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Primed lexical decision for orthographically similar rhyming words: Automatic or strategic?

Corl, Kathryn A., Ph.D.
The Ohio State University, 1990
PRIMED LEXICAL DECISION FOR ORTHOGRAPHICALLY SIMILAR RHYMING WORDS: AUTOMATIC OR STRATEGIC?

A Dissertation
Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University
by
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1990

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CHAPTER I
INTRODUCTION

The ability of a proficient speaker of a language to recognize rapidly and effortlessly the words of that language is rarely considered and usually taken for granted by the casual observer. A related ability that is "even more impressive" (Forster, 1976, p. 257) is the ability to recognize that an item, although a plausible word, is not a word in one's language. To a limited number of individuals, among them psychologists and linguists, these observations are not taken for granted: They are topics of great interest. They have formed the basis for many years of important theoretical and empirical work aimed at gaining a better understanding of the organization and mechanisms that allow speakers to recognize and produce fluent language with little perceived effort.

The Lexicon

Theories of word recognition generally assume the existence of a mental dictionary, or "lexicon," in which knowledge about all the words a reader or listener has acquired is stored. For most theories of the lexicon, this knowledge includes information about each word's spelling
and pronunciation, and possibly also information about word morphology (roots and affixes). Although some theories also locate word meaning in the lexicon (e.g., Forster, 1976), most theories propose that a word's meaning resides in a separate, semantic memory that can be accessed from lexical memory. The term "lexical access" is understood as the process whereby the reader successfully uses information extracted from the printed symbols on a page to contact a stored representation of the word's lexical entry in long term memory.

Coltheart, Davelaar, Jonasson, and Besner (1977) credit Treisman (1960, 1961) for first proposing a "dictionary store," which served as a basis for her theoretical model for reading and speech perception. Forster (1976) credits the concept of an internal lexicon to the work of R. C. Oldfield (1966) "...who first developed the notion of a mental dictionary and who first raised the question of how information about the meaning of the word is recovered" (Forster, p. 257). However, regardless of who was the first to propose the metaphor, it is now generally accepted that such an organized structure exists, and that it forms an integral part of the word-recognition process.

"Reader" is used here because the following discussion will focus on visual word recognition. The lexicon is also assumed to be engaged in spoken word recognition as well as in production tasks such as speaking and writing.
During the past 20 years an important part of the research effort on word recognition has focused on the lexicon and how it is that a reader or listener gains access to the information in it. As part of this research effort, several theoretical models of the lexicon have emerged that attempt to accommodate the various facts that have been learned about the recognition of words (Adams, 1979; Becker, 1976, 1979, 1980; Becker & Killion, 1977; Coltheart, 1980; Forster, 1976, 1978; Glanzer & Ehrenreich, 1979; Gordon, 1983; Landauer, 1975; McClelland & Rumelhart, 1981; Morton, 1969, 1970, 1979, 1980; Rubenstein, Lewis & Rubenstein, 1971; Rumelhart & McClelland, 1982). In the discussion that follows, the terms "theory" and "model," which might suggest different meanings to some readers, will be used interchangeably.

Factors Influencing an Account of the Lexicon

The picture that emerges from the word recognition data poses an awesome organizational task for theorists. One particular source of difficulty stems from a body of evidence garnered mainly from two common word-recognition research tasks, lexical decision and word naming. Evidence from studies using these two tasks leads to the seemingly paradoxical conclusion that entries in the lexicon are organized simultaneously along several different dimensions. For example, at least five major dimensions appear to affect lexical access: word frequency (Forster & Chambers, 1973;
Rubenstein, Garfield, & Millikan, 1970; Scarborough, Cortese, & Scarborough, 1973), semantic context (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1972), morphological structure (Snodgrass & Jarvella, 1972; Stanners, Neiser & Painton, 1979; Taft & Forster, 1975; Taft, 1979a, 1979b, 1981, 1984), and graphemic and phonological characteristics (Coltheart, Davelaar, Jonasson, & Besner, 1977; Coltheart, Besner, Jonasson, & Davelaar, 1979; Meyer, Schvaneveldt, & Ruddy, 1974; Rubenstein, Lewis, & Rubenstein, 1971). Although only two of the factors, graphemic and phonological characteristics, are involved in the current work, each of the five dimensions will be discussed briefly in order to provide an overview of the issue.

**Frequency Effects.** Frequency effects are one of the most robust findings in word-recognition research. Although frequency effects have been demonstrated in a number of tasks, they have been found to play an especially important role in the lexical-decision task. In the lexical-decision task subjects decide, as rapidly as possible, whether items presented in a display are words or nonwords. A basic finding from this type of experiment is that subjects classify words faster than orthographically regular nonwords, and words with high frequency of occurrence in the language are usually classified faster than low-frequency words (Forster & Chambers, 1973; Rubenstein, Garfield &
Millikan, 1970; Scarborough, Cortese, & Scarborough, 1977; Stanners & Forbach, 1973). The frequency effect also has been shown to affect production latencies in the word-naming task, in which the subject is instructed simply to pronounce a series of presented words (Forster & Chambers, 1973). The major implication that seems to follow logically from the frequency data is that high-frequency words either are searched first or they become available more readily than low frequency words during lexical access.

**Semantic Context Effects.** The facilitating effect of semantic context in word recognition is another robust finding that appears in a variation of the lexical decision task called a priming task. The priming task typically consists of two parts: a priming stimulus and a target stimulus. In one variation on the priming task the subject responds to both target and prime; in the other the subject responds only to the target.

A classic finding in priming studies is that reaction times to targets vary with the semantic relatedness of the primes. For example, subjects respond faster to the target word BUTTER if it is preceded by a semantically related prime such as BREAD as compared to a nonrelated prime word such as NURSE (Meyer & Schvaneveldt, 1971; Meyer et al., 1972) or a neutral control prime such as XXXXX (Neely, 1976).
Results from semantic context studies suggest that the activation of one lexical entry can affect related entries by making them temporarily more available. One widely-held conceptualization of the semantic facilitation effect is that semantically related concepts are organized in memory by a network structure consisting of interconnected nodes (Collins & Loftus, 1975). Activation of one of the nodes in the network spreads automatically to related nodes, making them temporarily more available for activation. The notion of automatic spreading activation, or some mechanism analogous to it, plays an important part in a number of theories of the lexicon.

Effects of Morphological Structure. Arguments for the inclusion of a morphological component in the lexicon have been made by several investigators (Snodgrass & Jarvella, 1972; Stanners, Neiser, & Painton, 1979; Taft & Forster, 1975; Taft, 1979a, 1979b, 1981, 1984), though the pattern of results from experiments in this area of inquiry does not lead to a very clear picture. Some findings (Stanners et al., 1979) lead to the conclusion that prefixed words are represented in the lexicon both as prefix and stem in some instances, but as unitary representations in others. Other results, such as the finding that nonwords that are the stems of genuine words (e.g., VIVE from REVIVE) take longer to classify than nonwords not formed from a word stem (e.g., NOLD), are taken as support for the assumption that word
stems are represented in the lexicon, and that in order to access these entries a process of prefix stripping must take place prior to access (Taft & Forster, 1975). Finally, some researchers have provided data to argue that morphological effects are neither the result of prefix stripping nor of the storage of stems in the lexicon, but are merely the result of strategies induced by the nature of the distractor items in the stimulus lists (Andrews, 1986; Rubin, Becker, & Freeman, 1979).

Graphemic and Phonological Factors. Although different in important ways, graphemic and phonological factors represent a set of similar issues in that they are the object of a long-standing debate concerning the nature of the codes and the processes necessary to gain access to the lexicon. Of primary concern in the debate is the question of whether the visual stimulus is transformed into a phonological code prior to lexical access. Two opposing theories were proposed in the early 1970s to address this coding question. The graphemic-encoding hypothesis (Bower, 1970; Bradshaw & Nettleton, 1974; Kolers, 1970) presumes that the printed word is recognized directly from a stored visual representation. The phonemic-encoding hypothesis (Rubenstein et al., 1971), on the other hand, holds that the visual representation is coded via a set of internal rules into a phonological representation, and that the phonological representation is subsequently used to access
the lexicon. A third hypothesis, the dual-coding hypothesis (Baron, 1973; LaBerge, 1972) integrates the main ideas from both the graphemic and phonemic theories, and proposes that lexical access can be achieved through either code, with the two types of retrieval process occurring in parallel (Meyer et al., 1974).

Several studies were conducted during the early 1970s in an effort to determine which of the three hypotheses was correct, but the outcomes of this research were not definitive. Part of the problem in interpreting the evidence in these studies of phonological coding was a lack of agreement on which experimental tasks produced allowable evidence (Coltheart et al., 1977; Forster & Chambers, 1973; Meyer et al., 1974), though lexical decision, a relatively new task, was generally favored over the previously used word-naming task.

A related problem was the lack of clear specification of the nature of the graphemic and phonological codes required by the naming and lexical decision tasks. Researchers were not in agreement, for example, about whether it was possible to pronounce words without accessing the lexicon, or whether phonological coding yielded the word’s pronunciation or merely an abstract phonological representation that gave no information about the pronunciation of the word (Forster & Chambers, 1973; Gough, 1972). Furthermore, it was not known whether the
orthographic code was sophisticated enough to allow subjects to reject orthographically irregular nonwords without first consulting the lexicon (Shulman, Hornak, & Sanders, 1978).

**Strategic Influences in Phonological Coding Tasks**

During the late 1970s Shulman et al. (1978) demonstrated that task factors such as the nature of the nonword items were strong determinants of whether subjects used phonological encoding in a lexical decision task. This implication of strategic influences on the lexical decision task came at about the same time that other researchers involved with work on attention were considering the roles of automatic activation and conscious attention in lexical decision and similar experimental tasks (e.g., Posner & Snyder, 1975; Neely, 1976, 1977; Schneider & Shiffrin, 1977). Neely applied the principles of Posner and Snyder's (1975) two-factor theory of attention to demonstrate that the effects of semantic priming in the lexical decision task could be attributed to both automatic and attentionally driven (strategic) processes. Neely's application of principles of attention theory to the priming task added a new and important dimension to the study of word-recognition processes. The attention framework allowed for a more meaningful analysis of task performance in terms of automatic and strategic performance characteristics.
Evidence for Automatic Activation of Phonological Codes

Using item sets based on the Meyer et al. (1974) and Shulman et al. (1978) studies, Hillinger (1980, Experiment 2) found a rhyming facilitation effect in the lexical-decision task for graphemically similar and dissimilar word-pairs (e.g., LATE-MATE and EIGHT-MATE) but failed to observe inhibition effects for pairs that were graphemically similar but phonologically dissimilar (e.g., COUCH-TOUCH). These findings directly contradicted earlier findings of Meyer et al. and Shulman et al., who observed inhibition for COUCH-TOUCH-type pairs in the lexical-decision task. On the basis of his results, Hillinger hypothesized that the rhyming effects were independent of the nonrhyming interference effects, and therefore not influenced by the method of presentation as were the nonrhyming (COUCH-TOUCH) pairs. In order to rule out the possibility that the rhyming effects were based on a strategy of active anticipation, Hillinger (1980, Experiment 3) employed a modified version of the task devised by Neely (1976). Results from this experiment led Hillinger to conclude that the rhyming facilitation effects were not strategic but were the result of automatic activation. Hillinger framed his discussion in terms of the theory of lexical search proposed by Forster (1976).
Purpose and Overall Plan of the Dissertation

The purpose of this dissertation was to investigate further the phenomenon of rhyming facilitation in visual word recognition and to examine within the framework of a two-factor theory of attention the claim that rhyming facilitation in lexical decision is the result of an automatic activation process. Chapter II begins with an overview of some of the major theoretical models of the lexicon, with particular emphasis given to provisions for phonological coding. A more detailed account of the major studies and assumptions leading up to the Hillinger study is then followed by a discussion of the two-factor theory of attention, as proposed by Posner and Snyder (1975) and as applied to word-recognition research by Neely (1976; 1977). The final sections of Chapter II include a critical appraisal of the Hillinger study, followed by a discussion of a more recent finding in which inhibition was observed for rhyming targets in the lexical decision task (Colombo, 1985, 1986). The chapter concludes with a brief review of three papers (Evett & Humphreys, 1981; Humphreys, Evett, & Taylor, 1982; Underwood & Thwaites, 1982), in which masking techniques were used to investigate the automaticity of the rhyming effect with unattended primes. Chapters III and IV contain the specific research questions, descriptions of the materials and procedures used, and the results and related discussion for Experiments 1 and 2. Chapter V is a general
discussion of the results with implications for future investigations.
CHAPTER II
REVIEW OF THE LITERATURE

Research on visual word recognition has produced a rich and diverse literature, spanning over a century and covering topics from alphabetic writing to working memory. The focus of this review is on the segment of the literature that deals with the issues of graphemic and phonological coding and the role they are assumed to play in the visual recognition of words. In order to provide a framework for the discussion that follows, the review begins with a description of some of the major models of visual word recognition and the lexicon.

Models of Visual Word Recognition and the Lexicon

The logogen model. Morton's logogen model (Morton, 1969, 1970, 1979, 1980; Morton & Patterson, 1980) has served as a framework for the generation of a number of other models (e.g., Becker, 1976, 1979, 1980; Becker & Killion, 1977; McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982). Although the logogen model has been modified to accommodate new research findings since its first description in 1969 (Morton, 1979, 1980), its basic functions have remained intact.

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The logogen model is based on the construct of the "logogen," a term coined by a colleague of Morton's from the Greek words logos, "word" and genus, "birth" (Morton, 1969). The logogen is a passive word-detection device that collects "evidence" about words based on information obtained from a preliminary sensory analysis. Each logogen has a predetermined threshold that dictates the amount of information the logogen needs to become activated. A logogen becomes activated when its response strength, compared with the summed response strength for all other detectors, exceeds its critical threshold value. Activation of a particular logogen for a word results in the recognition of that word and the subsequent availability of the word's meaning or pronunciation.

Arrays of logogenes form the three separate parts of the logogen system: the auditory-input logogen system, the visual-input logogen system, and the output logogen system. All three logogen systems have contact with the cognitive system, which Morton characterizes as "the cognitive residue," or the system that "contains everything which is not explicitly included elsewhere" (Morton, 1980, p. 120). One important characteristic of the cognitive system is that it is where semantic information about words is stored, and it is from the cognitive representation only that the meaning of words can be computed.
The two input logogen systems each receive output from a (loosely specified) sensory analysis of the stimulus. For example, information to the visual logogen system from an initial visual analysis might, according to Morton, include letter and positional information, word shape or perhaps even featural information. Because there is redundancy in the information to the input logogen systems, and because the detectors operate according to thresholds, it is possible within the logogen system to identify a word based on incomplete stimulus information. The threshold concept also can be used to account for frequency effects and for the recognition advantage found when a word is repeated on a list (repetition priming). Each time a logogen is activated, its threshold is lowered so that less evidence is required to activate it the next time.

In addition to information from preliminary sensory analyses, the visual and auditory input logogen systems also can receive input from, or send output directly to, the cognitive system. According to the 1980 version of the logogen model, each logogen has two thresholds. When a preliminary threshold has been exceeded, the logogen sends a code to the cognitive system; when (or if) the second threshold has been surpassed, a code is sent to the corresponding output logogen, which makes a word available as a response. The dual threshold system makes it possible to complement sensory input with contextual feedback from
the cognitive system. It also enables the model to account for effects such as priming without awareness (Marcel, 1983a, 1983b).

The third logogen system, the output logogen system, collects information from the two input logogen systems as well as from the cognitive system. According to Morton, the product of the output logogen system is a phonological code, which is sent to a response buffer where it is temporarily held. From the response buffer, the code can be fed into the speech output system or back into the system as a possible mechanism for silent rehearsal. A special route from the visual analysis system through a grapheme-phoneme conversion system to the response buffer enables the model to account for the ability to read aloud nonsense words, for which no logogens purportedly exist.

Models influenced by the logogen model. Two models that have been influenced by the logogen system concept are Becker's verification model (1976, 1979, 1980; Becker & Killion, 1977) and the interactive activation model of McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982). Both models employ some version of a detector mechanism and both specify in more detail the processes that occur between sensory analysis and word recognition. The detail of both models is focused on purely visual aspects of word recognition, and neither model has yet addressed the issue of phonological coding. The main objective in the
following discussion will be to describe the basic mechanisms of the models, to delineate how they handle frequency and semantic-context effects, and to speculate on how each one would handle phonological coding effects.

In Becker's verification model (1976, 1979, 1980; Becker & Killion, 1977), the sensory analysis phase consists of a feature extraction process that feeds into an array of logogen-like word detectors. The word features that are extracted in the sensory analysis phase are called primitives, and include the basic curves, verticals, horizontal, and diagonals that form letters. Not included in this set of primitives are relational characteristics such as the points of juncture between two primitives (the peaks on the letter "W," for example, ) or the spaces between letters. As in the logogen model, the detectors collect sensory information until a criterial threshold is exceeded. Because the feature extraction process of Becker's model identifies only the primitive aspects of the letters, however, the feature extraction process does not result in the recognition of a word. Instead, a set of candidate-word detectors is activated, each of which is consistent with the primitive features in the display. A verification process follows in which the candidate words, constructed from the feature-defined detectors, are searched serially and compared with the stimulus information, which has been
maintained in sensory memory. The word is recognized when a match is found.

Frequency and repetition effects can be explained by positing that high-frequency and recently encountered candidates will be searched first. Semantic-context effects are explained in the verification model by the creation of an expectancy set. When a word is recognized, its semantic features become available in the semantic-processing component. These features can activate a set of semantically related words in the semantic processor, which, in turn, exerts a top-down influence on the candidate set of word detectors in the detector array. In order to account for the semantic-facilitation effect, it is assumed that the semantic features alone are sufficient information to activate a feature detector and that the semantic set is searched before the information from the feature extraction process is even available.

Becker's model has not yet addressed how the model accounts for phonological influences on the processing of visual displays, but it would seem that the model's account would include a top-down expectancy-set explanation similar to that proposed for semantic-priming effects. Such an account would imply the addition of a phonological processor or the extension of the semantic processor to include phonological information. From the phonological information
a phonological expectancy set could be formed that would influence the set of candidates to be searched first.

The account of word recognition proposed by McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982) is a computer simulation that uses a somewhat different mechanism and specifies in great detail the processes that lead up to the recognition of visually presented words. The differences between the logogen model and the Rumelhart and McClelland framework are summarized by McClelland and Rumelhart (1981): "What we have implemented might be called a hierarchical, nonlinear, logogen model with feedback between levels and inhibitory interactions among logogens at the same level. We have also added dynamic assumptions that are lacking from the logogen model" (p. 388).

Like the Morton (Morton, 1969, 1970, 1979, 1980; Morton & Patterson, 1980) and Becker models (Becker, 1976, 1979, 1980; Becker & Killion, 1977), the McClelland and Rumelhart model (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982) presupposes a system of detectors, but unlike the previously described models, the detectors in the McClelland and Rumelhart model are organized hierarchically as a system of interconnected nodes. Each entity at a given level of processing, i.e., feature, letter, and word, is represented by a node in the system. Every node in the system has a specific resting-activation level and connections to other
nodes, termed neighbors. Presumably the resting level of the node is involved in producing frequency effects.

