation
spreading to semantically related entries occurs only upon
lexical access. We could similarly assume that activation
spreads to phonemically related entries only after phonemic
information is accessed. Therefore, if phonemic facilitate¬
tion is evident prior to the onset of semantic facilitation
we can conclude that phonemic information is available prior
to lexical access. However, if semantic facilitation begins
at the same time or before the onset of phonemic facilita¬
tion, then it would seem that phonemic information is a
product of lexical access.

Martin and Jensen (note 1) set out to measure the rela¬
tive onset times for the two spreading activations. To
measure this onset a lexical decision experiment was
designed in which semantic relationships existed between
some prime-target pairs while a phonological relationship
existed between others. Because spreading activation is
time-dependent, it is possible to present the prime and tar¬
get so close in time that activation will not yet have
spread from the lexical entry for the prime to that of the target before a response is required. The Martin and Jensen experiment was intended to have at least one SOA short enough that this activation would not have yet spread to either phonemically or semantically related lexical entries. This SOA was very short and made it impossible for subjects to respond to the prime prior to the presentation of the target. Therefore, subjects were required to simply read the prime, rather than to make a lexical decision to it as in the Hillinger experiment.

Three SOAs were chosen: two of these were very short (150 msec and 300 msec) and one was long (2000 msec). If only one relationship was facilitated at the 150 msec SOA but both were facilitated at the 300 msec SOA, then Martin and Jensen would conclude that the type of information which caused facilitation at the shorter SOA was also available earlier than the other type.

In all, five different prime-target relationships were compared. These were phonologically similar-graphemically dissimilar pairs (EIGHT-mate), semantically related pairs (TOAD-frog), graphemically similar-phonologically dissimilar pairs (LEMON-demon), unrelated pairs (HOUSE-file), and control pairs (*****-head).

A neutral prime was used as a control because targets preceded by an unrelated word could be artificially inhibited at long SOAs. This inhibition would occur if a subject used some kind of strategy (generating words phonemically
related to the prime is one such strategy). As discussed earlier, controlled or 'strategic' processes can contribute inhibition as well as facilitation to stimulus processing.

The results of this experiment revealed semantic facilitation at both the 150 msec and 300 msec SOA. However, there was no facilitation for phonologically related items. Although subjects were instructed to read the prime rather than make a lexical decision to it as in the Hillinger study, the semantic facilitation observed is evidence that the subjects were indeed processing the prime.

It may be argued that phonetic facilitation occurred sometime between the 300 msec and 2000 msec SOA. If this was the case then it would be possible to conclude that semantic activation precedes phonemic activation. This conclusion is not warranted, though, since phonemic facilitation was not actually observed.

Several more experiments similar to the one described above were conducted by Martin and Jensen but in none of them was graphemically independent phonetic facilitation found. In all, they utilized several different stimulus sets, different SOAs were tested, and different types of nonword targets were used (while all nonwords used were orthographically legal some experiments controlled for the graphemic similarity of the nonwords to the primes and some did not). Nonetheless, the results were consistent. Not once were the phonetically similar-graphemically dissimilar word prime-word target pairs facilitated.
Because the existence of automatic phonemic facilitation has important implications for the processes involved in visual word recognition, it is essential that the reasons behind Martin and Jensen's failure to find it be understood. The experiments presented in this paper represent an effort to find out which differences between Martin and Jensen's experiments and those conducted by Hillinger eliminated phonemic facilitation. The differences that were manipulated included the control of the SOA by the experimenter rather than by the subject, the type of prime-target relationships included in the stimulus set, the specific prime-target pairs used in the experiment, and the type of processing that a subject was required to performed on the prime.
Experiment 1

Because of the repeated discrepancies between the Martin and Jensen findings and Hillinger's results it was considered important to replicate the original Hillinger experiment. If facilitation for phonologically related items could not be replicated using the original paradigm, and given Martin and Jensen's repeated failure to find phonetic facilitation, then any claims of activation spreading to phonologically related lexical entries could be dismissed.

Method

Design: The Hillinger experiment consisted of 100 trials. Of concern were the RTs to 50 word target trials which were incorporated into a Latin Square design. These 50 trials were divided into 5 groups of 10 targets each. Each group was preceded by a particular prime type. The same 5 target groups showed up in each of 5 stimulus sets but were preceded by a different type of prime. Therefore, across all of the 5 stimulus sets each of the target groups were preceded by each type of prime. The 5 different types of primes were graphemically similar-phonemically similar word primes (LATE-MATE), graphemically dissimilar-phonemically similar word primes (EIGHT-MATE), unrelated word primes (VEIL-MATE), nonword primes (BAFF-MATE), or nonword control primes (**--MATE).

In addition to the 50 comparison trials, 50 filler trials were presented. All subjects saw the same set of filler trials. These 50 trials consisted of 10 each of the follow-
ing types: word prime-nonword target (FAME-RALL), nonword prime-nonword target (COFF-TULD), graphemically similar word prime-nonword target (MAME-FANE), graphemically similar-phonemically dissimilar word prime-word target (LEMON-DEMON), and a neutral prime-nonword target (****-PLINT). Because there was no control for these trials the RTs to filler trials could not be included in the subsequent analyses.

Subjects: 25 Rice University undergraduates participated in the experiment in order to fulfill a class requirement. Each subject was assigned randomly to a stimulus set with the restriction that there was an equal number of subjects assigned to each set.

Apparatus and Stimuli: The stimuli were presented on either a Radio Shack Model III or Model 4 microcomputer. The subjects responded via the 10-key pad on the computers keyboard.

All prime-target pairs were precisely those used by Hillinger (with the exception of 10 word-nonword filler trials which were not provided in the appendix of the Hillinger article). These stimuli never subtended greater than 2.8 degrees of visual angle at a viewing distance of 50 cm. Trials were presented in a different random order for each subject.

Procedure: The subjects initiated a trial by pressing the space bar on the computer keyboard. As soon as the subjects initiated a trial two plus signs ('+') were displayed on the computer screen. These plus signs were presented to
the center of the screen, one directly above the other. After 500 msec the top plus sign was removed and was replaced with the prime. Subjects were instructed to indicate whether the prime was a real word or a nonword as quickly and as accurately as possible (subjects were told to respond 'nonword' when the neutral prime was presented). Subjects responded 'word' by pressing the '1' key on the computer's 10-key pad with the forefinger of their right hand and responded 'nonword' by pressing the '2' key with their index finger. After subjects responded to the prime it was removed from the screen and the target was printed at the location of the second plus sign. Again, subjects were told to indicate as quickly and as accurately as possible whether the target was a word or a nonword. After the subjects responded to the target the screen was cleared and left blank for 1 second before a prompt requested the subjects to initiate the next trial.

After the first 50 trials of the experiment there was a 30 second break. When the rest period was over the subjects were prompted on the computer screen to press the 'enter' key on the computer keyboard in order to proceed with the experiment.