It is assumed in the model that the processing of a letter string occurs in parallel for all positions of the string and proceeds at all levels simultaneously. That is, processing at one level does not have to be completed before processing at the next level can begin. A further assumption is that there is communication between all adjacent levels via both excitatory and inhibitory messages. The addition of an active inhibitory mechanism gives the model the power to suppress and reject inappropriate candidate nodes at all levels.

The activation-inhibition mechanism operates as follows: When the activation level of a node in the system rises above its resting level, activation spreads to other nodes in the system with which the node is consistent. Thus, if the feature-level nodes for the letter "t" are excited, the letter-level nodes will be excited as well. Nodes that are inconsistent with the activated nodes are actively inhibited, i.e., their level of activation is pushed below the resting level. For example, at the letter and word levels, if the node for the letter "t" is activated in the first position of the word at the letter level, all words beginning with "t" will be activated at the word level. All words not beginning with "t" will be inhibited. In addition, whereas inhibition can occur both between
levels and laterally within a level, activation can occur
only between levels. Within a level, neighbors are in
competition with each other for access to output.
Therefore, as soon as a node at a given level reaches its
critical activation level, it starts sending out inhibitory
messages to its neighboring nodes.

Thus far the McClelland and Rumelhart (1981; Rumelhart
& McClelland, 1982) simulation can replicate human
performance in a number of tasks involving the detection of
letters in words, pseudowords, and letter strings. The
working simulation portion of the model has not yet been
extended to other processes, such as those that are
responsible for contextual-priming effects, phonological
coding or word and pseudoword pronunciation. However the
principles of the model can be extended into these areas as
well.

Rumelhart and McClelland (1982) propose that the
account of context effects in the interactive model would be
very similar to that of the logogen model: Appropriate
contexts prime nodes for words consistent with the context.
Interference for words inconsistent with the primed nodes
could come about in at least two ways: directly, by active
inhibition of inconsistent nodes by the contextual inputs or
indirectly through the within-level inhibition that occurs
as a result of the priming activation of consistent nodes.
Another possibility is that the bottom-up processing of the
inconsistent visual stimulus activates a different set of word-level nodes. Because the activation strength of all the nodes is taken into account during response selection, the probability of selecting the correct response will be reduced.

McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982) do not discuss explicitly how the interactive model would account for phonological coding effects, but the proposed excitatory and inhibitory connections between the letter and phoneme levels of the model could provide one mechanism for interaction of phonological and visual codes. Another possibility would be through top-down influences from the word level, if it is assumed that the nodes for a set of phonologically similar words could be primed in the same way that semantically related words are assumed to be primed.

Clues as to how the model might handle phonological coding are given in the explanations of how the model would handle the pronunciation of words and pseudowords and how it would handle the effects of set on the facilitation of letter perception in pseudowords. The mechanism for allowing the pronunciation of words and pseudowords described in the McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982) model is different from that described for the logogen model. Recall that a separate, direct route from sensory analysis via grapheme-phoneme conversion to the
response buffer was added to the logogen model to account for a person's ability to pronounce both unknown words and pseudowords. The interactive activation model has no such route, nor is there a provision for applying grapheme-phoneme correspondence rules. Instead, the pronunciation of a word or pseudoword is derived through the regular word-recognition system by the use of analogy.

The idea of pronunciation by analogy was first proposed by Glushko (1979), who found that it took longer to read aloud an exception word like HAVE, which has inconsistent spelling-to-sound correspondences (i.e., most words ending in -AVE rhyme with WAVE) than it did to read aloud a word with consistent correspondences like HAZE. Similarly, pseudowords that are spelled like inconsistent words (e.g., TAVE could be pronounced either like HAVE or like WAVE) took longer to pronounce than pseudowords that are spelled like consistent words (e.g., the pronunciation of TAZE is unambiguous). On the basis of this information, Glushko reasoned that pronunciation takes place by analogy to the structure and pronunciation of other words known by the subject.

In the language of McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982), to arrive at a pronunciation of an exception word, an unknown word, or a pseudoword, the subject first partially activates all words in the neighborhood of the target word and then synthesizes a
pronunciation from the information there. Words and pseudowords with inconsistent neighborhoods will take longer than words or pseudowords from consistent neighborhoods. There also should be a bias towards choosing a pronunciation that is similar to the best-represented neighborhood, provided that there has been no immediate prior activation of lesser-represented nodes that would increase their resting activation levels.

A second clue as to how the interactive model might handle phonological coding can be derived from McClelland and Rumelhart's (1981, Rumelhart & McClelland, 1982) discussion of how the model accounts for the effects of set on the facilitation of letter perception in pseudowords. The observed effects of set on the perception of letters in pseudowords have led some investigators (Carr, Davidson, & Hawkins, 1978) to hypothesize that there are two separate mechanisms available for the processing of words. One mechanism is the fast, direct, unmediated hookup of the stimulus representation with a lexical representation. The other, slower, mechanism requires the intentional use of an orthographic computational mechanism.

Experiments by Aderman and Smith (1971) and Carr et al. (1978) investigated the extent to which subjects' expectancies, or set, influenced the way in which they responded to letters in words, pseudowords, or nonsense letter strings. The paradigm used in both experiments was
the forced-choice paradigm (Reicher, 1969), in which the subject is presented with a letter string followed by a mask and two alternative letters, or two alternative letter strings, each differing in one critical position by one letter (e.g., BAND-LAND, RAIN-RAIL). One alternative letter or letter string is displayed above the masked stimulus, the other below it. The subject's task is to decide which of the two letters or letter strings displayed with the mask was in the previously displayed letter string.

Aderman and Smith (1971) found that the subjects' expectations about the type of target string they were about to receive dictated the way the string was processed. When subjects expected to see only unrelated letters in displays, recognition of probed-for letters in surprise pronounceable pseudowords did not benefit from a pseudoword context. On the other hand, when subjects were expecting pronounceable pseudowords, performance on these strings was better than for unrelated letter strings.

Carr et al. (1978, Experiments 3 & 4) added to the basic letter-string recognition experiment a word condition and whole-word and pseudoword probe pairs. They found that when subjects were told explicitly that either words, pseudowords, or unrelated letter strings would comprise a given list, subjects were always more accurate in identifying words over unrelated letter strings—regardless of whether they expected words or nonwords. Identification
accuracy for pseudowords, however, depended on whether they were expected. When pseudowords were expected exclusively, accuracy was higher for pseudowords than for unexpected nonwords; when either words or nonwords were expected, identification accuracy for pseudowords was equivalent to that for nonwords. As stated earlier, Carr et al., took these results as evidence in favor of an alternate orthographic computation mechanism that can be deployed strategically when pseudowords or words are encountered that are not yet known to the reader's visual word recognition system.

Rumelhart and McClelland (1982) offer an explanation of the results of these experiments within the confines of the interactive activation framework. Although the explanation is somewhat complex, the argument hinges around the assumption that when pseudowords are presented, letter-level activation spreads to all words that have two or more letters in common with the pseudoword in the display. Even though no single word gets strongly activated, the activations of the word candidates reinforce, in cascade, activations of their component letters at the letter level. Because the activation of candidates for words not completely consistent with the stimulus depends on the relative inhibition and activation values between the letter and word levels, manipulating the inhibition parameter at the letter-word level will allow some control over what gets
inhibited. If inhibition can be set to zero, then more candidate words will be activated at the word level. Some of these words will be deactivated because of lateral inhibition from competing neighbors, but many will remain active. As the inhibition parameter is increased, words that fit activated letters in only one position will be deactivated; following this will be words that fit activated letters in two positions, and so on. Therefore, when subjects expect pseudowords in the list, they set a very low inhibition parameter; when only words or unrelated letter strings are expected, subjects set a high criterion.

Rumelhart and McClelland propose that for most purposes it is probably advantageous to set a rather high inhibition parameter, since in the course of normal reading words are expected more often than pseudowords. They add, however, that the flexible criterion and its resulting multiple partial activations would be advantageous when encountering unfamiliar words for which a plausible pronunciation is needed.

**Forster’s search model.** The final model to be discussed in this section is a search model of lexical access proposed by Forster (1976, 1978). Forster’s model operates basically on the principle of ordered serial search, which means that items are searched serially until a match is found. It is also content-addressable, which, according to Forster, means that the information in the
lexicon can be addressed by knowledge of the access codes by which the information is stored. Forster's model consists of a master lexicon, called the master file, in which all the information about a word is contained, including its meaning. In addition, there are three peripheral "access files" that can be used to gain entry into the master file.

The orthographic access file is organized according to orthographic properties of words and is used when the stimulus is the printed word. The phonological access file is organized along phonological dimensions and is used in the case of auditory input. The production file is organized along semantic and syntactic dimensions and serves in choosing the right words during sentence production. Each of the access files contains an access code, which is a description of stimulus features, and an address or pointer to the appropriate entry in the master lexicon. Access files do not contain further information about words: Only after addressing the appropriate entry in the master file is the word and all the information about it available.

Thus, when a stimulus word is presented visually, it is first coded (in some unspecified manner) and the access file is searched for the appropriate access code. When a criterion of sufficiency has been met for a match, the lexical entry is addressed in the lexicon and a process of verification takes place. This post-access check is a comparison of the stimulus properties with the properties of
the lexical entry that has been addressed. Forster notes that the sufficiency criterion for a match in the access file must be less than a perfect match. If that were not the case, the model could not account for the fact that nonwords that are similar to words take longer to reject than nonwords not similar to words. The extra decision time required for word-like nonwords can be attributed to the time required to address a potential candidate and subsequently reject it as inappropriate through a post-access check.

In order to allow for a rapid search of the access files, each file is assumed to be subdivided into a system of bins. Calculating the correct bin to select for the search then becomes the first step in lexical access. The procedure for calculating the correct bin number for the initial search has not been fully specified, but is presumed to operate using the initial and final letters of the word, and the use of such a procedure has implications for the contents of each bin.

Forster (1976) specifies vaguely that the bin contents are items that have "similar descriptions" (p. 269). This implies that, in the case of the orthographic access file, the entries will be similar from left to right, like a section of pages from a dictionary, and that words that differ only by their initial consonants will not be in the same bin. However, if the ends of words are searched as
well, it would imply either that the bins are organized simultaneously in two ways, or that an ordering mechanism exists that allows the beginnings of words to be searched first. A parallel search of all bins for a match with any part of the stimulus string would not be a possibility, for such a search would obviate the need for ordered bins and would, in essence, change the nature of the model from ordered serial search to something more like a detector mechanism. Whatever the contents of each bin, the entries within each bin are ordered according to frequency. This stipulation allows the model to account for frequency effects.

The Forster (1976) model handles semantic-context effects by postulating that the master file contains cross-references between entries. Therefore, decisions about a second word in a two-word lexical-decision task can purportedly be made without entering through an access file. Since the cross-referencing system makes available related words, primed words are accessed from within the master file and responses to them are therefore faster and without frequency effects.

Because of the modality-specific nature of the access files, the Forster model does not subscribe to the notion of phonological recoding of visually-presented words as a means for accessing the lexicon, and it is unclear how the model would handle the various experimental effects that suggest
the possibility of such recoding. Furthermore, the 1976 version also fails to offer an explanation of how subjects are able to pronounce an unfamiliar word or pseudoword from an orthographic representation. The lack of such an explanation does not necessarily mean that the model could not accommodate pseudoword pronunciation or the pronunciation of unknown words. An analogy mechanism operating within the master file or within an output file could account for the ability to pronounce unknown words or pseudowords. The construction of a pronunciation would presumably occur after a search of the master file failed to yield an appropriate match for the stimulus string.

**The Issue of the Mode of Lexical Access**

In a speech honoring the 80th birthday of Sir Frederic Bartlett, Oldfield (1966) posed two important questions about the lexicon: "How is this stock or store organized, arranged and indexed? and by what means do we gain access to items in it?" (p. 341). The second question, concerning the means of access to the lexicon, has been a particularly absorbing occupation of psychologists and reading researchers over the past two decades. Initial inquiry into the question of how people gain access to the lexical store had its roots in early attempts to characterize the reading process on the basis of logical conclusions drawn from introspective and observational evidence. As Bower (1970) noted, "The study of reading begins in the armchair. From
this secure base, one produces an informal theory to guide subsequent research* (p. 135). Because reading in languages that use alphabetic scripts is a skill that is learned following the acquisition of spoken language, it was a natural assumption of some early researchers that the basis of reading was a translation of the orthographic stimulus into sound or some form of phonological representation that could be dealt with by the mechanisms that are used to process heard speech (e.g., Bloomfield, 1942; Gibson, Pick, Osser & Hammond, 1962; Gough, 1972). It was generally assumed that in learning to read, the child learns to map printed words onto already existing phonological forms. Further evidence for the use of a phonological or speech-related medium in reading was the observation that even proficient readers experience "inner speech*. According to Bower (1970), some theorizers assumed that "the visual text is not transformed into an auditory surrogate, but rather that it is transformed into subvocal speech, so that the reader understands what he is reading either by hearing himself or feeling himself reading it aloud" (p. 135).

One type of early experimental support for the notion that the printed symbol was translated into a phonological medium prior to access was given by Corcoran (1966). Corcoran engaged subjects in a visual search task in which they searched texts for instances of the letter "e". Corcoran found that subjects tended to miss the target
In a second experiment, Corcoran (1967) had subjects proofread texts in which the letter "e" was systematically deleted. Again, subjects tended to miss deletions of the letter "e" more frequently when the letter was unpronounced in a word.

Early evidence for the primacy of the visual aspects in reading was provided in an experiment conducted by Bower (1970). Bower measured the reading times of Greek-speaking subjects as they read aloud Greek-language texts that had been altered by replacing certain vowels with vowels having the same sound but a different graphemic realization. An English-equivalent example of the type of text subjects read is TWO BEE OAR KNOT TOO BEE (Coltheart, Davelaar, Jonasson, & Besner, 1977). Bower found that it took subjects on the average one and one-half times as long to read the altered text as it did to read the original, unaltered version. He considered this finding clear evidence that "the look of the word is more important in reading than its sound" (p. 143), and only in the case of the altered text was it necessary for subjects to produce "auditory-articulatory surrogates" before they could extract meaning from the text. These conclusions were later challenged by Coltheart et al., who noted that a model of phonologically mediated lexical access (Rubenstein, Lewis, & Rubenstein, 1971) could also explain the results of the Bower experiment.
As a result of the paradigm shift in the 1970s toward the information processing metaphor, Oldfield's original observations were rephrased, but remained in essence unchanged. Coltheart et al. (1977) write:

...what we need is more specific ideas about just how a reader proceeds from the information he extracts from a word stimulus to the corresponding lexical entry. This requires that two questions be answered:

1. What is the access code? That is, what is the nature of the information extracted from a printed word for use of lexical access?
2. What is the access procedure? That is, how is this stimulus information made use of in order to gain access to the desired lexical entry? (p. 537)

By the early 1970s a number of accounts of visual word recognition were prevalent. Congruent with the information-processing paradigm, the focus of the discussion was on the nature of the code and the procedure necessary to gain access to the lexicon. Although the various accounts of word recognition can be described as ordered along a "continuum of necessity" (McCusker et al., 1981), with theories postulating pure visual access to the lexicon at one extreme and theories requiring phonological recoding at the other, and a number of theories proposing varying degrees of necessity or sufficiency for either code in
between, three representative theories emerged that describe the basic positions subject to debate.

The graphemic-encoding hypothesis (Bradshaw & Nettleton, 1974; Frederiksen & Kroll, 1976; Kolers, 1970; Smith, 1971) proposed that the printed word is recognized from an analysis of the visual properties of the stimulus, and that no intermediate recoding of the stimulus into a phonological representation is necessary. On this view it is implied that in learning to read, the child develops a new system for accessing the lexicon. This system is based on visual input and is separate from the phonological system used in understanding spoken language.

The phonemic-encoding hypothesis, on the other end of the continuum, postulated that in order to extract meaning from the printed symbols on the page, the reader first decodes or translates the printed symbol into a corresponding phonological representation. The phonological representation then is used to search the lexicon and gain access to the word's meaning. Although there was (and continues to be) varying opinion on the exact nature of the
phonological code', proponents of the phonemic-encoding view, among them Gough (1972) and Rubenstein et al. (1971), considered the recoding step obligatory.

A third account of word recognition, the dual-access hypothesis, was in a sense, a compromise model. According to dual-access models (Baron, 1973; Coltheart, 1978, 1980; Laberge, 1972; Meyer, Schvaneveldt, & Ruddy, 1974; Morton & Patterson, 1980) lexical access can be achieved through either of two available routes: visually, using a visual code or phonologically, using a phonological code. The dual-access model described by Meyer et al. was hypothesized to operate in parallel, with the visual route and the phonological route in competition for first access to the lexicon.

As McCusker et al. (1981) note, even after more than a decade of research and debate on the subject, the coding issue still remains to be settled, although the dual access position is "almost universally accepted, if for no other reason than to hedge one's bets against contrary evidence;...

'There is also a distinct lack of consensus in the literature concerning the label for this internal representation. As McCusker, Hillinger, and Biss (1981) note, each of the various labels used (e.g., "speech recoding", "phonetic recoding", "phonemic recoding") carries with it important implications about the nature of the code and the process. Following McCusker et al.'s example, the term "phonological recoding" will be used in this paper, because it is the least specific about the abstractness of the code and it is most neutral with respect to theoretical assumptions about the nature of the code.
even those who appear to take one of the strong positions seldom rule out the other alternative" (p. 220).

Experimental Studies on the Coding Issue

Results from a number of experimental tasks were used as evidence to support or refute phonological recoding as a requisite to lexical access. Among the most widely-used tasks were naming latency, in which the subject was asked to read aloud a set of visually presented stimulus items, and lexical decision, in which the subject was asked to decide whether or not a visually presented string was an English word. The dependent measure in both tasks was response latency. Although the naming task was widely used, it was criticized by some researchers (e.g., Coltheart et al., 1977) as a nonvalid task. This criticism was based on the argument that because subjects could pronounce pseudowords, for which lexical access was not possible, it was therefore also possible for a subject to name words without necessarily accessing the lexicon. The preferred task was the relatively new lexical-decision task, for which, it was assumed, lexical access was required for a correct judgment.

Evidence for a phonological code. Rubenstein et al. (1971) have been credited with being the first to use the lexical-decision task in an attempt to resolve the phonological recoding question. In their investigations, Rubenstein et al. (1971, Experiments 2 & 3) compared high- and low-frequency homophones such as SALE or YOLK and
nonhomophones such as GRASS and WHIM against two types of pseudowords. The pseudowords were either nonhomophonic with a real word (e.g., MELP, SLINT), or they were homophonic with both high- and low-frequency English words (e.g., BURD, WORF). The logic behind the Rubenstein et al., experiments was that if there is a mediating phonological code, it should result in interference for homophones and pseudohomophones, because recoding has rendered them phonologically identical (e.g., SALE-SAIL and BIRD-BURD). The results of the experiments confirmed Rubenstein et al.'s predictions: It took longer to respond to homophones than it did to respond to nonhomophones (the "homophone effect"), and nonsense words that were homophonic with real English words were responded to more slowly than were nonhomophonic nonwords (the "pseudohomophone effect"). Furthermore, there were no frequency effects in the pseudoword conditions, and only a main effect of frequency in the word conditions. Rubenstein et al. interpreted the pseudohomophone result as evidence that the visual representations for the pseudowords had been recoded into a phonological form, which, after a post-access spelling check, resulted in a false match with the real-word representation in the lexicon. The false match was presumed to be followed by an exhaustive search of the lexicon before a decision could be made that the string was not a word. The absence of frequency effects for the homophonic nonsense words served as evidence for an
exhaustive serial search of the lexicon: If the search had been terminated at a mismatch, frequency differences between the two types of homophonic pseudowords would have been observed. In a separate experiment Rubenstein et al. (1971, Experiment 1) compared the effects of three different types of nonwords: orthographically and phonologically legal (e.g., STRIG, BARP), orthographically illegal but pronounceable (e.g., GRATF, LAMG), and illegal and unpronounceable (LIKJ, CREPW). Subjects were fastest to reject the illegal, unpronounceable strings, slowest to reject the homophonic nonwords, and intermediate at rejecting pronounceable nonwords. Rubenstein et al. interpreted this finding as additional support for phonological coding.

Although the Rubenstein et al. (1971) experiments seemed to be conclusive, criticism of the procedures and results followed, and contradictory evidence began to emerge from other studies. Clark (1973) argued that for the Rubenstein et al., findings to have generalizability beyond the specific sample indicated in the experiment, both subjects and items should have been treated as random effects. When the data were reanalyzed in this manner, neither the homophone effect nor the pseudohomophone effect was statistically reliable. In addition to this criticism, Coltheart et al. (1977) faulted the study for two reasons: first, that the homophones used were not matched in
frequency to their controls, a factor known to affect reaction times in lexical decision, and second, that the source of the pseudohomophone effect could have been an experimental artifact induced by a lack of control for the graphemic similarity to English of the two types of pseudowords. In a followup experiment that controlled for frequency and graphemic similarity, Coltheart et al. (1977) failed to find the homophone effect, but they did observe the pseudohomophone effect. Subsequent research using homophones in naming and lexical decision has shown that the homophone and pseudohomophone effects are somewhat elusive, and they appear to some extent to be dependent on task variables or strategic influences (Andrews, 1982; Besner & Davelaar, 1983; Davelaar, Coltheart, Besner, & Jonasson, 1978; Kreuz, 1987; Martin, 1982).

Evidence for visual access in word recognition. In an attempt to address the findings of Rubenstein et al. (1977), and to investigate the role of lexical access in the naming task, Forster and Chambers (1973) compared lexical-decision and naming times for pronounceable nonwords, unfamiliar words (very low-frequency words), and low- and high-frequency words. Forster and Chambers assumed that there were two possible ways to arrive at the pronunciation of a word: pre-lexically, by computing the pronunciation using a set of grapheme-phoneme conversion rules, or lexically, by searching memory for stored information about the word's
pronunciation. Because it was generally assumed that lexical access was required by the lexical-decision task, a comparison of the two tasks was expected to yield an answer to the question of whether lexical access was required for word naming.

From their results, Forster and Chambers (1973) concluded that naming time was influenced by the same variables as lexical-decision time: Lexical-decision and naming times were faster for words than for pseudowords, and high-frequency words were named and classified faster than low-frequency words. The implications of these results were that lexical lookup occurred before naming took place, and therefore no conversion to a phonological code was necessary for lexical search. In addition, there was a positive correlation between naming and lexical-decision latencies for words, but not for pseudowords.

Forster and Chambers (1973) argued that these results suggested that the two tasks shared a common underlying process, namely lexical search and access, that occurred for word stimuli. The lack of correlation between results for pseudowords in the two tasks suggested a race in the naming task between pronunciation assembly according to grapheme-to-phoneme correspondence rules and lexical search, with lexical search being, in the case of pseudowords, unproductive for arriving at a pronunciation.
Although the evidence from Forster and Chambers' (1973) experiment appeared damaging to the phonemic recoding hypothesis, the authors acknowledged that their results did not necessarily refute it or preclude the possibility that some form of phonological recoding was necessary for lexical search. They further speculated that this coding could take the form of an underlying, abstract representation that was inadequate for the process of naming. Forster and Chambers' consideration that "phonemic" coding need not necessarily be thought of as an analog to an auditory or articulatory process is one of the early indications of a pervasive and serious problem for this area of research—the lack of an operational definition of the code involved in the recoding process.

Forster and Chambers' (1973) conclusions regarding the non-necessity of phonological recoding for lexical access were verified, in part, by a series of studies conducted by Frederiksen and Kroll (1976). By comparing subjects' performance in lexical decision and naming on word and pseudoword strings that were controlled for length, syllabic structure, and frequency, Frederiksen and Kroll were able to compare both orthographic and phonological influences in the naming and lexical-decision tasks. They found that naming times increased as the length of the strings increased, regardless of whether the string was a word or a pseudoword and regardless of whether the items were presented in a
mixed list or blocked on the word-pseudoword dimension. Frederiksen and Kroll reasoned that the length effect, which amounted to approximately 28 msec for each additional letter in the string, would also be present in lexical-decision latencies for the same word items if a phonological code were used to access the lexicon. Results of the lexical-decision experiment revealed a frequency effect but no length effects for words, and an absence of frequency effects for pseudowords (formed from real words by changing one vowel). These findings, according to Frederiksen and Kroll, yielded no evidence in support of phonological translation prior to lexical access.

Although these two studies appear to have done serious damage to the phonological-recoding position, they were not considered conclusive. In fact, some researchers (e.g., Coltheart et al., 1977; Coltheart, 1978; McCusker et al., 1981) called into question the basic assumptions of the studies and the conclusions that followed from them.

The encoding-bias and dual-encoding models. As evidence and arguments for and against visual or phonological coding mounted, researchers also began to consider dual-coding explanations of lexical access (Baron, 1973; LaBerge, 1972), which integrated some of the main ideas from the graphemic and phonemic theories. In a 1974 paper, Meyer, Schvaneveldt, and Ruddy criticized the Rubenstein et al. (1971) study on the basis of a possible
confound between graphemic and phonemic properties of the letter strings used. Meyer et al. argued for the likelihood that pronounceability of letter strings was confounded with visual similarity to real English words. Thus, if the unpronounceable letter strings used in the experiments looked least like real English words, and the pseudohomophones looked most like real English words, the apparent phonological coding effect might instead be attributable to a graphemic encoding process. They claimed further that the observed differences between homophonic and nonhomophonic words could feasibly be explained by graphemic confusability rather than phonological confusability.

In accord with an earlier experiment conducted by Meyer and Schvaneveldt (1971) on the effects of semantic variables on word recognition, Meyer et al. (1974) used a simultaneous method to present pairs of words, nonwords, or mixed word-nonword pairs to subjects. The subjects’ task was to respond "yes" if both items were English words or "no" if they were not. Word-pair types included rhyming words considered to be graphemically and phonologically similar (e.g., BRIBE-TRIBE, FENCE-HENCE), pairs that were graphemically similar but phonologically dissimilar (e.g., COUCH-TOUCH, FREAK-BREAK), and control pairs for each condition that were formed by re-pairing words from the first two conditions (e.g., BRIBE-HENCE, FENCE-TRIBE and COUCH BREAK, FREAK-COUCH). Nonword stimuli included
graphemically similar word-nonword pairs and their corresponding controls (e.g., HEDGE-PEDGE, RUMOR-FUMOR and HEDGE-FUMOR, RUMOR-PEDGE), nonword-word pairs that were graphemically similar and their controls (e.g., SOIST-MOIST, FRUNK-DRUNK and SOIST-DRUNK, FRUNK-MOIST), and nonword-nonword pairs and their controls (e.g., DEACE-MEACE, CULSE-GULSE and DEACE-GULSE, CULSE-MEACE).

Predictions for the experiment were the following: (a) If the graphemic encoding hypothesis is correct, then reaction times to graphemically similar word pairs (BRIBE-TRIBE and COUCH-TOUCH) should differ from their respective controls in a similar way, regardless of phonological similarity; and (b) if either the phonemic-encoding or dual-coding hypothesis is correct, then the phonological relationship between the word pairs should influence lexical-decision latency for the two word-pair types relative to controls, i.e., differences in response latency between COUCH-TOUCH pairs and their controls will not be equivalent to differences in response latency between BRIBE-TRIBE pairs and their controls.

Results of the first experiment yielded no support for the graphemic-encoding hypothesis. Instead, there was a small but nonreliable facilitation for BRIBE-TRIBE type of item and a reliable interference effect for COUCH-TOUCH type, indicating the involvement of phonological processing in lexical decisions for these word pairs.
Analysis of the negative-response latency data indicated that the processing of items requiring a "no" response was influenced by the lexicality of the top string on the display. That is, when the top string was a pseudoword, subjects tended to answer negatively, without looking at the second word. This indication that subjects were processing the items on the displays in a serial, top-to-bottom fashion led Meyer et al. to suspect that the relationship between words (graphemic or phonological) could have an effect on the processing of the subsequent string, as had been shown in a previous study involving semantic relationships between words (Meyer & Schvaneveldt, 1971).

Meyer et al. (1974) conducted a second experiment using the same stimulus items as in Experiment 1, this time controlling for the serial, self-terminating scanning effects that subjects had displayed within the simultaneous-presentation method. Stimulus pairs in Experiment 2 were presented on a video display using a method of successive presentation, in which subjects were required to make a decision about the lexicality of each member of a successively presented pair. In the successive presentation method, onset of the second letter string of the stimulus pair followed immediately the offset of the first member of the pair. With this method of presentation, Meyer et al. reasoned that subjects would be forced to respond to each member of the pair, and the influence of the first member of
the pair on the reaction time to the second member of the pair could be assessed.

Results of this second experiment again suggested facilitation for graphemically and phonologically similar (BRIBE-TRIBE) pairs versus their controls, but the facilitation was not reliable (589 msec vs. 605 msec). The reliable interference effect observed in the first experiment for graphemically-similar, phonologically-dissimilar (COUCH-TOUCH) pairs versus controls was replicated (633 msec vs. 599 msec). Meyer et al. interpreted these findings as support for the existence of phonological encoding, but they added that the results did not disprove that direct visual access was also possible.

As a general model for word recognition, Meyer et al. proposed a parallel dual-coding model. However, in order to characterize the apparent biasing effects of the phonology of one word on a subsequently presented word as had been demonstrated in their experiments, and to address the fact that the grapheme-phoneme rules of English do not always lead to a single, correct pronunciation, Meyer et al. proposed an extension of Rubenstein et al.'s (1971) original phonological-encoding model that included an encoding bias factor. The encoding bias model assumed a mandatory phonological recoding step and attributed the interference effect found for COUCH-TOUCH pairs to a predisposition to apply the same grapheme-to-phoneme correspondence rules to
the second item of a stimulus pair as were applied to the first item.

In their discussion of how encoding bias could account for the interference effects observed, Meyer et al. noted that the degree of consistency in the pronunciation of orthographically similar words might also be a factor in determining the amount of bias that will result when a graphemically similar, phonemically dissimilar pair is encountered. For example, the graphemic representation BLOW has more words pronounced like it than does the word PLOW. If the word BLOW is processed immediately before PLOW, it might exert a larger interfering effect on the processing of PLOW than if PLOW had preceded BLOW.

Although Meyer et al. did not test this line of reasoning, they did note that an informal assessment of the COUCH-TOUGH-type pairs in the study showed that there were more instances in which the more frequent pronunciation preceded the less frequent one than vice-versa. They hypothesized that if the reverse had been true, the interference effect would have been attenuated. It is interesting to note that a similar line of reasoning was the basis of Glushko's (1979) account of lexical involvement in word pronunciation, a theory that argued against a prelexical grapheme-phoneme view of pronunciation assembly. This account of word pronunciation and recognition, and the extensions of it (Andrews, 1982; McCann & Besner, 1987;
Parkin, 1982, 1984; Seidenberg, Waters, & Barnes, 1984; Stanhope & Parkin, 1987; Taraban & McClelland, 1987; Waters, Seidenberg, & Bruck, 1984; Waters & Seidenberg, 1985) have recently led some researchers (e.g., Humphreys & Evett, 1985; Seidenberg, 1985a, 1985b) to reconsider the necessity of a phonological- or dual-encoding model for an explanation of the various experimental effects in word recognition and to consider in its place an account of word recognition and naming similar to that proposed by McClelland and Rumelhart (1981; Rumelhart & McClelland, 1982).

As a further extension of the encoding bias model, Meyer et al. (1974) also hypothesized how the model would handle subjects' performance on graphemically-dissimilar, phonemically-similar pairs such as GLUE-BLEW (NB: a poor example, because BLEW is homophonic with BLUE). Meyer et al. argued that the encoding bias model would not necessarily predict facilitation based on phonological similarity for GLUE-BLEW pairs. Instead, they considered the possibility that the opposite effect could occur— that the dissimilar graphemic representations in these types of pairs could "bias subjects to form dissimilar phonological representations" (p. 318), causing an interference effect in relation to pairs that were phonologically and graphemically dissimilar (e.g., GLUE-TREE).

It is difficult to understand logically how this kind of interference could occur. If one supposes that subjects
initially encode the first word of the pair using some type of phonological code, then, as with COUCH-TOUCH pairs, subjects should be biased toward the same phonological encoding for the second word, which would result in facilitation for these pairs, or at worst, reaction times equivalent to matched graphemically and phonologically nonrelated pairs. Furthermore, the only way that such an effect could occur prelexically would be if the graphemic string had more than one possible phonological realization, which in the case of BLEW, it does not. It seems unlikely that subjects would invent grapheme-phoneme mappings that are not part of the usual set for their native language. Even assuming that several alternative mappings were possible for each item, it would be more congruent with Meyer et al.'s consistency argument to propose that the second item of GLUE-BLEW pairs would be encoded with the most common grapheme-phoneme mapping, as would the second item in unrelated GLUE-TREE pairs. Subjects would not know that the second item rhymed with the first item until after the second one had been encoded, and because the mapping would yield a phonologically acceptable code for lexical search, the search would yield an appropriate match.

The extra processing time required for COUCH-TOUCH pairs can be accounted for by a failed lexical search, which was caused by a non-productive code, followed by a recoding attempt. A prelexical explanation for an inhibition effect
for GLUE-BLEW within the encoding bias model would have to hinge on the subject’s ability to control actively whether or not a search is conducted once a phonological code has been arrived at, since the first encoding would yield a phonological code adequate to conduct a successful search. This seems an unlikely assumption.

Although the arguments predicting interference for GLUE-BLEW pairs may have been flawed, the encoding bias model proposed by Meyer et al. (1974) did, as stated, account for the observed effects in their experiment. Meyer et al., however, echoed the observations of earlier researchers (e.g., Baron, 1973; Bower, 1970; Kolers, 1970), and stressed the likelihood that in reading, as well as in word-recognition experiments, the type of code employed is task dependent, and for that reason, they also proposed that a parallel, dual-encoding model might be the correct one.

In reference to the dual-encoding model, Meyer et al. (1974) argued for a specification of the temporal relations between the graphemic and phonological encoding operations. This specification amounted to a "horse race" between the two operations, in which, under some circumstances, phonological encoding and retrieval operations would be completed before the parallel visual operations. Whether the visual or the phonological encoding operations won out would be determined by the criterion adopted by the subject. Meyer et al. hypothesized that criterion-setting would be
dependent on task demands and the amount of available context. In concluding, they correctly anticipated the direction that future research into the coding question would take: "An interesting problem for future research will be to determine under what circumstances the visual or phonological representations of printed words contribute most to their recognition" (p. 319).

**Strategic and Task-Dependent Factors in Word Recognition**

By the late 1970s researchers interested in the coding issue had begun to investigate the effects of task demands and the explicit or implicit strategies adopted by subjects in word-recognition experiments. As Henderson (1982) noted, however, the focus of the interest was not necessarily on learning about subjects' strategies per se:

"...it must be conceded that at present theoretical attention to strategies in word recognition is largely limited to their nuisance value. The prevailing approach to strategy variation stems from a long tradition in which the Good Experiment is held to be one that tears aside the idiosyncrasies of strategy in order to allow us to gaze upon the underlying mental structures. This is probably why theorists have tended to resort to the concept of strategic options only when it is necessary to resolve some inconsistency in the outcome of experiments directed toward the
identification of the code used in a particular task."

(p. 285)

The plentiful supply of inconsistencies that had been observed across a variety of word-recognition tasks provided the incentive to study task factors that were most likely to influence the subject's processing strategies in word recognition. Most of the investigations were concerned with the stimulus items and how the subject's expectations about the type of stimuli to be encountered affected the level at which the stimulus was attended to and consequently, the code that was assumed to be used.

Proportion of stimulus materials. One method used to investigate task-dependent strategic factors was to manipulate subject expectancy, or set, by controlling the percentage of certain types of items in the experimental lists. In an early strategy experiment, Aderman and Smith (1971) compared performances of two groups of subjects to determine whether their expectancies about the stimulus influenced whether they used letters or grapheme clusters (spelling patterns) as the functional unit in the recognition of tachistoscopically presented letter strings. (For a description of the tachistoscopic forced-choice task, see p. 25 of this dissertation.) For the first 15 of 16 trials the first group of subjects saw pseudowords that contained spelling patterns allowable in English (e.g., STARM or SWILG), whereas the second group saw unrelated
letter strings such as RMAST and LGISW. On the 16th trial
the presentation condition was reversed, i.e., the subjects
who had received the pseudowords saw an unexpected,
unrelated letter string and subjects who had received
unrelated letter strings got an unexpected pseudoword. A
comparison of the mean number of correct recognitions for
trials 1-14 for both groups showed superior recognition
performance for the group that had received mostly
pseudowords.

A comparison of the mean correct recognitions for
trials 15 and 16 for both groups showed that when subjects'
expectancies were confirmed, performance was better for the
pseudoword group than for the unrelated-letter group. When
subjects' expectancies were violated, there were no reliable
differences in the performance of both groups, which led to
the conclusion that there are two functional perceptual
units in the recognition of letter strings, individual
letters and spelling patterns, and that expectancy can
determine which one is used.