Results

All RTs over 2000 msec and under 100 msec were counted as errors, as were incorrect target lexical decisions, and were excluded from the analysis of RTs. The median RT for each subject for each prime type was computed and subjected
to a latin square analysis of variance (medians were used instead of means because the distribution of RTs tend to be positively skewed). The analysis of error rates was performed on the arcsine transformed error proportions (Meyer, 1979; pg. 74).

There were two a priori hypotheses concerning the pattern of responses. These were based on the findings reported by Hillinger. Of specific interest was the difference in RTs and errors for the two types of rhyming prime-target pairs in comparison with the neutral control. The other comparison concerned the differences between the two types of rhyming pairs themselves.

It was found that targets which were primed by a phonemically similar prime were responded to significantly faster than word targets preceded by the neutral control, \( F(1,80)=4.66, p=.034 \) (see Table 1). In addition, fewer errors were made to these targets than those primed by the neutral control, although the size of this effect failed to reach conventional levels of statistical significance, \( F(1,80)=3.62, p=.06 \). A comparison of the graphemically similar and graphemically dissimilar phonemically related prime targets pairs revealed no significant differences for either RTs or error rates, \( F<1.0 \) in both cases.

**Discussion**

The results of this replication are nearly identical to those reported by Hillinger. Both types of phonologically related pair types, 'LATE-MATE' and 'EIGHT-MATE',
<table>
<thead>
<tr>
<th>Prime-Target Type</th>
<th>RT</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATE-MATE</td>
<td>559</td>
<td>.024</td>
</tr>
<tr>
<td>EIGHT-MATE</td>
<td>570</td>
<td>.020</td>
</tr>
<tr>
<td>******-MATE</td>
<td>596</td>
<td>.052</td>
</tr>
</tbody>
</table>
responded to significantly faster than the neutral control. In addition, these phonemically related pairs were not significantly different from each other (559 msec vs 570 msec respectively). And because low error rates were accompanied by fast RTs, a speed accuracy trade off can be ruled out.

It is curious that graphemically independent phonemic facilitation is found when the Hillinger experimental design is used but not with the Martin and Jensen design. Several of the differences existing between the design used by Martin and Jensen and Hillinger could be the cause of the discrepant results. First, the Hillinger study required subjects to respond to the prime. But because the target was not presented until the subjects responded to the prime, the subjects were essentially in control of the prime-target SOA. Secondly, the Hillinger study did not include semantically related prime-target pairs in the stimulus set.

It could be that one of these factors is the cause of Martin and Jensen's failure to demonstrate the phonemic priming effect. If this is the case then it is not reasonable to claim that the phonemic facilitation effect is due to an automatic process. Automatic processes should be resilient to design features which should only be affecting strategic processing.
Experiment 2

The purpose of this next experiment was to reduce the dependence of the SOA on the time the subjects take to respond to the prime. This was done by replicating the Hillinger experiment with the exception that the subjects were not required to make an overt response to the prime. To further test the hypothesis that subjects in the Hillinger experiment were allowing themselves enough time to generate possible targets to the prime, an SOA manipulation was introduced as a between subjects factor. Half of the subjects were shown the prime 250 msec before the presentation of the target while the other half first saw the prime 1000 msec before the target was presented. If subjects were tempted to generate phonemically similar items to the prime they would have time to do so in the long SOA condition but not in the short SOA condition.

Method

Design:

This experiment was identical to Experiment 1 with the exception of the introduction of a between subjects SOA manipulation and elimination of the prime response requirement. The introduction of the between subjects SOA factor means that the resulting design is two latin squares, one for each SOA.

Subjects: 30 Rice University undergraduates participated in the experiment in order to fulfill a class requirement. Subjects were randomly assigned to either of the SOA
conditions.

**Apparatus and Stimuli:** All apparatus and stimuli were the same as those used in the previous experiment.

**Procedure:** All procedures were identical to those used in the previous experiment with one exception. Subjects were told that a prime would be presented. Sometimes it would be an English word, sometimes a pronounceable nonword, and sometimes simply a string of asterisks. Subjects were explicitly asked to read the prime but were not required to make any overt response to it.

All subjects viewed the prime for 200 msec before it was erased from the computer screen. Then, depending on the assigned SOA condition, the screen remained blank for either 50 msec or 800 msec before the target was presented. Subjects were told to indicate whether the target was a word or a nonword as quickly and as accurately as possible.

**Results**

As with the last experiment, median RTs of correct responses were obtained for each subject for each prime-target relationship (all RTs over 2000 msec and below 100 msec were counted as errors as were incorrect responses). Likewise, the error analysis was performed on arcsine transformed error proportions.

The SOA manipulation was not significant nor was the interaction between SOA and type of prime for both RTs and errors, all $F_s < 1.0$. Therefore the same planned comparisons which were used in Experiment 1 were utilized. It was
found that RTs to the phonetically related prime-target pairs were not statistically different from those to the neutral control pairs, $F(1,80)=1.20, p=.28$. However, more errors were made to phonemically related pairs than to the control pairs, $F(1,80)=4.60, p=.035$ (see Table 2). Comparison of the RTs to the graphemically similar and graphemically dissimilar rhyming pairs revealed no significant differences, $F(1,80)=.43, p=.51$; however, more errors were made to the graphemically dissimilar pairs than to the graphemically similar pairs, $F(1,80)=8.92, p=.004$. Inspection of Table 2 shows that the significant difference in errors for the phonetically related pairs with respect to the neutral controls can be attributed solely to the error rate for the graphemically dissimilar rhymes.

Discussion

Because the phonemic priming effect was absent when a lexical decision to the prime was not required it may be possible that subjects were not reading the prime as they were instructed. In the Martin and Jensen experiments discussed earlier the subjects were required to merely read the prime and semantic facilitation was found, indicating that subjects were indeed processing the prime. However, those studies differed in that all primes were words (with the exception of the neutral prime). In the Hillinger design many of the primes were nonwords by necessity of the task. It could be that with so many nonword primes the subjects tended to ignore them. However, the significantly greater
TABLE 2

Mean of median reaction times to make a correct lexical decision to the target word and proportion of incorrect lexical decisions to the target in Experiment 2

<table>
<thead>
<tr>
<th>Prime-Target Type</th>
<th>RT</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATE-MATE</td>
<td>559</td>
<td>.046</td>
</tr>
<tr>
<td>EIGHT-MATE</td>
<td>566</td>
<td>.076</td>
</tr>
<tr>
<td>*****-MATE</td>
<td>552</td>
<td>.040</td>
</tr>
</tbody>
</table>
proportion of errors made to the graphemically dissimilar pairs suggests that subjects were perceiving the primes enough to be influenced by them.

The failure of the SOA manipulation to interact with the type of prime presented suggests that the subjects were not generating phonologically similar targets to the prime. It would be premature to make this conclusion about the Hil-linger study, though. If subjects were processing the prime only peripherally then it is possible that they did not notice the relationships between the primes and targets and therefore were not compelled to generate possible targets.

It is important that the results of this experiment change when the decision to the prime is not required. The next experiment was designed so as to further investigate the effect of prime response requirements as well as to introduce semantically related prime-target pairs into the design.
Experiment 3

In this next experiment the conflicting results of the two previous experiments were investigated. In a between subjects manipulation some subjects made a lexical decision to the prime and others did not. Furthermore, the stimulus set for this experiment contained semantically related items as well as the two types of phonemically related pairs. This allowed for a direct comparison of semantic facilitation with phonetic facilitation when a 'prime decision' was made (assuming that phonemic facilitation results from the subject making a lexical decision to the prime). Also, it tested whether semantic facilitation would occur in the absence of phonetic facilitation in a 'no prime decision' condition.

A new prime decision technique was introduced in this experiment. The lexical decision to the prime was made after the target had been responded to by half of the 'prime decision' subjects. These subjects were prompted for their prime decision after their response to the target had been recorded. By removing the time necessary for them to make the overt response to the prime from the pre-target presentation period the experimental control of the SOA was maintained as well as the lexical decision to the prime.

The rest of the 'prime decision' subjects were required to respond to the prime prior to the presentation of the target. This condition was similar to the original Hil-linger task. As described earlier, the drawback of this
method of presentation is that subjects essentially control the SOA themselves.

**Method**

**Design:** This design contained one within subjects variable and one between subjects variable. The within subjects variable was type of prime-target relationship and the between subject variable was prime response requirement. For the prime response requirement manipulation, a third of the subjects made no overt response to the prime, they were simply told to read it. Another third were required to respond to the prime prior to the presentation of the target. The final third were told to view the prime, the prime was erased, the target was presented, and the subjects responded to the target. Once these subjects responded to the target, a prompt was presented which requested their lexical decision to the prime.

**Subjects:** 54 subjects participated in this experiment in order to fulfill a course requirement. These subjects were randomly assigned to one of the three between subjects conditions.

**Stimuli:** 6 groups of 15 prime-target word pairs each were prepared. The target words in each group were balanced with respect to frequency in the English language according to the Kučera-Francis (1967) norms. These groups consisted of either graphemically similar-phonemically similar pairs (BRUISE-CRUISE), graphemically dissimilar-phonemically similar pairs (BAIT-CRATE), semantically related pairs
(DEADLY-FATAL), graphemically similar-phonemically dissimilar pairs (GRASP-WASP), unrelated pairs (DRAWN-SHORE), or neutral control pairs (*****-TRAMP). In both this experiment and Experiment 4, the primes and targets never contained more than 8 letters and did not subtend more than 2.8 degrees of visual angle at a viewing distance of 50 cm.

All rhyming pairs were drawn from the Webster Rhyming Dictionary while the semantically related word pairs were drawn from the Webster Synonym Dictionary. Unrelated word pairs and the targets for the neutral prime word trials were drawn from this same pool of words. The 'GRASP-WASP' type word pairs were (with one or two exceptions) drawn from the set published by Meyer et. al. The unrelated word pairs were chosen so that they had an average of two letters in common. This was done so that they had the same approximate amount of graphemic similarity as the graphemically dissimilar-phonemically similar word pairs. If this was not done, subjects might be biased towards responding 'word' whenever the prime and target shared more than one or two letters in common. Likewise, visual similarity between word primes and nonword targets was also controlled.

Because there was a greater proportion of rhyming word prime-word target pairs (so that graphemically similar and dissimilar pairs could be compared) additional filler items were added. Fifteen pairs each of the graphemically similar-phonemically dissimilar, semantically related, and unrelated pairs were added to the stimulus set. The RTs to
these items were not included in the analysis, though. In addition to the 120 word prime-word target pairs 100 pairs each of the following types were generated: word-nonword, nonword-nonword, and nonword-word. Fifteen of the nonword-nonword and nonword-word trials had '******' as their prime.

In all, this experiment consists of 420 trials. It is common practice for a lexical decision experiment to be designed with an unequal number of trials in each of the word/nonword combinations. The relative proportion of word-word trials in this experiment is lower than in most experiments so it is felt that the influence of this factor will be minimal. In addition, the advantage of having 420 trials as opposed to 480 (the number required for full balancing) is that subjects are less likely to become fatigued.

Procedure: Subjects were tested individually on either a Radio Shack TRS-80 model III or model 4 microcomputer. They were instructed that they would be asked to indicate whether a presented letter string was a real English word or a nonword. Subjects responded via the computers 10-key pad. They were instructed to depressed the '1' key with the forefinger of their right hand if the letter string was a word and the '2' key with the index finger of their right hand if the letter string was a nonword.

When the letter string was a real English word, they were told, it would be a relatively common one: one that they would read in a newspaper or magazine, or hear in an everyday conversation. They were also told that when the
letter string was a nonword it would be pronounceable and would contain relatively common combinations of letters.

Subjects initiated each trial by depressing the space bar with their left hand. When the trial was initiated, the screen was cleared and two plus signs ('+') were presented to the center of the screen, one above the other. After 500 msec the top plus sign was replaced with the prime. All subjects were told to read the prime. 'Early prime decision' condition subjects were instructed to make a lexical decision to the prime as quickly and as accurately as possible. As soon as they responded to the prime it was removed from the screen and the lower plus sign was replaced by the target. In both the 'late prime decision' and the 'no prime decision' groups the prime was presented for 500 msec before it was removed from the screen and the bottom plus sign was replaced by the target.

All subjects were instructed to indicate whether the target was a word or a nonword as quickly and as accurately as possible. As soon as the subjects responded to the target it was removed from the screen. In the 'late prime decision' condition the screen remained blank for 400 msec before a prompt appeared which read 'Was the prime a word or a nonword?'. 'Late prime decision' subjects were told to answer this question correctly, but it was stressed that the speed of this response was unimportant. Once the prompt was responded to these subjects saw a blank screen for 200 msec before the next trial could be initiated. All other sub-
jects simply saw a blank screen for 1 second after they responded to the target before they were prompted to initiate the next trial.

Results

All RTs greater than 2000 msec or less than 100 msec were treated as errors as were trials in which the subject made an incorrect lexical decision, and were not included in the analysis of RTs. Medians were computed for each subject for the six prime-target types of interest. The error data analysis reported was performed on arcsine transformed error proportions. All p values and degrees of freedom reported are corrected for nonindependence using the epsilon correction term (Winer, 1971). The means of median RTs and error proportions for each prime-target type for each prime response type are presented in Table 3.

The overall analysis found that the main effect for response requirement was not significant, $F(2,51)=2.18; p=.12$. The main effect for type of prime-target relationship was significant, $F(4.2,214.4)=6.91; p<.00001$. The prime-target relationship x response requirement interaction was also significant, $F(8.4,214.4)=3.18, p<.01$. While the main effect for type of prime-target relationship revealed that there were differences between the different prime-target relationship types, the interaction tells us that this pattern of differences was dependent on the prime response requirement.