Further experiments using the tachistoscopic forced-
choice paradigm to explore the apparent flexibility of the
word-processing system were conducted by Hawkins, Reicher,
Rogers, and Peterson (1976) and by Carr et al. (1978).
Hawkins et al. compared recognition performance on lists in
which 75% of the items were nonhomophonic word pairs (e.g.,
SOLD, COLD or RAIN, RAIL) to performance on lists in which
67% of the items were homophone pairs (e.g., SENT, CENT) or single letters. Results of the study showed that when most of the trials on a list could be distinguished on a phonological basis (i.e., when there was a low proportion of homophonic items), performance was worse for homophonic pairs, suggesting a phonological processing strategy. When a large proportion of the items could not be distinguished on a phonological basis (i.e., when there was a high proportion of homophonic items), there was no recognition performance difference for homophonic items and nonhomophonic items, suggesting a visual processing strategy.

In two experiments conducted by Carr et al. (1978, Experiments 1 & 2), no evidence for strategic processing for words versus pseudowords was found when subjects were told that several different types of stimuli would occur on each trial (word, pseudoword, or nonpronounceable letter string), and that one specified type would occur more often than the others. However, when subjects in two different conditions were told that words or nonpronounceable letter strings would occur exclusively, and subjects were then shown a small percentage of unexpected items late in the list, Carr et al. found an advantage for words that was independent of subject expectation (Experiment 3). In addition, recognition accuracy for unexpected pseudowords did not differ from performance on expected nonpronounceable letter
strings. A final experiment confirmed that recognition advantage of pseudowords over nonsense letter strings occurred only when subjects were expecting pseudowords.

**Blocked versus mixed presentation.** A variation on the techniques described above is to compare performance for a given group of stimulus items over both blocked and mixed presentation conditions. Frederiksen and Kroll (1976) used this technique to determine the role of lexical access in the naming task. In one condition of their experiment, subjects named words and pseudowords that were randomly intermixed in the list. In the second condition, one group of subjects named only words and a second group of subjects named only pseudowords. The experimental manipulation rested on the assumption that pronunciation of pseudowords cannot be arrived at via a lexical route, since pseudowords have no corresponding entry in the lexicon. Frederiksen and Kroll reasoned therefore, that if lexical access was not used in word naming, subjects' performance in both blocked and randomized presentations would be equivalent. Any observed differences in naming performance between the mixed and blocked conditions would be evidence for strategic flexibility. Results of the experiment supported the notion that there were two possible routes for word naming, and that the likelihood that a given approach would be used was determined by the proportion of word stimuli on the list.
Type of distractor items in lexical decision. Yet another experimental variation that has been used to detect the influence of task-dependent variables on the outcomes of word-recognition experiments has been to compare the effects of different types of distractor items on responses to stimulus items. James (1975) first demonstrated that the type of distractors had an effect on the way that stimuli were processed in lexical decision. James compared the effects of pronounceable pseudowords (e.g., BRAKE), pseudowords homophonous with real words (e.g., BRAKE) and nonpronounceable letter strings on decision times for abstract and concrete high and low frequency nouns.

James (1975) reasoned that any frequency effects observed would constitute evidence that the lexicon had been accessed, and because concreteness is considered a semantic dimension, any concreteness effects could be attributed to postlexical semantic processing needed to retrieve the meaning of the word. James found main effects for frequency in all three distractor contexts, but he did not observe concreteness effects for high frequency words, regardless of the type of distractor. This finding was interpreted in terms of response criteria and the depth of processing required to make a rapid lexical decision.

The lack of concreteness effects for high frequency words together with the speed advantage compared to low frequency words was an indication that subjects were using
familiarity as a criterion for making the lexical decision: If a word was found rapidly it could be classified correctly as a word without further processing. Abstract low frequency words, on the other hand, took reliably longer to identify than concrete low frequency words when pronounceable nonwords were the distractor items, indicating that further (semantic) analysis was necessary for subjects to make a decision. The concreteness effect disappeared, however, when nonpronounceable letter-string distractors were used, although the frequency advantage for high frequency words remained. James interpreted this latter finding as evidence that when nonpronounceable strings were the distractors, subjects still accessed the lexicon, but the presence of the unpronounceable distractors allowed a correct decision based solely on finding an entry in the lexicon.

In a final experiment, James (1975) found that when subjects were given a task that allowed them to familiarize themselves with all the word stimuli prior to the experiment, the concreteness-by-frequency interaction disappeared in the presence of pronounceable pseudowords, but the main effect for frequency remained. This finding suggested that familiarization (priming) can also reduce the amount of processing required for lexical decisions.

Manipulation of the type of distractor was subsequently employed by Davelaar et al. (1978) and Shulman, Hornak, and
Sanders (1978) to investigate possible strategic involvement in phonological coding in lexical decision. Davelaar et al. compared lexical-decision response times for homophonic words and their matched controls under two different pseudoword conditions, and found that responses to less frequent members of homophonic word pairs were slower than controls when distractors were pronounceable but not homophonic with a real English word (e.g., SLINT). The effect did not occur when the distractors were changed to pseudohomophones (e.g., GRONE) on the final portion of the list.

Davelaar et al. (1978) attributed the above finding to a strategic change from phonological encoding, which was productive when pseudowords did not sound like real words, to graphemic encoding, which resulted in fewer confusions when pseudohomophones were present. In a control experiment employing the high frequency members of the same homophonic pairs, the type of pseudoword distractors did not affect response times to homophones. These results were explained by positing that when phonological coding is used, both members of the homophone pair are accessed simultaneously and that a spelling check is necessary before a response can be made. Such a mechanism would allow subjects to avoid errors that would be incurred by responding "yes" to a pseudohomophone or to the wrong member of a homophone pair.
Davelaar et al. (1976) assumed that the spelling check is carried out on the high frequency member of the pair first, thus resulting in fast confirmation for high frequency homophones. Low frequency homophones, however, would be delayed by a mismatch on the spelling check of the high frequency member, this accounting for the slower reaction times compared to nonhomophonic word controls.

An alternative explanation, more in line with James' (1975) interpretation of lexical processing, is that the subjects in the high frequency homophone condition were able to make a correct decision based on a visual analysis and frequency alone. The presence of pronounceable pseudowords would not be an interfering factor if all the word items were of high frequency, which was not the case in James' study. (Recall that in James' study high and low frequency words were mixed in the list, so that when pronounceable pseudowords were present, subjects needed more information to discriminate low frequency words from pronounceable pseudowords.) However, when all the words in the list were of low frequency, subjects would not be able to rely on frequency information alone to make decisions between words and pseudowords, so further processing would be required. Because subjects in the Davelaar et al. (1976) experiment always received the pronounceable nonhomophonic SLINT condition first, it is logical to assume that subjects adopted a phonological criterion in the face of low
frequency words and pronounceable pseudowords. Indeed, this strategy would work well for three-quarters of the stimuli (low frequency words, their matched pseudowords, and the pseudowords matched to homophones). The phonological code had a cost in both time and errors, however, for the homophonic words. (There were 9% errors for homophones compared to 3% for control words. No nonword error data were reported.)

It is not clear whether Davelaar et al.'s (1976) spelling-check explanation of the reaction times can also account for the higher error rate for homophones. When pseudoword items changed in mid-list from SLINT-types (pronounceable nonhomophones) to GRONE-types (pronounceable homophones), phonological coding of the items would have created confusion for three-quarters of the items on the list, so subjects may have changed their processing mode to one that was more productive. Error rates in the transition portion of the list changed from 4% in the context of SLINT pseudowords to 16% in the context of GRONE pseudowords. (For high frequency words this change was much less radical--from 3% to 8%--another indication that frequency may have been the criterion for lexical decision to these words.). After subjects had switched strategies to what appeared to be an analysis based on the visual aspects of the words, the error rate for homophones fell to zero and the homophone effect disappeared.
Davelaar et al. (1976) note that subjects did not use a visual strategy when SLINT-type pseudowords were present, although it appears to be the optimal strategy in any case. It could be that subjects would have used a visual strategy in the SLINT condition if they had encountered the more difficult GRONE condition first. However, Davelaar et al.'s experiment did not control for this possibility, and the answer to this question must remain speculative.

Also based on the work of James (1975), Shulman, Hornak, and Sanders (1978) used a manipulation of distractor-item type to provide counterevidence to the claim of Meyer et al. (1974) for phonological coding as an addressing mechanism to the lexicon. Shulman et al. compared lexical decision times for two groups of subjects to word pairs such as BRIBE-TRIBE and COUCH-TOUCH in the context of pronounceable pseudowords or nonpronounceable letter strings. When distractors were pronounceable pseudowords, Shulman et al.'s results replicated and strengthened those of Meyer et al.: Reliable facilitation was obtained in two separate experiments for graphemically and phonologically similar word pairs (BRIBE-TRIBE) over controls, and inhibition was observed for graphemically similar, phonologically dissimilar pairs (COUCH-TOUCH) against their controls. However, when distractor items were consonant strings or unpronounceable letter strings, reaction times to stimuli were faster overall and there were
no inhibition effects for COUCH-TOUCH pairs. Instead, these pairs showed facilitation effects equivalent to BRIBE-TRIBE pairs.

The lack of inhibition effects was interpreted as evidence for direct visual access to the lexicon, but in order to rule out the possibility that lexical decisions had been made on a purely visual basis without necessarily accessing the lexicon, Shulman et al. conducted a third experiment in which sets of semantically related pairs (STREET-ROAD) and their controls were added to the stimulus lists from the first two experiments. The stimuli had been used in a previous experiment conducted by Shulman and Davison (1977), who compared semantic priming in the context of pronounceable and nonpronounceable distractors and found evidence for a small, but reliable semantic priming effect when nonpronounceable distractors were used. Results of the third experiment were in accord with the direct-access hypothesis: There was a 91-msec facilitation effect for BRIBE-TRIBE pairs, a 67-msec facilitation effect for COUCH-TOUCH pairs, and a smaller, but reliable facilitation effect of 43 msec for semantically related pairs.

From these results Shulman et al. (1978) concluded that direct visual access was the usual means of addressing the lexicon and that phonological mediation was "at most an option rather than a requirement" (p. 122). They further suggested that phonetic mediation was employed by subjects
in lexical decision "as a consequence of the difficulty in determining whether a pseudoword is a rare word or a nonword," (p. 122) and that its utility was probably as a short-term memory aid that allowed the subject to hold information about the stimulus in memory while searching the lexicon or arriving at a decision.

Whether one agrees with the interpretation of Davelaar et al. (1978) that phonological encoding is one of two options for accessing the lexicon, or with that of Shulman et al. (1978), that phonological mediation occurs only as a memory aid to lexical search, the results of these experiments show that there is considerable flexibility to the word-processing system and that subjects are able to make fine adjustments to their strategies to accommodate different experimental situations. Although the type of distractor has been cited as an important determinant of the kind of coding that is used in lexical decision, it seems more appropriate to say that it is the interaction of the type of distractor with the word stimulus items that determines the type of coding that will be used. For instance, in James' (1975) experiments, BRANE-type pseudowords appeared to induce processing strategies similar to SLINT-type pseudowords when the word items in the list did not include homophones. However, when pseudohomophones such as BRANE were used together in lists with homophonic words (Davelaar et al., 1978), interactions between the word
and pseudoword stimuli necessitated the apparent use of a visual strategy; when SLINT-type pseudowords were used in word lists containing homophones, a phonological strategy was evident. Therefore, it is not always safe to assume that a certain type of coding strategy will predominate when a pseudohomophone distractor is present. Other factors, such as frequency or homogeneity of frequency of the word stimuli appear also to play an important role in the processing strategies used.

Attention, Automatic Activation, and Strategic Processes

As the research surrounding the phonological coding issue evolved to accommodate strategic and task factors, researchers in the area of attention and human performance were concerned with building a theory to explain how conscious strategies and intentions affect the processing of information. One such theory was proposed by Posner and Snyder (1975; Posner, 1978) who posited the existence of two independent processing modes that, in combination, could account for performance in many cognitive tasks. One type of process, which they termed "automatic," was considered to be the result of past learning and occurred "without intention, without giving rise to any conscious awareness, and without producing interference with other ongoing mental activity" (p. 56).

The second type of processing defined by Posner and Snyder (1975; Posner, 1978) was the application of a
limited-capacity mechanism that was under the control of conscious attention and that could be deployed flexibly to different requirements of a task. "Limited capacity," according to Posner and Snyder, implied that when the processor is committed to one operation, its availability to perform other operations is reduced.

To explain how the two mechanisms interacted during performance of a given task, Posner and Snyder (1975) proposed a cost-benefit account with the following basic assumptions:

"An input item will automatically activate a specific pathway in the nervous system. Any item that shares the same pathway will be processed more rapidly and thus be facilitated.... However, as long as the activation pattern is confined to the memory system, there will be no cost or inhibition of the processing of items whose pathways are not activated. This produces a kind of one-way set, in which the nervous system is set to process an item, but is not set against any other item. According to this view, stimulating the memory system in this way produces facilitation but no inhibition.

Once a subject invests his conscious attention in the processing of a stimulus, the benefit obtained from pathway activation is increased, and this benefit is accompanied by a widespread cost or inhibition in the
ability of any other signals to rise to active attention....New items still continue to activate input pathways in a purely automatic way, but they are not easily associated to nonhabitual responses. This results in the usual two-sided set familiar in the psychological literature. Subjects do well when the expected stimulus occurs, but are slow in responding to or miss entirely any unexpected item." (p. 66)

Posner and Snyder (1975; Posner, 1978) demonstrated the cost-benefit principle through the use of a primed letter-matching task, in which subjects were to judge whether or not letter pairs such as AA were physically matched. On each trial the subject was presented with either a neutral warning signal or a priming stimulus, followed by an expected or unexpected target. One variable, the amount of active attention the subject gave to the prime, was manipulated by varying the proportion of prime-target trials in which the prime served as a valid cue for the target. Benefit, or facilitation, was measured by subtracting the reaction times to responses obtained for expected targets from those that followed the neutral primes. Cost, or inhibition, was calculated by subtracting the reaction times to targets following neutral primes from those obtained for unexpected targets. A second variable that was manipulated in order to plot the time course of cost and benefit effects was the amount of time between target and prime.
Posner and Snyder (1975) found that when the prime was not a valid predictor of the target, there was some facilitation for primed targets and no inhibition for targets not related to primes. By comparison, when the prime was a valid predictor of the target, facilitation accrued more rapidly over time and was accompanied by slower developing inhibition effects for unexpected items.

In discussing the application of their dual-factor theory to various types of research findings, Posner and Snyder (1975) suggested that some seemingly contradictory evidence concerning the source of semantic priming effects observed by Schvaneveldt and Meyer (1973) and Meyer, Schvaneveldt and Ruddy (1972) could be clarified using a dual-process approach. Schvaneveldt and Meyer had proposed two possible models to account for the facilitation that occurs for associated words in the lexical decision task. The spreading-excitation model assumed that memory was organized according to meaning, and that semantically associated words were located close to one another in a network. Retrieval from one memory location caused excitation to spread out into the network, partially activating related locations and thus facilitating subsequent retrieval for semantically related items.

The second model, the location-shifting model, assumed that information stored in memory could be "read out" from only one location at a time. Because it took time to shift
from one location to the next, associated words would have the advantage of being stored closer together, and would thus require less time for retrieval. Meyer et al. (1972) and Schvaneveldt and Meyer (1973) conducted a series of experiments to test which of the two models was correct, and although their results generally supported the spreading activation model, they were unable to rule out the location-shifting account.

Neely (1976, 1977) applied the Posner and Snyder (1975) cost-benefit framework in the design of two semantic-priming experiments that tested Posner and Snyder’s contention that automatic spreading activation and limited-capacity attention could act jointly in lexical decision to produce the semantic priming effect.

The design of Neely’s 1977 experiment was based on the premise that behavior in a lexical decision task could be attributed to two complementary mechanisms: fast-acting automatic processes, such as spreading activation in semantic memory, and slower-acting strategic processes. Neely constructed a task that manipulated subjects’ expectancies about the type of target they would receive, based on the semantic category of the prime. For example, subjects were told that each time they saw the prime BIRD, they could expect either a category member such as ROBIN or a pseudoword as a target. Pseudowords were pronounceable nonwords formed by changing one letter in a word matched to
each target word in frequency, number of letters, and number of syllables. In two other conditions, subjects were told to expect an unrelated word as a target: If they saw the prime BUILDING, they could expect a word target that was a part of the body (e.g., HEART), and if they saw the prime BODY, they could expect a word target that was a part of a building (e.g., DOOR). An additional neutral priming condition, consisting of a row of XXXs, was included in the experiment to function as a baseline from which facilitation (benefit) and inhibition (cost) were measured.

In addition to manipulating the subjects' expectations about the relationship between target and prime, Neely also varied the amount of time available for conscious attentional processing. He did this by varying the stimulus onset asynchrony (SOA), which is the amount of time between onset of the priming stimulus and onset of the target event. With prime duration constant at 150 msec, SOAs for the four subject groups in the experiment ranged from 250 to 2000 msec, distributed in the following manner: one group, the 2000-msec group, was presented all stimulus pairs at 2000 msec SOA; the remaining three groups received one-half the stimuli at 2000 msec SOA, and the other half at 250, 450, or 700 msec. SOAs in the 250/2000, 450/2000, and 700/2000 groups were randomly intermixed in the lists.

Predictions for the experiment, based on the dual-process model were (a) facilitation at short SOAs for all
semantically related pairs, regardless of expectation, a result of automatic spreading activation; b) no inhibition for unexpected targets at short SOAs, due to the inability of the attentional mechanism to exert an effect at short durations; (c) facilitation at long SOAs for expected targets, produced by the limited-capacity attentional mechanism; and (d) inhibition for nonexpected targets at long SOAs, including semantically related targets, as a result of the effects of limited-capacity attention.

Neely's (1977) data confirmed his predictions: There was priming facilitation at short SOAs for semantically related pairs, regardless of subject expectation, and facilitation at long SOAs was restricted to expected targets, regardless of whether they were semantically related to primes. Inhibition was observed at long SOAs both for semantically related (BUILDING-DOOR or BODY-HEART) and unrelated (BIRD-DOOR) pairs that violated subjects' expectations. In addition, no inhibition effects were found at short SOAs.

From these data Neely (1977) concluded that semantic priming effects could be attributed to two types of facilitation. One type was fast-acting, occurring rapidly after presentation of the prime, and not accompanied by inhibition. The other type of facilitation was not dependent on the semantic relationship between target and prime, but rather on the probability that a particular
target would follow a particular type of prime in the experimental situation. This second type of facilitation took place much later than the first, and was always accompanied by inhibition. Thus, Neely successfully brought together Posner and Snyder’s theory and Schvaneveldt and Meyers’ results. In doing so, he further operationalized the definition of automaticity as it referred to "semantic structures connected by automated associative links" in memory:

If two items mutually facilitate the processing of each other without at the same time inhibiting the processing of other items, these two items can be considered to be linked by a well-established automated link in semantic memory. If, on the other hand, two items mutually facilitate the processing of each other only if they inhibit the processing of other items, the facilitation may be considered to be the result of a conscious inference and not the result of those two items’ being connected by an automated associative link in semantic memory. (Neely, 1977, p. 253)

Neely’s (1977) results have been corroborated, in part, by other researchers (e.g., Fischler, 1977; Tweedy & Lapinski, 1981), and some researchers have adapted the paradigm to investigate other related issues in word recognition (Becker, 1980; Favreau & Segalowitz, 1983; Pring & Snowling, 1986). However, Neely’s apparently clear-cut
distinction between automatic and strategic processes has not been without criticism. For example, Antos (1979) pointed to a possible speed-accuracy trade-off in Neely’s data at the 250-msec SOA and to the possibility that subjects in Neely’s experiment could have relied on superficial processing of category-member words to arrive at a decision, because pseudowords used in the task had not been formed from possible category members. Results from two experiments conducted by Antos, however, confirmed most of Neely’s results with the exception of two: a) Antos found evidence for inhibition in the absence of facilitation at 250 msec SOA, and b) he also observed inhibition for pseudoword items ("no" responses) in some cuing conditions, whereas Neely had observed an uneven pattern of facilitation for these items, and only at the 2,000-msec SOA.