While these results are interesting, the real purpose
<table>
<thead>
<tr>
<th>Prime-Target Type</th>
<th>No Prime Decision</th>
<th>Early Prime Decision</th>
<th>Late Prime Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Error</td>
<td>RT</td>
</tr>
<tr>
<td>BRUISE-CRUISE</td>
<td>515</td>
<td>.029</td>
<td>452</td>
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<tr>
<td>BAIT-CRATE</td>
<td>529</td>
<td>.063</td>
<td>521</td>
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<tr>
<td>DEADLY-FATAL</td>
<td>519</td>
<td>.037</td>
<td>497</td>
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<td>GRASP-WASP</td>
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<td>DRAWN-SHORE</td>
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<td>.052</td>
<td>527</td>
</tr>
<tr>
<td>*****-TRAMP</td>
<td>499</td>
<td>.011</td>
<td>511</td>
</tr>
</tbody>
</table>
of this experiment was to check for facilitation or inhibition for each prime-target type relative to the neutral control. To do this, each prime target type was compared individually to the control group.

Comparing the graphemically similar-phonemically similar pairs to the control group revealed a borderline significant effect of response requirement, $F(2,51)=3.10, p=.0533$. 'Late prime decision' RTs were longer than 'no prime decision' RTs, which in turn were longer than 'early decision' RTs. The effect of prime-target type was significant, $F(1,51)=5.13, p=.027$. The means of the median RTs reveal that the 'BRUISE-CRUISE' pairs were significantly facilitated compared to the neutral control. Likewise, the prime-target type x response requirement interaction was significant, $F(1.51)=7.90, p=.001$. As is evident from table 3, the 'BRUISE-CRUISE' pairs were facilitated in the early and late decision conditions but were not in the 'no decision' group.

For the graphemically dissimilar-phonemically similar pairs there was a different pattern. There was not a significant effect of prime response, $F(2,51)=2.08, p=.13$. But there was a significant effect of prime-target type, $F(1,51)=6.17, p=.016$; indicating that the 'BAIT-CRATE' pairs were significantly inhibited compared to the neutral prime controls. The prime-target type x response requirement interaction was not significant, $F<1$. That the interaction is not significant shows that the inhibition was present
across the different prime response requirement groups.

The results obtained when the semantically related pairs were compared with the control group were surprising. While there was no significant effect of prime response, \(F(2,51)=1.5, p=.23\), there was also no significant semantic facilitation, \(F<1\). The interaction between prime response requirement and prime-target type bordered on significant, \(F(2,51)=2.85, p=.066\). This interaction suggests that the amount of facilitation/inhibition of the semantically related pairs differed depending on what the prime response requirement was. It appears from table 3 that some semantic facilitation occurred in the 'early decision' and the 'late decision' groups, while none was evident in the 'no decision' group.

Graphemically similar-phonemically dissimilar types, when compared to the controls, revealed a nonsignificant effect of prime response, \(F(2,51)=2.08, p=.134\). The prime-target type effect was significant at the \(p=.05\) level, \(F(1,51)=4.07; p=.048\). This was due to a significant inhibition when compared to the controls. The prime response requirement x prime-target relationship interaction was also significant, \(F(1,51)=4.26, p=.019\). This means that the inhibition for the LEMON-DEMON types was different for different response requirements. In fact, the table 3 shows that while these pairs were inhibited compared to the controls in the 'late' and 'no' prime decision groups, they were essentially no different in the 'early' decision group.
When the unrelated pairs were contrasted with the controls, there were no significant effects for prime-target type, response requirement, or their interaction:

\[ F(2,51) = 0.97, \ p = 0.38; \ F(1,51) = 2.81, \ p = 0.099; \text{ and } F(1,51), \ p = 0.096 \text{ respectively.} \]

An overall analysis of the arcsign transformed errors found a significant effect of prime-target relationship, \[ F(4.36, 222.51) = 5.92, \ p < 0.001. \] The prime response requirement and the relationship x prime response interaction were not significant, \[ F(2,51) = 0.04, \ p = 0.95, \text{ and } F(1.87, 222.55) = 1.26, \ p = 0.25. \] As with the RTs, the errors for each prime-target type were individually compared with errors made to the neutral control pairs. The error rates for both the graphemically similar-phonemically similar pairs and the semantically related pairs were significantly greater than for the neutral controls; \[ F(1,51) = 4.65, \ p = 0.035, \text{ and } F(1,51) = 5.66, \ p = 0.021, \text{ respectively.} \] The error rates for the graphemically dissimilar-phonemically similar pairs, graphemically similar-phonemically dissimilar pairs, and the unrelated pairs were significantly larger than for the neutral controls to an even greater extent; \[ F(1,51) = 19.42, \ p < 0.0001; \]

\[ F(1,51) = 22.62, \ p < 0.0001; \text{ and } F(1,51) = 13.28, \ p < 0.001, \text{ respectively.} \] In none of these individual error analyses were any other effects significant, all \( p's > 0.2 \).

In contrast to the results of Experiment 1, RTs for graphemically similar and graphemically dissimilar rhyming pairs were significantly different, \[ F(1,51) = 31.46, \ p < 0.0001. \]
Targets preceded by a graphemically similar rhyming prime were responded to 39 msec faster than those preceded by a graphemically dissimilar rhyme. Fewer errors were made to 'BRUISE-CRUISE' pairs than to BAIT-CRATE pairs as well, although this difference was not statistically significant; $F(1,51) = 3.40, p = .070$.

The preceding analyses were also performed treating words as random effects. These analyses revealed the same pattern of results that was observed when subjects were treated as random effects. This indicates that the results of this experiment are not due to peculiarities of the specific words presented to the subjects.

**Discussion**

Phonemic facilitation occurred, but only when the prime and target were graphemically similar. Graphemically dissimilar-phonemically similar pairs were significantly inhibited compared to the neutral control. This result is very different from the results that Hillinger reported. If activation spread automatically to phonemically related words, phonemically related primes would facilitate decisions to word targets whether or not they were graphemically similar. Another interesting finding is that this facilitation for the 'BRUISE-CRUISE' pairs did not occur when the subjects were not required to respond to the prime, suggesting that this facilitation is strategy dependent.

That the 'BRUISE-CRUISE' pairs were facilitated while the 'BAIT-CRATE' pairs were not cannot be attributed solely
to a graphemic similarity effect. If graphemic similarity had been the cause of the effect then the LEMON-DEMOM pairs should have been facilitated as well. However, the LEMON-DEMOM pairs were inhibited, not facilitated.

Another unexpected result of this experiment was the failure to find significant facilitation for the semantically related pairs. Semantic facilitation has typically been an indication that subjects were processing the prime. However, most of the subjects in this experiment were in conditions which required them to process the prime at least enough to make a lexical decision to it. Inspection of the responses to the primes in these conditions revealed that subjects made a correct lexical decision to the prime on more than 90% of the trials. Besides, the facilitation for 'BRUISE-CRUISE' type pairs indicates that subjects were processing the prime.

Some research of late has suggested that the semantic priming effect is not as automatic as we have believed. First, Tweedy, Schvaneveldt, and Lapinski (1978) found that the amount of semantic priming was related to the proportion of semantically related pairs in the stimulus set. They conducted a lexical decision experiment in which they presented stimulus sets with either 12.5%, 50%, or 87.5% semantically related prime-target pairs. The amount of semantic facilitation was found to be a linear function of the proportion of these pairs.

Also, Henik, Friedrich, and Kellogg (1983) reported
that semantic priming was found when subjects were required to read the prime aloud, but were unable to find this facilitation when subjects performed only a letter search task on the prime (a letter search task is one in which subjects must respond 'yes' if a particular letter is contained in a presented word and 'no' if it is not). Indeed, a letter search clearly involves the processing of graphemic information. If facilitation is capacity free the activation should occur whenever a word is perceived. Unfortunately, there was a problem with the Henik et al. experiment. The subjects were presented with a lexical decision 1700 msec after the presentation of the prime. This could allow facilitation to fade or subjects to invoke a competing strategy.

Another unusual finding in Experiment 3 was that none of the prime-target pair types were facilitated in the no prime decision group. This result is very similar to what was found in Experiment 2. In that experiment no RTs were significantly shorter than those associated with the neutral prime. One possible explanation is that the control pairs were simply responded to very quickly in the no decision group. The existence of an obviously non-lexical prime may have allowed subjects to respond to the target very quickly. It may be that presenting any word demands some of the subjects' attention. When the subjects must process the prime, this attentional demand has little or no effect. However, when no processing of the prime is required, the presence of
a word prime may be more distracting than the neutral prime (a position similar to this one is defended by den Heyer, Briand, & Dannenbring; 1983). If this is the case, there may have been facilitation for certain prime-target pairs but that this is not apparent when compared with the abnormally fast responses made to the neutral prime pairs.

Several other aspects of these data suggest that the neutral prime-word target was not an optimal control condition in this experiment. The first is that the control pairs had significantly fewer errors than any of the other prime-target pairs in the analysis. One possible explanation for this is that the subjects were expecting a word target whenever the prime was a string of asterisks, even though the neutral prime was preceded by a word or a nonword with equal probability. Inspection of the error rates to the neutral prime-nonword target trials shows that subjects made almost 4 times as many errors to the nonwords targets preceded by a neutral prime than the words targets (6.5% vs 1.8%). If subjects were expecting a word on the neutral prime trials then their lexical decisions should have been faster as well.

The contention that the neutral prime-word target trial RTs were artificially fast is supported by another aspect of the data. That is the observed inhibition for the graphemically dissimilar rhyming pairs. Failure to find facilitation for these pairs is important but it is difficult to explain why graphemically dissimilar pairs would be inhib-
ited. Unless some strategy that subjects were employing caused these pairs to be inhibited, we would at least expect the 'BAIT-CRATE' pairs to be responded to about as fast as the unrelated pairs.

As a precautionary measure, an additional analysis was performed treating the unrelated pairs as the control condition. In this analysis RTs to the targets of graphemically similar-phonetically similar pairs were facilitated. The targets of semantic pairs were also responded to faster than the unrelated pairs, \( p = .055 \). However, RTs to neither the graphemically similar-phonetically dissimilar targets nor the graphemically dissimilar-phonetically similar targets were inhibited, although they were still not facilitated. This same analysis was repeated with the error data. While graphemically similar-phonemically dissimilar targets were responded to incorrectly a significantly great number of times than were the neutral targets, all other target types did not have significantly greater errors than did the neutral targets. In fact, both the semantic targets and the phonemically similar-graphemically similar targets were responded to with fewer errors than were the neutral targets, although these differences were not statistically significant. While the results of this second analysis are more interpretable than those from the first, the conclusions that can be drawn from them are nearly the same.

While we can assume that subjects were making lexical access in this experiment, we cannot be sure that they were
accessing the phonetic code of the prime. If subjects do not need to access the phonetic code of the prime in order to achieve lexical access then it would be possible to make a lexical decision without ever knowing how the word sounded. The next experiment was designed so that subjects had to obtain the phonetic code to some of the primes. If phonetic facilitation is found only when subjects have accessed the phonology of the prime then several conclusions can be drawn. The first is that phonological access is not a necessary step in lexical access. Secondly, phonetic priming would appear to be the result of a conscious strategy employed by the subjects in Hillinger's experiment.
Experiment 4

Although the automaticity of phonetic facilitation is in doubt it would still be interesting to compare phonological and semantic priming. Certainly semantic information about a word requires lexical access, but this is not necessarily true with regard to phonological information. Although 'neap' is not a real word, most people would be able to pronounce it and would also agree that it rhymes with the word 'weep'.

Experiment 4 specifically compared phonological and semantic access. Instead of having subjects decide whether a presented target was a real English word or not, subjects made one of two types of decisions regarding the prime prior to the presentation of the target. These decisions required the subject to specifically access either the semantic or phonetic attributes of the prime.

Method

Design: Two within subjects factors were employed. These were type of prime-target relationship and type of orienting question. There were four types of word prime-word target relationships. These types were graphemically similar-phonemically similar (VAULT-FAULT), graphemically dissimilar-phonemically similar (HEARSE-NURSE), semantically related (TWINE-STRING), and unrelated (MOUNT-FLUID). In this experiment the unrelated prime target pairs served as the control group. The use of the unrelated prime-target word trials as a control condition can be justified in this
experiment on several grounds. First, in Experiment 3 RTs
to the targets of unrelated word prime trials and neutral
control prime trials were not significantly different. Sec¬
ondly, because this experiment requires a word prime, a neu¬
tral control prime cannot be employed without adding an
unnecessary level of confusion.

**Stimuli:** 4 groups of 36 prime-targets were con¬
structed, each group having one of the above mentioned
prime-target relationships. These word pairs were drawn
from the same word pool described in Experiment 3. The tar¬
gets for each group were balanced closely for their fre¬
quency of occurrence in the English language.

Each prime-target pair had associated with it 3 addi¬
tional words. These words were constructed so that one
rhymed with the prime, one was semantically related to the
prime, and the third had no relationship with the prime.
During a given trial a subject would see only one of these
words. This one word was presented in conjunction with the
prime and served as the basis for the response to the ori¬
enting question.

For each subject, the computer program selected one of
the three words to be paired with the prime. The selection
was random with the restriction that, for each group of 36
prime-target pairs, 9 words were selected to have a semantic
relationship with the prime, 9 were selected to have a pho¬
nemic relationship with the prime, and the remaining 18 were
unrelated to the prime.
As with the previous experiment, 72 filler prime-target pairs were constructed, 36 each for the semantic and the unrelated conditions to compensate for the greater proportion of rhyming prime-target pairs. For the 36 filler prime-target pairs of each type 18 were matched with a word that was unrelated to the prime, 9 were matched with a word phonemically related to the prime, and the remaining 9 were matched with a word semantically related to the prime. As before, responses to the targets of filler pairs were not included in the subsequent analyses.

In all, there were 216 word target trials. Therefore, 216 nonword target trials were constructed. Each nonword target trial also had a word which was paired with its corresponding word prime. Of these, 54 were related semantically, 54 were related phonemically, and 108 were unrelated to the prime.

**Subjects and Apparatus:** 14 Rice university undergraduates participated in this experiment in order to fulfill a class requirement. These subjects were run individually on a Radio Shack TRS-80 model III or model 4 microcomputer.