Becker (1980) presented data in favor of the argument that in priming studies such as Neely’s, the size of the target candidate set can determine the type of strategy a subject uses, and this determines whether the data show a pattern of interference or facilitation dominance. When the candidate set is small, as with antonym pairs such as HOT-COLD, a rather specific prediction strategy can be used, which leads to a facilitation-dominance effect in the data. When there are several possible candidates, such as DOGS-COLLIE, a more general expectancy strategy is used, which yields an inhibition-dominant pattern of data.
Automatic Phonological Priming in Lexical Decision

Elements of the two-factor theory of attention were employed in an experiment by Hillinger (1980, Experiment 3), in order to determine whether the rhyming facilitation effects he had observed for orthographically similar (LATE-MATE) and orthographically dissimilar (EIGHT-MATE) pairs could be attributed to automatic or strategic processes.

The rhyming facilitation effects had been observed in experiments designed to test the encoding bias hypothesis of Meyer, Schvaneveldt, and Ruddy (1974). To review, the encoding bias hypothesis accounted for the interfering effects of graphemically similar, phonologically dissimilar primes by positing that when prime and target were processed sequentially, the phonological encoding of the first item influenced the encoding of the second item. In the case of BRIBE-TRIBE pairs, encoding bias would lead to facilitation, and in the case of COUCH-TOUCH pairs, the bias would lead to interference. An additional, untested prediction made by the Meyer et al. hypothesis was that graphemically distinct, phonologically similar pairs such as (GLUE-BLEW) might be subject to interference because of a bias to encode the second item in a different manner from the first.

Hillinger (1980) proposed and tested two predictions that could be made from a logical extension of the model. The first prediction stated that because encoding bias placed the locus of the facilitation and interference
effects at phonemic recoding (encoding, according to Meyer et al., 1974), removing the grapheme-phoneme conversion of the first item should eliminate the effects. The second prediction, which was also discussed by Meyer et al., was that graphemically different pairs such as EIGHT-MATE or GLUE-BLEW should not be facilitated. (An evaluation of this second prediction was made earlier in this review.)

Both predictions are based on a strong interpretation of encoding bias that assumes that it is the act of encoding itself that is biased by the way the encoding was carried out on the previous item. This kind of encoding bias would be more or less blind to the result of the first encoding. A more liberal interpretation of encoding bias is one in which the result of the first encoding works as part of the biasing mechanism, as a form of priming. Although Meyer et al. (1974) did not elaborate on the nature of the representation or its role in the encoding bias process, certain statements indicate that the more liberal interpretation could also be taken:

"It is possible that phonemic encoding of the second word in a pair depends on graphemic and phonemic similarities with the first word. Such a dependence is reminiscent of effects that semantic similarity has on successive operations in a variety of word recognition tasks" (p. 315).
"This supports our conjecture that graphemic and phonemic properties of preceding words may influence phonemic encoding of subsequent words" (p. 317).

Hillinger (1980, Experiment 1), tested the first prediction assuming a strong interpretation of encoding bias. He reasoned that by using auditory presentation of the priming stimulus, the phonological encoding process (grapheme-phoneme conversion) would be bypassed. He predicted that if encoding bias were correct, auditory presentation of primes should eliminate the rhyming facilitation effect for BRIBE-TRIBE pairs and the interference effect for nonrhyming TOUCH-COUCH pairs. In Experiment 1, subjects were presented with either an auditory prime or a visual prime, followed by a visual target stimulus, which was presented 250 msec after the subject had responded to the prime. Type of prime event was not blocked, and therefore subjects did not know whether each ensuing target-prime pair would be auditory or visual.

Word stimuli for the experiment consisted of an equal number of graphemically similar rhyming pairs (e.g., PITCH-DITCH), their word controls (LOAD-DITCH), which consisted of re-paired words from the rhyming condition, graphemically similar nonrhyming pairs (LEMON-DEMON), and their controls (BLOW-DEMON). Nonword stimuli consisted of nonword-word pairs (PLIG-FOIL), word-nonword pairs (MONK-GORL), and
nonword-nonword pairs (BINE-CLUW). The ratio of word items to nonword items was 64:48.

The most interesting result of the experiment was that there was no effect of nonrhyming (LEMON-DEMON) pairs, but there was reliable facilitation for rhyming pairs, regardless of whether the primes were presented visually or auditorally. Although a strict interpretation of the encoding bias hypothesis predicted that there should not be rhyming facilitation in the auditory-visual condition (because there would be no preceding grapheme-phoneme coding operation to bias the coding of the target), Hillinger (1980) noted that the encoding bias hypothesis could accommodate the rhyming facilitation effects if it were assumed that graphemic codes were not eliminated by auditory presentation (Jakimik, Cole, & Rudnicky, 1985; Seidenberg & Tanenhaus, 1979). Thus, if subjects used a graphemic code at some point in the auditory recognition process, it might have been possible to influence the visual encoding of a target.

The fact that performance was parallel in both the auditory and visual presentation conditions (although the auditory condition was slower overall), seems to indicate that subjects were treating the stimuli in the same way, regardless of input modality. This leads to the question of whether the subjects in Experiment 1 had devised a specific
strategy for accommodating two possibly different forms of input.

It is not clear why Hillinger (1980) chose a mixed form of presentation over one blocked for modality, or why performance in blocked conditions was not compared against performance in a mixed-prime condition for this task. It seems that the addition of uncertainty about the modality and location of the prime stimulus could have introduced strategies for coping with the diversity of the input. The disappearance of the established inhibition effect for COUCH-TOUCH pairs in the presence of pronounceable nonword distractors (Meyer, Schvaneveldt, & Ruddy, 1974; Shulman, Hornak, & Sanders, 1978) also raises the suspicion of strategic influences in the Hillinger task, particularly in light of Shulman et al.'s demonstration that the COUCH-TOUCH interference effect is susceptible to variations in the type of distractor used.

An informal study of the stimuli used in the Hillinger (1980) experiment shows that none of the nonword stimuli rhymed with their prime partners. This means that rhyming pairs always led to a yes response. A strategy based on graphemic similarity would have resulted in correct responses to both rhyming and nonrhyming pairs. In terms of difficulty of the word lists, the LEMON-DEMON list contained more multisyllabic pairs than the PITCH-DITCH list, (eight versus three), and two of the eight had different stress
patterns: BAKED-NAKED (same vowel sound, different syllabic structure), NATURE-MATURE (different stress pattern, different vowel sounds).

There were also further problems in the nonword lists that could have invited strategic processing. A number of the nonword items were orthographically odd or illegal for English, or they represented very low-frequency combinations: CLOGE (as in loge, horologe), SERL, GORL, CORL (as in whorl), TUGHT, MEAB, HASD, BIMT, CLUW. Although these nonwords can be pronounced, it can be argued that they could be discounted on the basis of a visual check for orthographic irregularity. In addition, one string listed as a nonword was a word, BULGE, one string listed as a word was incorrectly spelled, SWET, and four strings could conceivably have been pronounced as real words CORL (choral), GORL (girl), cail (kale), and cluw (clue).

Finally, three of the nonwords were fairly high-frequency words in other languages: LAVER, SONT (French), HING (German). Obviously, an informal analysis such as this one does not prove that strategic processing caused the effects obtained, but in light of what is known from other experiments that have controlled more closely for stimulus factors, the possibility must be considered.

Because the results of Experiment 1 did not conclusively rule out the encoding bias hypothesis, (although some rather strong assumptions about auditory
speech recognition would have to be made to satisfy a strong account of encoding bias), Hillinger conducted a second experiment to test further the predictions of the encoding bias hypothesis. Experiment 2 tested the second prediction of the encoding bias position—that there should be no facilitation for graphemically-dissimilar pairs such as EIGHT-ATE, because there is no graphemic similarity to bias the encoding operation. As pointed out earlier, this prediction could only be true for a strong version of encoding bias, and even then some assumptions would have to be made about the person's ability to inhibit lexical search in the presence of a valid search code.

Experiment 2 employed a visual lexical decision task in which the target and prime were displayed sequentially, with a response required to each. Each word-pair trial was preceded by a fixation point. The stimuli of interest consisted of ten each of the following types: graphemically similar rhymes (LATE-MATE), graphemically dissimilar rhymes (EIGHT-MATE), word controls (VEIL-MATE), graphemically similar nonword-word pairs (JATE-MATE), and graphemically dissimilar nonword-word pairs (BAFF-MATE). In addition, there were 20 word-nonword filler pairs (GRAPH-BLATE), 10 nonword-nonword pairs (COFF-TULD), and 10 graphemically similar nonrhymes (HORSE-WORSE) included to make the task demands similar to other studies (Hillinger, 1980, p. 117). There were no rhyming-nonword target conditions, e.g., GATE-
JATE and EIGHT-JATE, and the data analysis included only the stimuli of interest because the filler items were not counterbalanced.

Results indicated that subjects were reliably faster and less error prone for LATE-MATE pairs (490 msec) and EIGHT-MATE pairs (488) compared to the VEIL-MATE control words (527 msec). There appeared to be no interference effect for HORSE-WORSE pairs. In fact, reaction times for these pairs were very fast (467 msec), but because these pairs did not have matched controls on the stimulus list, Hillinger (1980) suggested caution in interpreting the reaction times. Reaction times to word-nonword and nonword-nonword filler pairs were relatively slow and error-prone, with mean reaction times of 645 msec for GRAPH-BLATE pairs and 653 for COFF-TULD pairs. Error rates for these items were 15.2% and 13.0%, respectively. In discussing the findings, Hillinger pointed out the possible argument that an active anticipation strategy based on rhyme could be advanced to account for the rhyming effect:

Given an initial item, the subject might generate a number of rhyming candidates that are then compared with the target item. If there is a match between one of these candidates and the target, an immediate positive response can be made. If none of the generated words matches the target, subjects revert to the regular word recognition process. Given a "hit" on
some proportion of trials, average decision latencies for rhyming targets will be reduced, perhaps enough to account for the rhyming effect. (p. 118)

Although Hillinger (1980) expressed doubt that a subject would have enough time between prime and target to generate the necessary rhyme candidates for the rhyming strategy to be successful, he conducted a third experiment to test for the possibility that the rhyming effect was strategic.

Before discussing the third experiment, however, there is one other strategic possibility not considered by Hillinger (1980). An explanation of this possibility places the locus of the experimental effects at the decision stage of lexical decision, after the lexicon has been consulted for both prime and target (Balota & Chumbley, 1984; Seidenberg, Waters, Sanders, & Langer, 1984; Tanenhaus, Flanigan, & Seidenberg, 1980; Waters & Seidenberg, 1985). It is assumed in this account that that the orthographic and phonological codes can be made available as a result of lexical access, or (in the case of a nonword) that a representation of the stimulus can be held in memory and transformed into a graphemic or phonological representation if necessary. Once the second word has been accessed, subjects compare the outcome of the word-recognition process for the target with the outcome of the process for the prime before making a decision about the lexicality of the target.
An analysis of the task demands in the Hillinger (1980) experiment reveals three possible combinations of information that subjects could have used for a post-access comparison strategy. The strategy variation used by subjects probably reflects the selection for comparison of the code or combination of codes that offers the fewest conflicts among the stimuli on the list. Table 1 shows a comparison of the three possible post-access decision strategies subjects could have used in the Hillinger (1980) experiment. Each strategy has the common question: Are both items words? (W?) The orthographic strategy assumes an additional comparison on the dimension of orthographic similarity: Are both items orthographically similar? (O?) The phonological strategy assumes an additional comparison based on phonological similarity: Are both items phonologically similar? (P?) A combined strategy would entail three questions and would probably involve an ordering factor determined by the comparison that yielded the most useful information for decision making, or possibly the order in which the information is available, but in the simplified version presented here, no order is specified. Although none of the simplified strategies presented here predicts the results perfectly, the orthographic comparison strategy probably comes closest to predicting the data most accurately.
**Table 1**

Comparison of Possible Post-Lexical Decision Strategy Outcomes for Hillinger (1980, Experiment 2)

<table>
<thead>
<tr>
<th>DECISION STRATEGY</th>
<th>W?/O?/P?</th>
<th>W?/P?</th>
<th>W?/O?</th>
<th>RT (msec)</th>
<th>Errors (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Pairs (n)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LATE-MATE (10)</td>
<td>+ + +</td>
<td>+ +</td>
<td>+ +</td>
<td>490</td>
<td>2.0</td>
</tr>
<tr>
<td>EIGHT-MATE (10)</td>
<td>+ +</td>
<td>+ +</td>
<td>+</td>
<td>488</td>
<td>1.3</td>
</tr>
<tr>
<td>VEIL-MATE (10)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>527</td>
<td>8.0</td>
</tr>
<tr>
<td>JATE-MATE (10)</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
<td>530</td>
<td>7.3</td>
</tr>
<tr>
<td>BAFF-MATE (10)</td>
<td></td>
<td></td>
<td></td>
<td>538</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Fillers

| GRAPH-BLATE (20)   |          |        |        | 645       | 15.2       |
| COFF-TULD (10)     |          |        |        | 653       | 13.0       |
| HORSE-WORSE (10)   | + +      | +      | + +    | 467       | 3.3        |

Note. A + indicates that the prime word and target match on a given dimension. W? = Are both words? P? = Are both strings phonologically similar? O? = Are both strings orthographically similar?
The strategy notion is further suggested by an informal appraisal of the stimulus lists, which reveals that a number of the dissimilar rhymes (EIGHT-MATE, VEIL-TALE, VEIN-CANE, MAUL-WALL, MAIN-TAME, SIGN-WINE, FOUR-MORE, SEEN-CREAM) are homophonically with words that have the same spelling as the target (ATE, VALE, VANE, MALL, MAME, SINE, FORE, SEAM). If both members of homophone pairs are activated as a result of access, the graphemic match process might benefit from the availability of a graphemically congruous word.

Additionally, a large number of the pronounceable nonwords can be pronounced as words, or are recognizable as words: SATE, SADE, CEAR (sear), BIEF (beef), SIAR (sire or sear), KILE (Kyle), DERK (Dirk), GIES (guys), VOAL (vole), KOOT (coot), CUDE (cued), FONE (phone), BOUR (bower), KIELD (keeled), FOOR (four), COFF (cough). The presence of homophones and pseudohomophones in the lists probably encourages the use of a strategy, just as the presence of pseudohomophonic nonwords influenced the homophone effect under certain strategic conditions in the Davelaar et al. (1978) study.

This post hoc explanation of the data from Experiment 2 is not meant as a general model of strategic processing. It is suggested merely as an example of how the outcome of lexical access might have interacted with the decision process in lexical decision to produce the pattern of reaction times observed. There are probably a number of
variations on this basic idea that could predict the same results.

Experiment 3 was conducted by Hillinger (1980) in order to test whether subjects had engaged in an anticipation strategy based on rhyming in the first two experiments. A control condition, consisting of a string of asterisks (******) and followed by both word and nonword targets, was added to the experimental conditions in order to provide a neutral baseline from which to measure any inhibition or facilitation effects (Neely, 1976). In order to counter the criticism that no word targets were followed by rhyming nonwords in the first two experiments, 10 of the 20 nonwords in the word-nonword filler list (GATE-SAPH) from Experiment 2 were changed to form graphemically and phonologically similar word-nonword pairs (GATE-JATE). However, the rhyming nonword-word condition (JATE-MATE) was dropped. Otherwise the materials were the same as those used in Experiment 2.

Results from Experiment 3 paralleled those from Experiment 2. Once again, there was a reliable rhyming facilitation effect for both LATE-MATE and EIGHT-MATE pairs, measured from the neutral baseline control, and there were no reliable differences in reaction times to nonword targets, although the error rate for GATE-JATE pairs (24.8%) was reliably higher in comparison to the error rates for other pairs. Hillinger (1980) considered these results,
together with the results from the first two experiments, sufficient evidence to discount the encoding bias hypothesis.

In proposing an explanation for the consistent pattern of facilitation obtained for rhyming pairs in the three experiments, Hillinger (1980) noted that the nonrhyming interference effect for COUCH-TOUCH pairs had been shown to depend on the type of nonword distractor used (Shulman et al., 1978), whereas the rhyming effect was obtained regardless of the type of distractor.

It should be noted, however, that although rhyming has not been shown to fluctuate between facilitory and inhibitory effects as does the nonrhyming interference effect, the magnitude of the rhyming effect does vary. Meyer et al. (1975) did not observe reliable rhyming effects in their experiments, although the data were in the right direction, and although the rhyming effects were reliable in the Shulman et al. studies, the magnitude of the effect was diminished when pronounceable nonwords were used as distractors.

Hillinger (1980) further observed that the amount of delay between presentation of the pair members appeared to influence response times to COUCH-TOUCH pairs, but not to rhyming pairs. As evidence, Hillinger stated that nonrhyming interference effects were larger in the studies in which prime-target pairs were displayed simultaneously
Meyer et al., 1974; Shulman et al., 1978), than they were when primes and targets were displayed sequentially (Meyer et al., Experiment 2). When target and prime were separated by a 250-msec delay (Hillinger, Experiment 1), the nonrhyming effects disappeared.

Again, it should be mentioned that the connection with timing of presentation is not as neat as it was portrayed. Although the inhibition effect was attenuated in the Meyer et al. (1975) experiment when stimuli were presented sequentially, it was nonetheless reliable. COUCH-TOUCH pairs (albeit without controls) showed very fast reaction times in Hillinger’s (1980) second and third experiments when presentation was sequential. Therefore, the connection with type of presentation may or may not be a valid one. However, Hillinger’s observations are correct in that reaction times to graphemically similar, phonologically dissimilar word pairs seem to vacillate between inhibition and facilitation, whereas reaction times to graphemically and phonologically similar word pairs always seem to go in the same direction. More needs to be known about graphemically dissimilar rhymes (EIGHT-MATE) before a conclusion about their behavior in various contexts can be made.

Based on these arguments, Hillinger (1980) concluded that rhyming facilitation and nonrhyming interference effects could be dissociated, and that the fluctuating
nonrhyming effects were probably strategic. The stability of the rhyming effects, on the other hand, and the fact that rhyming facilitation was observed in Experiment 3 in the absence of inhibition and under conditions of immediate sequential presentation, gave rise to the possibility that rhyming facilitation in lexical decision was an automatic process, similar to the automatic spreading activation that was assumed to account for semantic priming effects.

Although facilitation was observed in the absence of inhibition effects in Hillinger’s (1980) third experiment, the high error rate for MANE-FANE pairs, which was reliably higher than the error rates for the other nonword-target pairs, should be noted. As Hillinger notes, the reason subjects found this condition more difficult is unclear. One possible source of the difficulty could have been the stimulus items themselves. FANE, for example, is homophonic with the real word FEIGN. Response competition could also account for the high error rate in the MANE-FANE condition. If the subjects were using orthographic and phonological similarity between prime and target as criteria for a decision about whether the target was a word, MANE-FANE pairs would lead them in the direction of a "yes" response, which would be incongruent with the fact that the target was not a word. Regardless of the source, the high error rate for these items weakens an argument for automatic facilitation of the other items.
An additional point of weakness for the automaticity argument is the amount of time subjects had to process the prime items. In Neely's (1976, 1977) experiments, subjects were not required to make decisions about the priming stimuli. This feature of the experiment allowed the stimulus onset asynchrony to be controlled. In the Hillinger experiment, subjects responded to both prime and target, pressing a key marked "nonword" for the ***** primes. Thus, although the onset of the target in the Hillinger experiment followed immediately the offset of the prime, the SOA varied depending on the amount of time the subject took to process and respond to the prime. There is some indication in the literature (Henik, Friedrich, & Kellogg, 1983; Smith, 1979) that the way attention is drawn to the prime can influence the response to the target. For these reasons, the claim of automaticity for phonological priming in these particular lexical decision experiments can be questioned.

Rhyming Primes in Related Lexical Decision Experiments

Although the following experiments did not investigate directly the question of automatic versus controlled or strategic processing for rhyming and nonrhyming targets in primed lexical decision, they did investigate further the effects of phonologically and graphemically similar primes on word and pseudoword targets in lexical decision, and for this reason they are important to this discussion. In a 1985 experiment, Colombo investigated the time course of
semantic and rhyme priming effects using the lexical
decision task with Italian-speaking subjects. In the
experiment, subjects responded only to targets, which were
presented successively after offset of the primes. The
targets of interest were primed as follows (although English
examples are given, all stimuli were in Italian): semantic
associates (CAT-DOG), rhymes (FOG-DOG), rhyming pseudoword
primes (ROG-DOG), and unrelated primes (CHAIR-DOG), with
filler pairs used to balance the number of word and
pseudoword targets in each priming condition. SOA, measured
between onset of the prime and onset of the target, was a
between-subjects variable with four levels: 80, 160, 240,
and 320 msec.

Results of the experiment showed the expected
facilitation for semantically associated pairs compared to
the unrelated control condition, and an unexpected
inhibition effect for rhyming pairs relative to the
unrelated controls. There were no effects of SOA in the
experiment, although there was a tendency for faster
reaction times at the longer SOAs.

In discussing the inhibition found for the rhyming
targets, Colombo (1985) noted that in all the previous
studies (Meyer, Schwaneveldt & Ruddy, 1974; Shulman, Hornak
& Sanders 1978; Hillinger, 1980), subjects were asked to
respond to both prime and target. In Meyer et al. and
Shulman et al., the prime-target pairs were presented
simultaneously, and in the Hillinger study, primes and targets were presented successively. Colombo argued that the additional time spent processing the prime in these experiments could have allowed subjects to engage in search strategies that were under attentional control, thus influencing the outcome for rhyming targets. Colombo found the inhibition for rhyming targets observed in her experiment consistent with McClelland and Rumelhart's (1981; Rumelhart & McClelland 1982) framework, which predicts lateral inhibition for physically similar words as a function of the word recognition process.

In a subsequent series of experiments, Colombo (1986) investigated further the inhibition effect with rhyming targets. In an extension of the 1985 experiment, Colombo (Experiment 1) measured reaction times to both word and pseudoword targets primed by rhyming words, unrelated control words, rhyming pseudowords, and control pseudowords. Reaction times were evaluated at two levels of SOA (240 vs. 640 msec) as a between-subjects factor.

Results of the 1986 experiment showed a reliable rhyming interference effect of 15 msec for word targets (624 msec for rhyming targets, 609 msec for controls) regardless of whether these targets were primed by rhyming words or pseudowords, and a (non-reliable) tendency toward facilitation of 15 msec (695 msec for rhyming targets, 709 msec for controls) for pseudoword targets primed by rhyming
words or pseudowords. The only reliable effect involving the SOA variable was a main effect of SOA, which showed that subjects responded faster at the short (240 msec) SOA. The inhibition effect in this experiment was not as large as that observed in the first experiment, in which word targets preceded by rhyming word primes were 28 msec slower than unrelated controls, and word targets preceded by rhyming pseudoword primes were 35 msec slower than unrelated controls.

In a second experiment, Colombo (1986, Experiment 2) found that when rhyming word targets were blocked for frequency and presented at a 320-msec SOA, frequency interacted with target-prime relationship such that inhibition occurred relative to unrelated controls for high-frequency rhyming targets only (51 msec); low-frequency rhyming targets were facilitated (55 msec). Colombo interpreted this result as consistent with a modified version of the McClelland and Rumelhart (1981; Rumelhart &McClelland) account of word recognition, as well as with Becker’s (Becker, 1979, Becker & Killion, 1977) verification model. In Colombo’s modified version of the McClelland and Rumelhart model, certain conditions, namely very low resting activation levels for the word-level nodes of low-frequency targets, allow these nodes to escape inhibition. Instead, the word-level nodes receive positive feedback from the
letter-level nodes, ultimately resulting in a facilitation effect.

An explanation of the results according to the verification model would place the locus of the effect at the verification stage, in which each member of the candidate set is compared with a representation of the target word, and high-frequency candidates are checked before low-frequency candidates. According to Colombo, if the target is a high-frequency word, it is possible that it will be submitted to the verification stage before the prime. In this case, the target could interfere with the processing of the prime and the result will be inhibition. On the other hand, low-frequency candidates are less likely to be submitted to verification before the primes, and are therefore also less likely to be inhibited during the verification stage. Because of their orthographic similarity to the prime, all rhyming targets enter the candidate set more easily than nonrhyming targets and if they do not get inhibited at the verification stage, they will be facilitated.

Orthographic and Phonological Priming with Unattended Primes

The phonological priming effect in visual word recognition has been investigated by a few other researchers, using techniques that involve priming of target stimuli by unattended primes. Evett and Humphreys (1981, Experiment 2) used the technique of backward masking in a
word identification task to investigate orthographic and phonological priming for word pairs such as BRIBE-TRIBE and COUCH-TOUCH. Interest in the masking techniques and subthreshold presentation for the investigation of automaticity issues has grown since Marcel (1983a; 1983b) demonstrated that subjects have information about the form and the meaning of masked words they are unaware of having experienced.

In Evett et al.'s (1981) experiment, subjects were presented with the following in rapid sequence: pattern mask/lower-case prime/UPPERCASE TARGET/pattern mask, and their task was to write down any word or words they thought they saw on the display. Prior to the experiment, threshold trials determined the appropriate display duration for each subject, and a preliminary semantic priming experiment was conducted to determine that the lexicon could be accessed with the procedure.

Results of the experiment, which involved identity primes (hand-HAND) and their controls; phonological pairs (file-TILE) and their controls (loft-FILE), and graphemic pairs (couch-TOUCH) and their controls (flown-COUCH), showed that recognition performance was best for the identity targets (76.6% correct identifications), and that both phonological (54.9%) and graphemic targets (56.1%) were recognized reliably better than their controls.
The fact that more targets were recognized when primed by a word with a large number of letters in common led to the conclusion that the automatic facilitation effect was graphemic and not phonological. The higher recognition percentage for identity pairs was presumed to be due to additional facilitation from the semantic activation of the identical word. Evett et al. (1981) stressed that their paradigm precluded the effects of subject intention and noted that their failure to obtain phonological priming effects similar to those of Meyer et al. (1974) and Hillinger (1980) could stem from two possible reasons: a) phonological coding may be a strategic option, or b) automatic access to the lexicon may take longer with a phonological code than with a graphemic code, and therefore the masking conditions of the experiment might not have allowed phonemic coding a chance to exert an effect.

In a 1982 paper, Humphreys, Evett, and Taylor added a third possible reason to the list: Primes and targets in the first experiment were not phonologically similar enough. By this they meant that the phonological stimulus pairs in the first experiment differed in their first letter, so that "a complete overlap between the phonological representations of the stimuli" was prevented (p. 577). In four separate experiments, Humphreys et al. used the technique of backward masking that had been used in their previous investigations to determine whether automatic phonological priming effects
could be demonstrated using homophones. The results of the first two experiments confirmed that recognition was reliably better for targets preceded by homophonic word primes (hare-HAIR) than it was for graphemic (harn-HAIR) or unrelated control primes (food-HAIR).

With evidence for automatic phonological priming for homophones established in the first two experiments, Humphreys et al. (1982) investigated the source of the phonological priming effects in Experiments 3 and 4. In Experiment 3, Humphreys et al. compared recognition performance on word targets preceded by identity primes (small-SMALL), pseudohomophone primes (smorl-SMALL), graphemic control primes (smoul-SMALL), and unrelated control primes (thoke-SMALL) to determine whether phonological priming effects could be attributed to a non-lexical grapheme-phoneme conversion process, or whether lexical access was necessary for priming effects to occur.

Results of the experiment showed no reliable facilitation for the pseudohomophonic pairs, which suggested that lexical access might be required for the phonological priming effects to occur. However, because of ambiguity as to whether the pseudohomophone strings were identical to their targets, the results could not be considered conclusive. Therefore, a fourth experiment manipulated the regularity of the target in order to determine whether
lexical access was required to obtain phonological priming effects with homophone pairs in the word recognition task.

The logic of the experiment was as follows: If phonological priming effects occur as the result of lexical processing, there should be no differences in recognition between regular targets and irregular targets (i.e., targets that do not conform to the spelling-sound rules of English), because lexically processed primes always activate the phonology of targets, regardless of the targets' regularity. However, if the effects are the result of a non-lexical grapheme-to-phoneme translation process, facilitation should vary as a function of target regularity. Stimulus types used in the experiment were homophonic exception pairs (e.g., shoot-CHUTE) and their graphemic and unrelated controls (short-CHUTE; trail-CHUTE), and regular pairs (e.g., stair-STARE) and their graphemic and unrelated controls (stark-STARE; quiet-STARE). Because phonological priming effects were observed for both regular and irregular prime-target pairs, Humphreys et al. concluded that phonological information in word recognition is automatically activated via a lexical route.

Underwood and Thwaites (1982) investigated the issue of automaticity of phonological coding using unattended primes in the lexical decision task. Specifically, Underwood and Thwaites investigated the effects of unattended heterographic homophonic primes such as WAIST and WASTE on
an attended target such as RUBBISH that is a semantic associate of one of the primes. Their reasoning was that if phonological coding is automatic (a term they seem to equate initially with the term prelexical), both primes should have an effect on the processing of the target. On the other hand, if the phonological code is not automatically generated, unattended primes such as WAIST should have no influence on the lexical decision times to targets such as RUBBISH. Primes and targets were presented simultaneously, with primes in the right periphery of a screen, preceded and followed by a visual noise mask, and targets in the center, preceded by a fixation dot.

Underwood and Thwaites' (1982) first experiment yielded results that were difficult to interpret. Non-homophonic primes such as TRASH inhibited lexical decision times to associates such as RUBBISH, a finding, according to Underwood et al., that "has been demonstrated in several other studies and indicates the automaticity of lexical access" (p. 438). Further, non-semantically related homophone primes such as WAIST reliably inhibited the processing times of pseudoassociates such as RUBBISH, but the effect was not reliable for homophonic pairs such as WASTE-RUBBISH that were associates.

Inhibition for all three prime-target types was demonstrated, however, in a second experiment in which the pseudoword targets were replaced with pseudohomophones
(e.g., COFF, KREEN, TUTC) in order to discourage subjects from employing a phonological coding strategy when making lexical decisions to attended targets (Davelaar, Coltheart, Besner, & Jonasson, 1978). In view of the fact that other researchers (e.g., Fowler, Wolford, Slade & Tassinary, 1981; McCauley, Parmalee, Sperber & Carr, 1980) had observed facilitation for semantically related targets primed subliminally, Underwood and Thwaites (1982) suggested that the timing of the presentation of target and prime may have some effect on whether the prime influences the encoding of the target, or on whether it exerts its influence postlexically in the decision or output stages of the task. They, like Humphreys and Evett (1982), argued in favor of automatic, preattentive postlexical generation of phonological codes.
CHAPTER III

EXPERIMENT ONE

Two experiments were conducted in order to investigate further the question of the automaticity of priming effects for orthographically and phonologically similar (rhyming) words in the lexical decision task. The experiments were based on results of an experiment conducted by Hillinger (1980), who observed priming facilitation both for orthographically similar (LATE-MATE) and dissimilar (EIGHT-MATE) rhyming target words compared to neutrally primed control pairs (**-MATE) in a lexical-decision task. The facilitation effects occurred in the absence of inhibition for invalid prime-target pairings, thus ruling out anticipation as a possible factor in the priming facilitation. Hillinger's results, interpreted within the Posner and Snyder (1975) two-factor theory of attention, were given as evidence for automatic facilitation of word targets by phonologically related primes.

In the discussion of the Hillinger (1980) paper in Chapter II of this dissertation, it was noted that although the interstimulus interval in Hillinger's third experiment was zero, the stimulus onset asynchrony was variable,
depending on the amount of time the subject took to make a lexical decision to the prime word. Thus, an interpretation in favor of fast-acting automatic processing compared to slower acting, controlled processing for the primed target items could be questioned. In addition to the issue of the amount of time available to process primes is the potential problem that the priming stimulus that directs the subject’s attention to a particular location in memory is confounded with any automatic effects that might accrue from that particular prime-target relationship (Neely, 1977).

Experiment 1 tested whether priming for visually similar rhyming words could be demonstrated using a lexical-decision task that controlled for time and the automatic-effects confounding.

A modified version (Favreau & Segalowitz, 1983) of the primed lexical-decision task employed by Neely (1977) was used in Experiment 1. The task involved manipulation of the subject’s expectancy about the rhyming relationship of orthographically similar prime and target words over two different stimulus onset asynchronies (SOAs): 250 and 1250 msec. These two SOAs were selected because they were representative of the range of SOAs used by other researchers in this task (e.g., Colombo, 1986; Lorch, Balota, & Stamm, 1986; Neely, 1977). In each block of 40 trials there were two possible word primes and their corresponding word or pseudoword targets. In the expect-
rhyme condition, subjects were instructed to expect the targets to rhyme with their respective primes on most trials. If the prime words were TREE and WINE, for example, possible prime-target word pairs would be TREE-FREE or WINE-FINE; in the expect-nonrhyme condition, subjects were told to expect the opposite relationship, namely, TREE-FINE and WINE-FREE. Subjects' expectations about the validity of the word primes were confirmed on 80% of the trials, but on 20% of the trials subjects who were expecting rhymes got surprise nonrhymes and subjects who were expecting nonrhymes got surprise rhymes. Facilitation and inhibition over the two SOAs for each condition were assessed against a neutral priming condition consisting of a row of XXXXXs.

The following predictions for Experiment 1 were based on the two-factor theory of attention (Posner & Snyder, 1975) and the work of Neely (1977):

1. If the priming of orthographically similar rhyming pairs is the product of automatic spreading activation among entries in memory that are related along these dimensions, there should be inhibitionless priming facilitation for targets of rhyming pairs at short (250-msec) SOAs, regardless of subject expectation. That is, facilitation, as measured against the neutral XXXXX condition, should be observed at the 250-msec SOA for expected rhymes in the expect-rhyme condition and for surprise rhymes in the expect-nonrhyme condition.
2. If the priming of orthographically similar rhyming pairs is the product of expectations on the part of the subject, facilitation will be observed at the long (1250-msec) SOA for expected targets in both the expect-nonrhyme and expect-rhyme conditions, and inhibition will be observed for all non-expected targets, i.e., surprise non-rhyming pairs in the expect-rhyme condition and surprise rhyming pairs in the expect-nonrhyme condition.

Method

Subjects

Subjects were 64 undergraduate Psychology 100 students enrolled at The Ohio State University. They received class credit for one hour's participation in the experiment. All were native speakers of English and had normal or corrected-to-normal vision.

Materials

Stimuli were prepared from 13 base lists consisting of 40 prime-target letter-string pairs (see the Appendix for complete stimulus lists). In each list, there were 20 word primes (10 instances each of 2 different prime words, e.g., TREE and WINE) and 20 neutral primes consisting of a string of XXXXXs. The XXXXX trials were used as a baseline from which to measure facilitation and inhibition in the word-prime trials (Posner & Snyder, 1975). Half the word primes and half the XXXXX primes were followed by a word target, and the other half were followed by a pronounceable nonword
(pseudoword) target (James, 1975; Shulman & Davison, 1977; Shulman, Hornak & Sanders, 1978.)

From the base lists, two sets of thirteen stimulus lists were prepared, and these corresponded to the two expectancy conditions in the experiment, expect-rhyme and expect-nonrhyme. List items were constructed such that in the expect-rhyme condition, eight of the ten word targets rhymed with the prime (e.g., four TREE-FREE pairs and four WINE-FINE pairs) and in the expect-nonrhyme condition, eight of the ten word targets did not rhyme with the prime, but they did rhyme with the opposite prime (e.g., four TREE-FINE pairs, four WINE-FREE pairs). Similarly, eight of the ten pseudoword targets either rhymed (condition expect-rhyme) or did not rhyme (condition expect-nonrhyme) with their primes (e.g., TREE-CREE, WINE-SLINE and TREE-SLINE, WINE-CREE).

In addition to the expected targets just mentioned, each list contained four surprise prime-target pairings: two word targets and two pseudoword targets. For example, each list in the expect-rhyme condition contained two unexpected prime/word-target pairs (TREE-FINE, WINE-FREE) and two unexpected prime/pseudoword-target pairs (TREE-SLINE and WINE-CREE); correspondingly, the four surprise prime-target pairs in each list in the expect-nonrhyme condition contained four rhyming pairs. Thus, in each condition, subjects saw expected word- and pseudoword-target items 80% of the time and unexpected target items 20% of the time.
Finally, ten of the 20 targets following the XXXXX primes in each list were words and the other ten were pseudowords. Half of these word and pseudoword targets rhymed with one prime, the other half rhymed with the remaining prime (e.g., XXXXX-FREE, XXXXX-FINE, XXXXX-CREE, XXXXX-SLINE). All prime-target pairs were constructed such that no subject saw the same target twice in an experimental session.

A rhyming dictionary (Whitfield, 1981) was used to generate the necessary sets of single-syllable words of three to six letters in length, and only rhyming words whose rhyming segments were orthographically similar were included on each list. Thus, orthographically dissimilar rhyming pairs such as LATE-EIGHT were excluded from the experiment in order to discourage subjects from adopting a strategy of post-lexical phonological comparison for such strings. However, this exclusion carried with it the disadvantage of confounding the effects of phonology and orthography. Thus, any observed effects cannot be attributed solely to phonological or orthographic similarity.