**Procedure:** Each trial was initiated when the subject depressed the space bar on the computer keyboard. Once a trial was initiated by the subject an orienting question was presented at the top of the screen. At the same time that the orienting question was presented, three plus signs were presented to the center of the screen. These were presented one above the other with the top two plus signs two lines
apart and the bottom plus sign on the line below the middle one. The distance between the top two plus signs subtended 2 degrees of visual angle while the distance between the middle and the bottom plus sign subtended 1 degree of visual angle.

The orienting question required the subject to make a decision about either the phonemic or semantic characteristics of the prime. The rhyming question was 'Do the following words sound similar?' while the semantic question was 'Do the following words have similar meanings?'. Two hundred milliseconds after the orienting question had been presented two words were presented on the screen in place of the top two plus signs; the prime always appeared as the lower word. The subjects were instructed to answer the orienting question with respect to the two presented words only after being sure of the correct response. Subjects were admonished not to make mistakes in responding to the question and it was made clear that there was no time constraint to answer the question. Subjects indicated a 'yes' response by pressing the '1' key on the computers 10-key pad, and a 'no' response by pressing the '2' key.

Once the orienting question had been responded to the screen was cleared and the target was immediately presented at the location of the bottom plus sign. Subjects were required to make a lexical decision to the target as quickly and as accurately as possible. Subjects responded 'word' by pressing the '1' key and 'nonword' by pressing the '2' key.
Once the subjects responded to the target the screen was cleared and there was a 500 msec pause before the subjects were prompted to initiate the next trial.

In all, 432 trials were presented. Subjects were required to take a 20 second rest every 36 trials in addition to a full minute rest after the first 216 trials (half way point). At the end of a rest period the computer displayed a message indicating that the trials would resume once the 'enter' key on the computer keyboard was depressed.

**Results**

Due to an unfortunate programming error, it was not possible to distinguish between the two types of 'no' responses. These response were coded the same regardless whether they were no responses to the meaning or to the sound question. Therefore, the data were treated as if there were three levels of the question variable. These were semantic yes, phonetic yes, and no (either semantic or phonetic). The loss of this information is not critical however, because regardless of what question was asked, there was one of four relationships between the prime and its word target.

Responses were coded as errors if the RT to the lexical decision was greater than 2000 msec or less than 100 msec, or if the lexical decision was incorrect. Median RTs for each subject were computed for each question for each prime-target relationship. These were subjected to a 2-way repeated measures analysis of variance. A separate analysis
was performed on the arcsine transformed error proportions as well. Means of median RTs and error proportions for each prime-target type are presented in table 4.

There was a significant effect of prime-target relationship, \( F(2.53,32.97) = 5.12, \ p = .007 \). The main effect for question type and the prime-target relationship x question type interaction were not significant, \( F(1.9,24.8) = 1.26, \ p = .29 \); and \( F(4.1,53.33) = 1.26, \ p = .29 \) respectively. There was also a main effect of errors for prime-target relationship, \( F(2.7,35.6) = 7.38, \ p < .001 \). There was no effect on errors of the question type, \( F < 1 \). Also, the question x relationship interaction was not significant, \( p > .15 \).

Because the intent of the study was to investigate patterns of facilitation and inhibition, each prime-target relationship was individually compared with the unrelated control.

Semantically related prime-target pairs were significantly facilitated as were the graphemically similar-phonemically similar pairs, \( F(1,13) = 5.38, \ p = .037 \); and \( F(1,13) = 7.55, \ p = .016 \) respectively. On the average, semantically related pairs were responded to 26 msec faster than the control while 'VAULT-FAULT' type pairs were responded to 37 msec faster than the control. The question x relationship interactions for all relationships types were not significant, all \( p \)'s > .10.

Average RTs to graphemically dissimilar-phonemically similar pairs were not significantly different than the
<table>
<thead>
<tr>
<th>Prime-Target Type</th>
<th>RT</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAULT-FAULT</td>
<td>550</td>
<td>.041</td>
</tr>
<tr>
<td>HEARSE-NURSE</td>
<td>583</td>
<td>.115</td>
</tr>
<tr>
<td>TWINE-STRING</td>
<td>561</td>
<td>.029</td>
</tr>
<tr>
<td>MOUNT-FLUID</td>
<td>587</td>
<td>.061</td>
</tr>
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controls, \( F(1,13) = .16, p = .69 \). There were, however, significantly more errors made to the 'HEARSE-NURSE' type pairs than to the control pairs, \( F(1,13) = 6.96, p = .02 \).

The RTs to graphemically similar and dissimilar rhyming prime-target pairs were compared as they were in Experiment 3. Graphemically similar rhyming pairs were responded to significantly faster than the dissimilar rhyming pairs, \( F(1,13) = 8.61, p = .011 \). Additionally, fewer errors were made to targets preceded by a graphemically similar-phonemically similar prime than by a graphemically dissimilar prime, \( F(1,13) = 11.60, p < .005 \).

As was done with the previous experiment another set of analyses was performed treating words as random effects. Again this word analysis revealed a pattern of effects which concurred with that obtained from the subject analysis.

**Discussion**

Facilitation was found for phonemically similar pairs only when they were also graphemically similar. The graphemically dissimilar-phonemically similar pairs were not inhibited in this experiment, but the higher error rate suggests that these pairs were processed slower than the controls.

Both of these effects did not significantly interact with question type. In other words, facilitation was apparent for the graphemically similar-phonemically similar prime-target pairs when the subject answered either a meaning or a rhyme question. Also, no facilitation was observed
for the graphemically dissimilar-phonemically similar pairs even when the subject had to access the phonemic structure of the prime. This result alone implies that phonemic facilitation is not graphemically independent.

It would have been desirable to differentiate between the two different types of 'no' responses (no to the phonemic or the semantic question). However, the data for the 'no' responses are still worth keeping in the analysis. Although we do not know what question the subject was responding 'no' to, we do know what the prime-target relationship was. And because there was not a significant prime-target type x question type interaction with respect to the 'yes' responses it seems that the question type was not influencing the effects of the prime-target relationship.
General Discussion

The results of these four experiments have demonstrated some of the limitations of the phonetic priming effect. Experiment 1 replicated the original Hillinger study with surprising accuracy. It was found that by using the same word pairs, the same design, and the same prime response instructions the same pattern of results that Hillinger reported are found. Phonemically similar words were responded to significantly faster than a neutral control pair regardless of whether the prime-target pairs were graphemically similar or dissimilar. In addition, responses to the graphemically similar and dissimilar rhyming pairs were not significantly different from each other.

In his paper, Hillinger reported two experiments which used this design. Experiment 1 of this thesis and Experiment 2 and Experiment 3 of his paper are nearly identical. The only difference is that some of the nonword targets in his Experiment 2 were slightly different. His Experiment 2 had no nonwords targets which rhymed with the word prime it was matched with. In his Experiment 3 some nonword targets were made to sound like their word prime. He argued that if subjects were using the strategy of generating rhymes to the prime in Experiment 2 the presence of these rhyming nonword targets in Experiment 3 would discourage such a strategy. That the results in Experiment 3 replicated those of Experiment 2 lead Hillinger to conclude that the phonemic facilitation effect was not a product of a rhyme generation strat-
egy (however, an inflated error rate for those rhyming word-nonword pairs contradicts this conclusion).