Because at least 11 orthographically similar rhyming words were needed for each rhyming set, (one prime plus ten targets), it was not possible to control for frequency, although the most common words from each potential set were chosen. Additionally, some of the word items included were heterographic homophones (e.g., WINE is homophonic with
WHINE in most dialects of American English). Only one member of such pairs was used, however, and that member, by definition, had a large number of orthographic neighbors. Decisions about which words to include were based on the Kucera-Francis (1967) norms, and in the case of some low-frequency words, on the judgment of the experimenter. Although nouns were preferred, lists also included other parts of speech.

Pseudowords were derived from each target word by replacing the initial consonant with one, or if necessary, two consonants of similar ranked frequency, as determined by the Underwood and Schulz (1960) count. This requirement reduced the number of possible consonants available for constructing pseudowords. Care was taken to ensure that all substitutions were orthotactically legal, and that no pseudoword, when pronounced, was homophonically with a real word (e.g., TRATE).

In determining which two prime words would be paired in each list, care was taken to match the two primes on approximate length; primes with similar vowel sounds were not used together in a list, e.g., CROP and SOCK.

Following selection of the stimulus words and pairing of the primes to be used in each list, a random procedure was used to determine which targets were paired with a word prime and which were paired with the neutral prime. The random procedure was used twice, once to form pairings for
the expect-rhyme lists and once to form pairings for their corresponding expect-nonrhyme lists. The final result was 25 lists of 40 items, divided as follows: 12 experimental lists in each expectancy condition and a single practice list that was used for both the expect-rhyme and expect-nonrhyme conditions.

The final lists were typed in uppercase letters into a Northstar Computer and displayed in black and white in the center of a Televideo 920 C monitor. Fourteen lists of random numbers from 1-40 were generated, and these were used by the software to provide a random order of items for each subject. The only constraint on the random number lists was that surprise items could not occur during the first four trials of each list. Determination of which random number list would be paired with the stimulus list was made using a separate set of random numbers from 1-14 generated for each subject.

**Design**

A mixed design was used, with expectancy condition (expect-rhyme and expect-nonrhyme), SOA (short, long), prime-target relationship (rhyme-nonrhyme or expected-surprise), and response type (word-pseudoword) as within-subjects factors and the task order (expect-rhyme first, expect-nonrhyme first) a between-subjects factor. The expectancy conditions were presented in blocks. Half the
subjects received the expect-rhyme condition first and the other half received the expect-nonrhyme condition first.

The SOA, prime-target relationship, and response type variables were presented randomly within each list, with the above-mentioned exception that no surprise items occurred before the fourth item in a list. The inclusion of this constraint allowed the subjects at least four trials to engage in the expectation strategy before they encountered an item that violated their expectations. Order of expectancy condition (expect rhyme vs. expect-nonrhyme), lists within rhyming conditions, and assignment of items to short or long SOA was completely counterbalanced across subjects.

Overall, each subject made responses to targets in 12 experimental lists and two practice lists, six in each expectancy condition, and in doing so generated 480 observations. With the exception of the practice list, which was used to introduce both the expect-rhyme and expect-nonrhyme conditions, no list was presented twice to a given subject. The number of observations contributed by a subject to each prime-target pair was as follows: 48 word-word expected, 60 XXXXX-word, 12 word-word surprise, 48 word-pseudoword expected, 60 XXXXX-pseudoword, and 12 word-pseudoword surprise. Half of each of the above responses were in the long SOA condition and the other half in the Short SOA condition. Prior to data analysis, the mean
reaction-time score for all correct responses in each of the resulting 12 experimental conditions was calculated for each subject. These sets of 12 means for each subject were used in the actual data analysis.

**Procedure**

Subjects were tested individually in sessions lasting approximately 50 minutes. At the beginning of the session, subjects received oral instructions from the experimenter. The instructions introduced the subjects to the equipment and the general nature of the task. Subjects were told that they were participating in a word recognition experiment and that their main task was to decide whether the second string in each two-string pair they saw was a real English word. Further, the general instructions emphasized the following:

a) the first part of each display pair in a given list always was either a string of XXXXXs or one of two prime words, presented in the center of the display; b) subjects should attend to the first word in each display, even though they were not required to respond to it directly; c) responses to the second item in each trial should be made by pressing one of two keys indicated on the keyboard—"yes" for a word and "no" for a nonword; d) reaction times were being measured, so subjects should respond as quickly as possible without making too many errors; e) after each trial one of two messages would appear on the screen: "THAT IS CORRECT" or "YOU MADE A MISTAKE"; f) the amount of time
between the onset of the first word and the onset of the second word varied between fast (250 msec SOA) and slow (1250 msec SOA), but subjects were told they would not be able to predict when it would be fast or slow. Because subjects were exposed to both expect-rhyme and expect-nonrhyme conditions within an experimental session, they additionally received expectation instructions particular to the experimental condition they were about to receive.

In the expect-rhyme condition, subjects were told that the word prime-target pairs would rhyme most of the time and that they should use this information to help them predict what the target would be like. In the expect-nonrhyme condition, subjects were told that the word prime-target pairs were related in that the target would usually rhyme with the word prime not shown. Thus, if the word primes were TREE and WINE, subjects could expect that if the prime TREE appeared, the target would rhyme with WINE most of the time; conversely, if the prime WINE appeared, the target would rhyme with TREE most of the time. In both expect-rhyme and expect-nonrhyme conditions, subjects were told that on a small number of trials their expectation about the rhyming relationship would not be met, but that the number of such trials was very small and the occurrence of the surprise trials would not be predictable. Subjects were further reminded that although they should pay attention to
the rhyming relationship, the main task was still to decide whether or not the target was a word.

Following the instructions, and before responding to the six lists of experimental trials in the first block, subjects responded to a practice list of 40 trials. At the end of the first block, subjects were given a short break, and then they received a new set of instructions for changing tasks, followed by another practice list.

Prior to the display of a new list in a given condition, subjects were told the word primes for that list and, depending on condition (expect-rhyme or expect-nonrhyme), they were reminded either to expect a rhyme or to expect the opposites to rhyme.

Release of each trial was controlled from a separate terminal by the experimenter. Speed and accuracy information for each trial was displayed on the experimenter's screen, so that the experimenter could pace the release of each trial.

The first trial began with a verbal READY signal, after which the prime word appeared immediately in the center of the screen. Duration of the prime display was controlled by a timing loop in the computer software program. Short SOA items were displayed for 250 msec and long SOA items for 1250 msec, (plus raster scan time of 0 - 33 msec). Upon offset of the prime, the target appeared in the center of the screen and remained in view until the subject pressed
one of the keys designated as response keys. All "yes" responses were made with the index finger of the subject's right hand; "no" responses were made with the index finger of the left hand.

Results

Before describing the results, there are two points that should be noted. First, the design of the experiment is such that one variable, the relationship between the prime and the subsequent target display, is an attribute of the experimental conditions, but it is not an attribute of the control conditions. That is, because the prime in the control condition is always a row of XXXXXs, there can be no relationship of rhyming or nonrhyming or of expectancy (expected vs. surprise). For that reason, there can be no single, overall analysis of the data that includes both the experimental conditions and the control conditions. Consequently, separate overall analyses were done for these two major conditions. The results will therefore be reported as follows: (a) preliminary analysis of experimental conditions (expected vs. surprise), (b) analysis of expected targets versus controls, and (c) analysis of surprise targets versus controls. Latency results for correct responses will be reported first, followed by error results.

The second point to be noted is that for the experimental conditions, there are two ways the data can be
aligned in the analysis to represent the relationship between the prime and the target. One way is to compare all rhyming responses against all nonrhyming responses, in which case the overall effect of a rhyming or nonrhyming relationship would be apparent in a main effect, and expectancy (whether subjects received an expected or a surprise item) would emerge as an interaction between the type of relationship expected and the type of relationship presented. (See Figure 1.)

Alternatively, the data can be arranged such that the prime-target relationship variable reflects whether the target was expected or not expected (i.e., a surprise item). (See Figure 2.) By this arrangement, an effect of expectancy would appear as a main effect. Although the effects of rhyming and nonrhyming appear in the expectancy analysis in the interaction between what subjects expected and what they got (a surprise or an expected target), these effects are available only as a function of expectancy condition, and thus an analysis of all rhyming responses compared to all nonrhyming responses is not possible in the analysis for expectancy.

In that these two analyses yield overlapping results for a number of possible interactions, with the difference being primarily which effects are revealed in main effects and which are revealed in various interactions, the choice
Figure 1. Structure of the analysis for rhyming in Experiment 1.
Figure 2. Structure of the analysis for expectancy in Experiment 1.
between them was made on the basis of simplicity of report and explanatory power.

**Response Latency Data**

**Preliminary Analysis of Experimental Conditions**

The latency data for correct responses in the analysis of rhyming versus nonrhyming responses are presented in Table 2. For comparison, latency data for the alignment by expectancy are in Table 3. In both analyses, task order (expect-rhyme first or expect-nonrhyme first) was a between-subjects variable, and expectancy condition (expect-rhyme or expect-nonrhyme), SOA (250 msec or 1250 msec), prime-target relationship (rhyming vs. nonrhyming response in the analysis for rhyming; expected vs. surprise response in the analysis for expectancy) and response type (yes—word or no—pseudoword) were within-subjects variables.

Overall, there was no significant main effect of task order in either analysis, $F(1, 62) = 1.71, p > .05$, which indicates that independent of other task variables, it made no difference whether subjects expected a rhyme or a nonrhyme as their first task. In addition, there was no overall effect of expectancy condition, that is, whether subjects expected a rhyme or a nonrhyme, regardless of which was actually presented, $F < 1.00$, and there was no overall effect of SOA, $F < 1.00$. Subjects did respond faster to rhyming targets than to nonrhyming targets, regardless of expectancy, $F(1, 62) = 4.64, p < .05$, and their responses
### Table 2

**Average Response Latencies (in msec) to Rhyming, Nonrhyming, and Neutral Control Targets in Experiment 1. Analysis for Rhyming**

<table>
<thead>
<tr>
<th></th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td><strong>Condition Expect-Rhyme</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Target Relationship</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>800</td>
<td>782</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>814</td>
<td>822</td>
</tr>
<tr>
<td>Control</td>
<td>807</td>
<td>812</td>
</tr>
<tr>
<td><strong>Condition Expect-Nonrhyme</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>812</td>
<td>799</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>784</td>
<td>771</td>
</tr>
<tr>
<td>Control</td>
<td>787</td>
<td>806</td>
</tr>
</tbody>
</table>
Table 2 (continued)

Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)

<table>
<thead>
<tr>
<th>Target Relationship</th>
<th>Condition Expect-Rhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhyne</td>
</tr>
<tr>
<td></td>
<td>Nonrhyme</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
</tr>
</tbody>
</table>

Condition Expect-Nonrhyme

|                     | Rhyne | 819 | 863 | 841 | 973 | 993 | 983 |
|                     | Nonrhyme | 848 | 820 | 834 | 955 | 937 | 946 |
|                     |        |     |     |     | 838 |     | 964 |
|                     | Control | 834 | 854 | 844 | 976 | 949 | 963 |
Table 3
Average Response Latencies (in msec) to Rhyming, Nonrhyming, and Neutral Control Targets in Experiment 1. Analysis for Expectancy

Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)

<table>
<thead>
<tr>
<th>Condition Expect-Rhyme</th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>SOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td>800</td>
<td>782</td>
</tr>
<tr>
<td></td>
<td>814</td>
<td>822</td>
</tr>
<tr>
<td>Control</td>
<td>807</td>
<td>812</td>
</tr>
</tbody>
</table>

Condition Expect-Rhyme

Target Relationship

Expected               784     771  777  883   880  881
Surprise              812     799  806  869   893  882
Control               787     806  797  886   876  881
Table 3 (continued)

Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)

<table>
<thead>
<tr>
<th>Target Relationship</th>
<th>Condition Expect-Rhyme</th>
<th>Condition Expect-Nonrhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected</td>
<td>Surprise</td>
</tr>
<tr>
<td>Expected</td>
<td>824</td>
<td>881</td>
</tr>
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<td></td>
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<td>845</td>
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<td>929</td>
</tr>
</tbody>
</table>
were faster when the target was a word (a yes item) than when it was a pseudoword (a no item), $F(1, 62) = 284.79, p < .001$. In the analysis for expectancy, a main effect of prime-target relationship indicated that subjects responded faster to expected targets than to surprise targets $F(1, 62) = 10.75, p < .01$.

Expectancy condition interacted with rhyming relationship in the analysis for rhyming, $F(1, 62) = 10.75, p < .01$. The pattern of data for this interaction shows that subjects responded faster to both rhyming and nonrhyming targets when they were expected. Subjects who expected rhymes took 46 msec longer to respond to surprise nonrhyme targets than to expected rhymes, and subjects who expected nonrhymes took 18 msec longer to respond to surprise rhyme targets than to expected nonrhymes. These differences in reaction times between expected rhymes and surprise nonrhymes and between expected nonrhymes and surprise rhymes were reiterated in an interaction between expectancy condition and prime-target relationship (expected targets vs. surprise targets) in the analysis for expectancy, $F(1, 62) = 4.65, p < .05$.

The interaction between expectancy and rhyming relationship interacted with SOA in the rhyming analysis, $F(1, 62) = 10.55, p < .01$ (see Figure 3). This interaction appeared as a two-way interaction between SOA and prime-target relationship in the analysis for expectancy, $F(1, 62)$
Figure 3. Mean reaction times as a function of expectancy condition, SOA, and target relationship in Experiment 1, analysis for rhyming.
= 10.56, p < .01, but failed to reach significance in the same analysis as a three-way interaction between expectancy condition, SOA, and prime-target relationship, $F(1, 62) = -0.02, p > .05$. Results of these interactions showed generally that at the long SOA there was facilitation for expected targets and inhibition for surprise targets in both expectancy conditions, but at the short SOA there was no evidence for facilitation or inhibition for expected or surprise targets. Although in the three-way interaction in the analysis for rhyming there appeared to be an effect of inhibition for surprise nonrhyme responses at the short SOA, this effect proved to be unreliable, $F(1, 62) = 2.38, p > .05$.

**Summary.** The relevant reaction-time data from the preliminary analysis of expected versus surprise responses can be summarized by saying that at the short SOA there were no effects of rhyming or expectation. Subjects responded consistently to all targets. On the other hand, at the long SOA, the effects of expectancy became apparent and subjects were faster when the target item was expected.

**Task-order effects.** Although the order in which subjects received each experimental condition did not emerge as a main effect in either the rhyming or expectancy analysis, task order was involved in a number of interactions in the preliminary analysis. In general, the interactions revealed two major points: Subjects were
faster on their second task compared to their first task (an expected outcome of task familiarization), and their responses to surprise targets varied as a function of task order. This second major finding implies that strategies or learning that occurred in the first task in some way carried over to the second task. Because of the apparent strategic carryover effects, the data were re-analyzed, using only the first task for each subject group (expect-rhyme first, expect-nonrhyme first) as a between-subjects variable. The following paragraphs provide for the interested reader a detailed account of the task-order interactions that led to the first-task-only reanalysis. Results of the first-task-only analysis, which provide a clearer, uncontaminated picture of the subjects' actual behavior in the experimental task, begin on p. 134.

In the task-order analysis, an interaction between task order and expectancy condition, $F(1, 62) = 4.19, p < .05$, was observed in both the rhyming and expectancy analyses. The pattern of data, when graphed as a function of the first and second tasks that subjects received, showed that subjects were faster on the second task that they received, indicating a general effect of task familiarization. This effect was revealed as a reliable main effect of task order in a separate analysis in which the task order data for the expect-rhyme and expect-nonrhyme conditions were aligned along the dimensions of first and second task, $F(1, 62) =$
4.19, p < .05. In addition, although it appeared that responses in the expect-nonrhyme condition varied more as a function of task order than did responses in the expect-rhyme condition (64 msec vs. 26 msec), neither of these differences was reliable in post hoc comparison using the Tukey procedure, p > .05.

The interaction between expectancy condition and the order in which the two tasks were presented to subjects interacted with whether the response was yes or no, $F(1, 62) = 7.24, p < .05$. The pattern of data indicated that whereas subjects were faster in their second task compared to their first task for the pseudowords (no items), they were faster in their second task for words (yes items) only when they had completed the expect-rhyme task first. For the subjects who completed the expect-nonrhyme task first, the average reaction time to the second task was actually 7 msec slower than it was to the first task. Separate analyses of the word and pseudoword data showed that the interaction between task order and expectancy was significant for pseudowords, $F(1, 62) = 8.67, p < .01$, but it was not for words.

When the task-order data are plotted as a function of expectancy condition (expecting a rhyme or expecting a nonrhyme), a second interesting effect appears for pseudowords. As shown in Figure 4, task order had little effect (10 msec) on response times to pseudowords in the expect-rhyme condition, but responses to pseudoword targets
in the expect-nonrhyme condition were 82 msec faster when the expect-nonrhyme condition was preceded by the expect-rhyme condition. There were no significant differences in the word data between the two expectancy conditions as a function of task order. This result suggests that responses to pseudowords in the expect-nonrhyme condition were for some reason more prone to task-order effects than were responses to pseudowords in the expect-rhyme condition, and that the task order expect-rhyme followed by expect-nonrhyme yielded the best reaction times in the expect-nonrhyme condition for pseudowords.

In the analysis for rhyming, task order also interacted with whether the target was a word or pseudoword and with rhyming relationship, that is, whether the target rhymed with the prime, $F(1, 62) = 6.01$, $p < .05$. Subjects responded equally fast to rhyming and nonrhyming word targets when they had the task order expect-rhyme followed by expect-nonrhyme. Subjects who had the task order expect-nonrhyme followed by expect-rhyme responded 32 msec slower to nonrhyming word targets than they did to rhyming word targets. A different pattern appeared for the pseudoword data. Subjects were 20 msec slower to respond to nonrhyming pseudoword targets compared to rhyming pseudoword targets when they had the task order expect-rhyme followed by expect-nonrhyme. For both words and pseudowords, the task order expect-rhyme followed by expect-nonrhyme yielded the
Figure 4. Mean reaction times as a function of task order, expectancy condition, and response type in Experiment 1.
fastest reaction times, though the task order variable failed to reach significance as a main effect.

The qualitative effects of the above-mentioned interactions are difficult to interpret meaningfully within the context of the experiment because the rhyme and nonrhyme effects are collapsed over expectancy condition. That is, task order effects are expressed as a function of all nonrhyming and rhyming responses, regardless of whether they were encountered as expected or as surprise targets. For this reason, it is instructive to look at the effects in terms of the analysis for expectancy, in which the task order effects were expressed as a four-way interaction, $F(1, 62) = 6.07, p < .05$, involving the task order, expectancy condition (expect-rhyme, expect-nonrhyme), prime-target relationship (expected, surprise) and response type (word, pseudoword) variables.