That subjects' RTs were not influenced by the presence of the rhyming word prime-nonword target pairs does not mean that subjects were not generating rhymes to the prime. Data reported by Humphries et. al. demonstrated that target identification was not facilitated when a word target was preceded by a phonemically similar nonword prime. They used this evidence to argue that subjects do not encode nonwords phonemically. Therefore, it is unlikely that Hillinger's subjects were accessing the phonological structure of the nonword targets. This means that we cannot rule out the possibility that subjects were generating phonemically similar items to the prime.

There are at least two replications of Hillinger's Experiment 2, Experiment 3 reported by Hillinger and Experiment 1 of this thesis. If the phonemic priming effect is automatic it should be possible to replicate it with a different design. Experiment 2 of this thesis used a nearly identical design except that subjects were not required to respond to the prime. And although subjects were instructed to read the prime the phonemic priming effect was not evident. Because of a between subjects SOA manipulation, Experiment 2 could be considered two attempts to replicate the original experiment. At neither of the two SOAs was anything like the phonemic priming effect detected.

By simply eliminating the requirement of a lexical
decision to the prime the effect disappeared. That the effect was not evident when subjects were not required to make a lexical decision to the prime does not necessarily mean that phonemic facilitation is not automatic. What it does suggest is that lexical access is not an automatic process. Possibly subjects were not willing to access the lexical entry of the word primes given that so many of the primes were nonwords. Perhaps requiring a lexical decision to the prime is necessary in order to make the subjects process the prime deeply enough to cause a spread of activation.

The results of the prime decision manipulation in Experiment 3 support this interpretation to some extent. When subjects were required to make a lexical decision to the prime graphemically similar rhyming pairs were facilitated. This facilitation indicated that the prime was being processed in these conditions. However, in the 'no prime decision' group no such facilitation was evident. In fact, this condition replicates the failure in Experiment 2 to find any facilitation for phonemically similar pairs.

Experiment 3 also demonstrates that phonemic priming is not independent of graphemic similarity. When semantically related prime-target pairs are included in the lexical decision task RTs to graphemically dissimilar-phonemically similar pairs are no longer facilitated even when a lexical decision to the prime is required. The interesting thing about Experiment 3 is that facilitation was found for the
graphemically similar-phonemically similar pairs. It was also shown that this effect was not due solely to the graphemic similarity of these types because the graphemically similar-phonemically dissimilar pairs were not facilitated. While it may be proposed that visual similarity rather than graphemic similarity was being manipulated (because the same case letters were being used between the prime and target as well the same graphemes in the graphemically similar conditions) this argument and its implication do not change.

Semantic facilitation was not found in Experiment 3 when semantically related pairs were contrasted with the neutral prime controls. Only if these pairs were compared to the unrelated prime-target pairs did a small semantic priming effect become detectable. This is troublesome because many other experiments have shown this effect to be a robust one. But as discussed, this could be due to several factors which could have affected the way in which the subjects processed the prime. One consideration is that phonological and semantic relationships have never been compared in the same experiment (Shulman et. al. did compare prime-target pairs which were graphemically similar-phonemically similar to semantically related pairs, but they did not include graphemically dissimilar-phonemically similar pairs in the stimulus set).

Another consideration is that the semantically related pairs used in this series of studies were all synonyms. There is no agreed upon criterion for establishing that two
words are semantically related. Some researchers have used category names and category members as their semantically related pairs (BIRD-ROBIN, Neely; 1977). Others (Warren, 1977) have used antonyms (HOT-COLD), synonyms (TWINE-STRING), and sex shifts (BOY-GIRL).

In fact, it was Warren who demonstrated that the patterns of semantic facilitation are different for different associative relationships. In one experiment he varied the SOA between 75 msec and 225 msec. He found that for antonym and sex shift prime-target relationships the amount of semantic facilitation increased proportionally with the SOA. However, synonyms were facilitated the most with the 75 msec SOA and this facilitation decreased as the SOA was increased. Therefore it could be that semantic facilitation occurred in the experiments presented here but that much of it had decayed by the time the target was presented.

In Experiment 4, all of the subjects made decisions concerning every prime. The most interesting thing is that in half of the trials subjects were required to access the phonemic structure of the prime in order to answer the presented question. Experiment 4 replicated the results of experiment 3 by showing that graphemically similar-phonemically similar prime-target pairs are facilitated. Also, the phonemically similar-graphemically dissimilar word target pairs were not significantly facilitated even though subjects were accessing the phonetic structure of the prime on half of the trials. Importantly, in both Experiment 3 and
Experiment 4, RTs to graphemically similar and graphemically dissimilar rhyming word prime-word target pairs were significantly different.

Experiment 4 also found facilitation for the semantically related pairs. While semantic priming was not evident in Experiment 3 in the 'no prime response' condition, there was a tendency for the semantic pairs to be facilitated when a lexical decision to the prime was required. In Experiment 4 the prime was always processed for either phonemic or semantic information. When the prime was processed for semantic information the semantically related targets were facilitated 38 msec. When the prime was processed for phonemic information this facilitation was smaller, but still apparent.

The overwhelming impression this gives is that the amount of semantic facilitation is related to the way in which the prime is processed. If this is the case, then semantic facilitation may not be 'automatic' as the term is defined by Posner and Snyder. Even the Neely (1977) experiment, which has been hailed as demonstrating the automaticity of semantic priming, required subjects to process the prime rather deeply. That is, subjects were compelled to generate some subset of possible targets based on the semantic category of the prime. This entails even more processing than a simple lexical decision requires. When the prime is processed minimally, whether it is due to task characteristics (as in Henik et. al. where a letter search was per-
formed on the prime) or because the prime is related to the
target only on a few trials (as reported by Tweedy et. al.),
then much less activation is present to spread.

Alternatively, it may be lexical access that is not
automatic (den Heyer et. al., 1983; Tweedy & Lapinski,
1981). If lexical access is not achieved, then we would not
expect to find activation spreading to related lexical
entries. As a word prime is processed deeper the probabil-
ity that the lexical entry of that word is accessed
increases. Whenever lexical access is achieved then activa-
tion would spread automatically to related lexical entries.
Unfortunately the results of the experiments reported here
do not allow us to select one of the above hypothesis over
the other.

It is important to note, however, that one of the
implications that both of the above explanations share is
that semantic facilitation cannot possibly occur when the
prime is presented subliminally (below the threshold of per-
ception). If the prime must be processed to a relatively
deep level before semantic facilitation can occur then it is
not possible for a prime which is not perceived to cause
spreading activation.

As was discussed earlier, there is still some question
as to whether phonemic facilitation is due to subjects gen-
erating targets which rhyme with the prime. That there was
no facilitation for the graphemically dissimilar rhyming
pairs is not conclusive evidence that subjects were not gen-
erating rhyming targets. There are experimental results which suggest that subjects do not treat all rhyming pairs alike. Seidenberg & Tanenhaus (1979) noted that subjects were significantly faster in an auditory rhyme monitoring task when the target word was graphemically similar to the probe word than when it was graphemically dissimilar (in a typical rhyme monitoring task subjects are presented with a probe word and must respond with a button press every time an auditorally presented word which rhymes with the probe is detected). While the subjects could perform this task purely on the auditory characteristics of the target the influence of the graphemic qualities of the target was none-theless significant (see also Tanenhaus, Flanigan, & Seidenberg; 1980).

Yet another finding, reported by Donnenwerth-Nolan, Tanenhaus, and Seidenberg (1981) suggests that rhyme generation is not graphemically independent. In order to develop probe-target controls for a rhyme monitoring experiment Donnenwerth-Nolan et. al. gave subjects a reference word and asked them to write down as many rhymes to the word as they could think of. They found that 65% of the first words generated were graphemically similar to the reference word.

Therefore, it could still be argued that graphemically similar-phonemically similar prime-target facilitation was due to a rhyme generation strategy. This possibility was investigated in one of the experiments conducted by Martin and Jensen. They employed two stimulus sets, one with a
high proportion of phonemically related prime-target pairs (70%), and one with a low proportion of phonemically related pairs (20%). In all cases half of the rhyming pairs were graphemically similar and half were graphemically dissimilar. Subjects were presented with only one stimulus set. In addition to the between subjects stimulus set factor, a within subjects SOA manipulation was employed. Half of the trials used a 250 msec prime-target SOA while the rest were presented with a 1000 msec SOA.

Martin and Jensen reasoned that if subjects were generating targets to the prime they would only be compelled to do so in the high proportion condition, and then facilitation would only be evident at the 1000 msec SOA. However, if the facilitation was automatic then it would be detected at the 250 msec SOA in both of the prime-target rhyme proportion conditions. The results of that experiment support those reported in Experiment 3 and Experiment 4 of this thesis. Facilitation was found at both SOAs in both rhyme proportion conditions for graphemically similar rhyming prime-target pairs. Additionally, the graphemically dissimilar rhyming pairs were not facilitated in any of the conditions. While these results verify that phonemic facilitation is not graphemically independent, it also suggest that there is automatic facilitation for graphemically similar rhyming targets. However, in order to account for the failure to find facilitation for targets preceded by graphemically and phonemically similar primes in Experiment 2 and the 'no
prime response' condition of Experiment 3 it is necessary to assume that this facilitation will not occur if the subjects are not actively processing the prime.

The only unresolved problem is that of the the Hillinger experiment results. It is very difficult to explain the Hillinger experiment results without suggesting that some peculiarity of Hillinger's stimuli is to blame. There were several strange words which were included as primes. Words like 'PUKE', 'WOO', and 'HEWS' were used as word primes in some of the rhyme prime groups. However, the use of the Latin Square design that Hillinger employed should have tempered the influence of the occasional odd trial. In any case, because graphemically independent phonemic priming can only be replicated with a specific design and stimulus set, Hillinger's contention that automatic activation spreads to phonologically related lexical entries must be rejected.

Since the experiments reported in this thesis have used several different stimulus sets, a number of different task characteristics, and quite a few subjects, the conclusion must be drawn that the phonemic priming effect is not graphemically independent. What is apparent is that facilitation to graphemically similar phonemically similar prime-target pairs is a robust effect. As long as the subjects were compelled to process the prime (because some decision had to be made about it) then significant facilitation for these pairs was found. This result is supported by the work
of Shulman et al. who reported facilitation for graphemically similar-phonemically similar prime-target pairs regardless of whether nonword foils were orthographically legal or illegal.

That graphemically similar-phonemically similar prime-target pairs are facilitated in a lexical decision does little to distinguish between the models which were presented earlier. The logogen model predicts facilitation for 'LATE-MATE' type pairs, but it also predicts facilitation for both the 'EIGHT-MATE' and the 'LEMON-DEMON' pairs, although to a lesser extent. Within this model, facilitation for graphemic and phonemic similarity would equal the facilitation for graphemic similarity plus that for phonemic similarity.

The Forster model cannot predict this result either. The only way that it could account for the data is if more assumptions are made about the structure of the file system. One such addition would be a link among master file entries simultaneously based on orthography and phonology. Yet another assumption could be that the phonological peripheral access file is also organized on the basis of graphemes. However, even without these additional assumptions the Forster multiple access file model is not very parsimonious.

Some aspects of the graphemically dependent phonemic facilitation effects support the encoding bias hypothesis of Meyer, Schvaneveldt, & Ruddy. The hypothesis is relevant when two graphemically similar words are encoded, in succes-
sion, via a grapheme to phoneme conversion procedure. Once the first word has been recoded into a phonetic code, and the second (graphemically similar) word is perceived, the perceiver is strongly biased toward using the same rules of grapheme to phoneme conversion that were used with the first word. When the target word is phonemically similar to the prime then these same rules will correctly encode the target word. The result is a facilitated identification time. If the prime and target are graphemically similar yet phonemically dissimilar then these rules will incorrectly encode the target. The target must then must be encoded a second time, resulting in an inhibited RT.

Unfortunately, the encoding bias hypothesis cannot account for all of the data presented in this paper. While RTs to the 'LEMON-DEMON' pairs were longer than the control pairs as would be expected with the encoding bias hypothesis, there is no explanation for the longer processing times required for the 'EIGHT-MATE' type pairs. These pairs should not have been responded to slower than either the control pairs or the unrelated prime-target pairs. In fact, when compared to the unrelated prime-target pairs they are not inhibited. However, if the unrelated pairs are used as controls then the 'LEMON-DEMON' pairs are not inhibited either.

What these data provide is a big clue to some underlying process in visual word recognition. That lexical decisions to graphemically similar-phonemically similar prime-
target pairs are facilitated while those to graphemically
dissimilar-phonemically similar prime-target pairs are not
facilitated (and possibly even inhibited) is truly striking. In
addition, the priming of a target by a graphemically and
phonemically related prime appears to be automatic. This
suggests a process or a structure in lexical access that is
at the same time both grapheme and phoneme dependent.

What still needs to be done is to extend the methodol-
ogy of Experiment 4 to include various orienting questions
that require the subject to process the prime to a lesser
extent than either the rhyming or meaning questions did.
One possibility would be to have the subject perform a let-
ter search on the prime before the target is presented.
This would require the subject to process the entire word
for graphemic information. Another possibility would be to
make the subject decide whether the prime was presented in
upper case or lower case letters. This would entail even
less processing than a letter search. What should happen is
that some type of orienting question would be found that
would cause the prime to be processed so little that either
the semantic or the graphemically dependent phonemic facili-
tation should cease to be measureable. If it is assumed
that the processes in visual word recognition proceed seri-
ally (that is, either phonological access precedes semantic
access or visa versa) and that the type of facilitation to
disappear first is associated with a later process, then it
would be possible to identify the relative location of the
processes or structures that produce these types of facilitation.
Notes


References