The patterns of data for this interaction are shown in Figure 5, and the means for the interaction are shown in Table 4. An examination of the interactions for the word data reveals that although expected targets were responded to faster than surprise targets, and subjects' responses to expected targets were slightly faster on the second task that they received, their responses to surprise targets varied as a function of task order.

For subjects who had the task order expect-rhyme followed by expect-nonrhyme, responses to expected and
Figure 5. Mean reaction time as a function of task order, expectancy condition, target relationship, and response type in Experiment 1, analysis for expectancy.
Table 4

Average Response Latencies (in msec) as a Function of Task Order, Expectancy Condition, Target Relationship, and Response Type in Experiment 1. Analysis for Expectancy

<table>
<thead>
<tr>
<th>Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)</th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Condition Expect-Rhyme</td>
<td>Condition Expect-Nonrhyme</td>
</tr>
<tr>
<td>Target Relationship</td>
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<td></td>
</tr>
<tr>
<td>Expected</td>
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<tr>
<td>Surprise</td>
<td>818</td>
<td>939</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Condition Expect-Nonrhyme</td>
<td></td>
</tr>
<tr>
<td>Expected</td>
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<td>881</td>
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<tr>
<td>Surprise</td>
<td>806</td>
<td>882</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)</th>
<th>Condition Expect-Rhyme</th>
<th>Condition Expect-Nonrhyme</th>
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</thead>
<tbody>
<tr>
<td>Target Relationship</td>
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<td></td>
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<tr>
<td>Expected</td>
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<td>906</td>
</tr>
<tr>
<td>Surprise</td>
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<td>953</td>
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<tr>
<td></td>
<td>Condition Expect-Nonrhyme</td>
<td></td>
</tr>
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<td>Expected</td>
<td>834</td>
<td>946</td>
</tr>
<tr>
<td>Surprise</td>
<td>841</td>
<td>983</td>
</tr>
</tbody>
</table>
surprise targets followed the same pattern in both the expect-rhyme and expect-nonrhyme conditions: Responses to expected nonrhyme targets were 14 msec faster than responses to expected rhyme targets and responses to surprise rhyme targets were 12 msec faster than responses to surprise nonrhyme targets, reflecting a small advantage of practice for the second task. This pattern was not found for the task order expect-nonrhyme followed by expect-rhyme. Whereas responses to expected rhymes (the second task) in the expect-nonrhyme, expect-rhyme task order were 25 msec faster than responses to expected nonrhymes (the first task), responses to surprise nonrhymes in the second task were 39 msec slower than responses to surprise rhymes in the first task.

A comparison of the expect-rhyme conditions for both task orders helps to clarify this effect. When subjects had expect-rhyme as their first task, their responses to surprise nonrhymes were 27 msec slower than their responses to expected rhymes. When subjects had the expect-rhyme condition as their second task, following the expect-nonrhyme condition, the difference between their responses to expected rhymes and surprise nonrhymes was 71 msec. It was as if having learned to expect nonrhymes as the first task increased the surprise value of the surprise nonrhymes in the subsequent expect-rhyme task. A similar effect
occurred for the expect-nonrhyme conditions, though the effect was much less severe.

When subjects had the expect-nonrhyme task as their first task, their responses to surprise rhymes were only 7 msec slower than they were to expected nonrhymes, indicating that surprise rhymes were not very disruptive to subjects who were expecting nonrhymes as their first task. For subjects who had the expect-nonrhyme condition as their second task, following the expect-rhyme task, the reaction-time difference between expected nonrhymes and surprise rhymes was 29 msec.

Task-order interactions were also evident in the pseudoword data. Generally, the pattern showed that subjects in both task orders responded faster to both expected and surprise targets on the second task that they completed. Subjects who had the expect-rhyme task as their first task, however, did not find surprise rhymes in the subsequent expect-nonrhyme task as disruptive as subjects who had the expect-nonrhyme task as their first task. In fact, there was only a 1-msec difference between responses to expected nonrhymes and surprise rhymes for subjects who had the expect-rhyme task first, whereas subjects who had the expect-nonrhyme task as their first task took 37 msec longer to respond to surprise rhymes. Thus, the task-order effects for pseudowords resulted in facilitation (or lack of inhibition) for surprise rhymes when they occurred as part
of the second task. This contrasts with the findings for words, in which task-order effects resulted in a large inhibition effect for surprise nonrhymes when they occurred as part of the second task.

It is also interesting to note the relationship that exists between words and pseudowords within each task order. When expect-rhyme was the first task, subjects' responses to expected and surprise word targets were consistent across experimental conditions (i.e., they appeared as a main effect of experimental task, which translates into a practice advantage for the second task), and the facilitatory effects of having had the rhyming task first were observed in the pseudoword response data. Conversely, when expect-nonrhyme was the first task, the opposite was true. The pseudoword data revealed a main effect of experimental condition (the practice effect), and the word data showed the increased inhibitory effect for surprise nonrhymes when nonrhymes had been practiced as expected items in the previous task.

First-Task-Only Analysis of Experimental Conditions

In view of the apparent strategic carry-over effects from the first task to the second, the expected and surprise data from experiment one were reanalyzed, using only the first task each group of subjects encountered. In this analysis, expectancy condition (expect-rhyme, expect-nonrhyme) was a between-subjects variable, and SOA, prime-
target relationship (rhyming vs. nonrhyming in the analysis for rhyming; expected vs. surprise in the analysis for expectancy), and response type (word vs. pseudoword) were within-subjects variables. Mean reaction times for the first-task-only data are shown in Table 5.

As in the larger task-order analysis, there was a reliable main effect for response type, $F(1, 62) = 183.40, p < .001$, which showed that overall, subjects responded faster to words than they did to pseudowords. Similarly, there was also a main effect for expected responses versus surprise responses in the analysis for expectancy, $F(1, 62) = 10.36, p < .01$, which showed that subjects responded faster to targets when they were expected. In contrast to the results of the task-order analysis for rhyming, however, there was no main effect for rhyming responses versus nonrhyming responses, $F(1, 62) = .51$. Thus, the previously reported advantage for rhyming responses over nonrhyming responses can be attributed to the strategic carry-over effects of task order.

Rhyming did interact with expectancy condition in the analysis for rhyming, $F(1, 62) = 10.36, p < .01$. The pattern of data indicated that for both the expect-rhyme and expect-nonrhyme conditions, subjects responded faster to expected targets than to surprise targets. This result was reiterated in the previously mentioned main effect for expected versus surprise targets in the expectancy analysis.
Table 5

Average Response Latencies (in msec) for the First-Task-Only Data of Experiment 1. Analysis for Rhyming

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th>No (Pseudowords)</th>
<th></th>
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<tr>
<td></td>
<td>SOA</td>
<td>Short</td>
<td>Long</td>
<td>Mean</td>
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<tr>
<td>Condition</td>
<td>Expect-Rhyme</td>
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<tr>
<td>Target Relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>800 782 791</td>
<td></td>
<td></td>
<td>906 890 898</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>814 822 818</td>
<td></td>
<td></td>
<td>909 968 939</td>
</tr>
<tr>
<td></td>
<td>804 919</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>Expect-Nonrhyme</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>819 863 841</td>
<td></td>
<td></td>
<td>973 993 983</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>848 820 834</td>
<td></td>
<td></td>
<td>955 937 946</td>
</tr>
<tr>
<td></td>
<td>838 964</td>
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</tr>
</tbody>
</table>
The interaction also revealed, however, that responses to rhyming targets varied more in magnitude as a function of expectancy condition than did responses to nonrhyming targets. Subjects responded 67 msec faster to rhymes that were expected than to rhymes that were not expected, but the difference between expected and surprise nonrhymes was only 12 msec. Responses to expected rhymes were 45 msec faster than responses to expected nonrhymes. Taken together, these differences seem to indicate that the expect-rhyme task may have been easier than the expect-nonrhyme task. The absence of a main effect for expectancy condition, however, places a limit on this interpretation.

Expectancy condition and prime-target relationship (rhyming vs. nonrhyming) interacted with whether the target was a word or a pseudoword, $F(1, 62) = 4.19, p < .05$. This interaction was expressed in the analysis for expectancy as a two-way interaction between prime-target relationship (expected vs. surprise) and response type (word vs. pseudoword), $F(1, 62) = 4.18, p < .05$. Whereas responses to surprise targets were slower than responses to expected targets for both words and pseudowords, the surprise effect was more pronounced for pseudowords than it was for words. This interaction, taken together with the main effect for response type, indicates that in making their lexical decisions, subjects had more difficulty rejecting pseudowords than accepting words, and although they
generally took longer to respond to any targets that did not meet their expectations, they had more trouble rejecting pseudowords that were also a violation of their expectancy about the kind of target they were to receive.

Expectancy condition and prime-target relationship also interacted with SOA in the rhyming analysis, $F(1,62) = 12.21, p < .01$. This interaction was expressed in the analysis for expectancy as a two-way interaction between prime-target relationship and SOA, $F(1,62) = 12.21, p < .01$. As shown in Figure 6, it made no difference at the short SOA whether the target was an expected item or a surprise, and it made little difference whether the target was a rhyme or a nonrhyme. At the long SOA, however, expected targets, regardless of rhyming status, were responded to faster than surprise targets.

**Summary of first-task-only analysis.** The results of the first-task-only analysis of the two experimental conditions revealed patterns similar to those found in the task-order analysis. There was a clear pattern of facilitation for expected targets and inhibition for surprise targets at the 1250-msec SOA, which suggests that the rhyming facilitation effect is strategically motivated and is not an automatic effect. Although there appeared to be a reaction-time advantage for targets in the expect-rhyme condition, there were no overall differences between the expect-rhyme and expect-nonrhyme conditions, an observation
Figure 6. Mean reaction times as a function of expectancy condition, target relationship, and SOA in the first-task-only analysis for rhyming in Experiment 1.
that lends further credence to the assertion that the facilitation observed at long SOAs in Experiment 1 was strategic.

Cost-Benefit Analysis: Comparisons between Experimental and Control Conditions

Following the preliminary analyses, reaction-time data for the expect and surprise conditions, respectively, were analyzed separately against the reaction-time data for the neutral control conditions. As discussed in the first part of this chapter and in the review of the literature, the XXXXX-primed control condition provides a neutral baseline against which cost and benefit (i.e., facilitation and inhibition) can be measured. The comparisons consisted of two five-factor analyses of variance, with task order as a between-subjects variable and prime-target relationship (expected vs. control or surprise vs. control), expectancy condition (expect-rhyme vs. expect-nonrhyme), SOA, and response type (word vs. pseudoword) as within-subjects variables.

Expected conditions versus controls. In the analysis of expected responses versus neutral controls there were main effects of prime-target relationship, $F(1, 62) = 14.66$, $p < .001$, and response type, $F(1, 62) = 317.45$, $p < .001$. These main effects indicated that overall, subjects responded faster to expected targets than to controls, and they responded faster to words than to pseudowords.
As in the preliminary analyses, task order interacted with expectancy condition, $F(1, 62) = 9.35, p < .01$, revealing the benefit of practice on reaction times in the subjects' second task. Because of the task order effects, a separate analysis of variance was conducted on the data from the subjects' first task only, and these results will be reported along with the remaining results from the overall analysis.

In the overall analysis of response times to expected targets versus controls, prime-target relationship interacted with SOA, $F(1, 62) = 7.56, p < .01$. Responses to expected targets were faster than responses to neutral controls at the long SOA, but not at the short SOA. Further, there was only a 1-msec difference in responses to controls at the long SOA compared to the short SOA, and a 17-msec difference in responses to expected targets as a function of SOA. This indicated that responses to controls were fairly stable over SOA, and there was a clear facilitation pattern for expected responses at the long SOA. Although the interaction was not reliable in the first-task only analysis, $F(1, 62) = 3.24, p > .05$, the pattern of data was the same.

In both task-order and first-task-only analyses, the prime-target relationship and SOA variables also interacted with the response type variable, $F(1, 62) = 15.73, p < .001$ (task-order analysis), and $F(1, 62) = 5.02, p < .05$, (first-
task-only analysis). The pattern of data in both analyses showed that the previously mentioned effect of expectancy at the long SOA held for the word data, but not for the pseudoword data. Figure 7 shows the interaction from the first-task-only analysis.

Surprise conditions versus controls. In the analysis of surprise responses versus the neutral controls, there were main effects of prime-target relationship, $F(1, 62) = 4.38, p < .05$, and of response type, $F(1, 62) = 323.81, p < .001$. These results indicated that overall, responses to surprise targets were slower than control responses and responses to word targets were faster than responses to pseudoword targets. The main effect of response type was also present when the data from the subjects' first task only were analyzed, $F(1, 62) = 201.09, p < .001$, but the main effect of prime-target relationship was not, $F(1, 62) = 2.51$.

The task-order variable interacted with the expectancy condition and response type variables, $F(1, 62) = 10.00, p < .05$. Similar to the task-order interaction observed in the analysis of expected responses versus controls, this interaction indicated that subjects were faster on their second task when the target was a pseudoword or when the target was a word in the task order expect-rhyme followed by expect-nonrhyme. The pattern was different, however, for responses to words for subjects who had the task order
Figure 7. Mean reaction times as a function of prime-target relationship, SOA, and response type in Experiment 1, expected targets versus controls, first-task-only analysis.
expect-nonrhyme followed by expect-rhyme. When subjects had this task order, they were slower to respond to targets in their second task compared to their first. This result can be attributed to the disruptive effect of having learned the more difficult expect-nonrhyme task first. After having learned to expect nonrhyming targets in their first task, subjects had difficulty when nonrhymes were encountered as surprise items in their second task. There was no interaction between expectancy condition and response type when the first-task-only data were analyzed, $F(1, 62) = 0.40$.

The prime-target relationship variable (surprise versus control) interacted with SOA and response type in the task-order analysis, $F(1, 62) = 6.78$, $p < .05$, and with SOA in the first-task-only analysis, $F(1, 62) = 5.79$, $p < .05$. The pattern for the task-order analysis, shown in Figure 8, revealed that subjects' responses to surprise pseudoword targets were inhibited (43 msec) relative to neutrally primed pseudoword targets at the long SOA, but the same was not true for responses to word targets. There was no inhibition effect for surprise word targets relative to neutral controls, and there appeared to be a slight tendency for slower reaction times to both surprise word targets and controls at the long SOA, compared with the short SOA.

When the marginal means for expected and surprise response times (collapsed over expectancy condition) from
Figure 8. Mean reaction times as a function of prime-target relationship, SOA, and response type in Experiment 1, surprise targets versus controls, task-order analysis.
the first-task-only analysis are plotted together with the
response times from the neutral controls, an interesting
pattern in the control responses becomes apparent (see
Figure 9). When the target was a word, the pattern of data
was facilitation dominant for expected targets. Neutral
controls and surprise targets appeared to be processed in a
similar way by subjects: Both tended to be weakly inhibited
at the long SOA. When targets were pseudowords, however,
the pattern shifted: Subjects responded to the neutral
controls and expected pseudoword targets in the same way,
resulting in a pattern of weak facilitation for these
targets, whereas surprise pseudowords were strongly
inhibited. The fact that subjects' responses to the neutral
controls mirrored their responses to expected or surprise
targets depending on whether the target was a word or a
pseudoword casts some doubt about the effectiveness of the
XXXXX primes as truly neutral controls and it seems to
suggest strategic processing in the decision stage of the
task.

The validity of the XXXXX-prime condition as a truly
neutral control has been questioned by other researchers.
Jonides and Mack (1984) have contended that because the
XXXXX-prime condition is repeated over a number of trials,
it can therefore be processed more rapidly than a word prime
by subjects. The difference in time to encode the stimulus
could lead to longer reaction times to targets primed by
Figure 9. Mean reaction times as a function of prime-target relationship, SOA, and response type in Experiment 1, first-task-only analysis.
words because subjects are still processing the word primes when they encounter the targets. The end result would be that the XXXXX prime underestimates the facilitation effect. Although this may be an important consideration in general lexical decision paradigms, underestimation of facilitation for targets primed by words in Experiment 1 should have been reduced by the fact that there were only two possible word primes repeated within each list, and these were told to the subjects at the beginning of each list.

Error Data

Error data for Experiment 1, expressed as the proportion of errors for each condition for each subject, are shown in Table 6. These data were analyzed in a series of analyses of variance that paralleled those conducted on the reaction time data. Cell means from the reaction-time and error analyses were then correlated using the Pearson formula. Overall, reaction times and errors for all experimental conditions were weakly negatively correlated, \( r = -.114, (N = 48) \). Separate correlations of reaction-time and error data for words and pseudowords yielded a weak positive correlation for words (\( r = .145, N = 24 \)) and a positive correlation for pseudowords (\( r = .454, N = 24 \)).

Results of the overall analysis of variance on errors for the expected versus surprise conditions revealed a main effect of expectancy condition, \( F(1, 62) = 6.67, p < .05 \), which indicated that overall, subjects made more errors in
Table 6
Proportion of Errors in Responses to Rhyming, Nonrhyming, and Neutral Control Targets in Experiment 1, Analysis for Rhyming

<table>
<thead>
<tr>
<th>Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)</th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition Expect-Rhyme</td>
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<tr>
<td>Target Relationship</td>
<td>Short</td>
<td>Long</td>
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<td>Rhyme</td>
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<td>.077</td>
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<tr>
<td>Nonrhyme</td>
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<td>.110</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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Table 6 (continued)

Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)

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</tbody>
</table>
The expectancy condition variable also interacted with the task order variable, $F(1, 62) = 19.78, p < .001$. The pattern of data for this interaction paralleled that of the reaction-time data in showing that in addition to a reduction in response times on the second task that they completed, subjects also made fewer errors in the second task. The accuracy advantage for the second task was verified as a reliable main effect of task order (first task vs. second task) in a separate analysis of variance, $F(1, 62) = 19.78, p < .001$. In addition, the interaction also showed that the reduction in errors from the first task to the second was greatest for subjects who had the expect-rhyme task first.

The expectancy and task order variables also interacted with the SOA and response type variables in a reliable four-way interaction, $F(1, 62) = 4.63, p < .05$. Because of the involvement of task order and the difficulty of interpreting a four-way interaction, no attempt was made to interpret this interaction. Instead, the error data for the first task only for each group of subjects was analyzed separately in order to remove the effects of task order.

**First-Task-Only Analysis of Errors**

The first-task-only analysis on the error data revealed two interactions. The first interaction, between expectancy
condition and response type $F(1, 62) = 5.25, p < .05$, showed that although subjects made a higher proportion of errors on words in the expect-rhyme condition than in the expect-nonrhyme condition (.097 versus .066), the reverse was true for pseudowords: Subjects made a higher proportion of errors to pseudowords in the expect-nonrhyme condition than they did in the expect-rhyme condition (.077 versus .086).

The reason for the differences in error rate is unclear, although a comparison of the error data for this interaction with the reaction time data at the corresponding level indicates that a speed-accuracy tradeoff may have been in effect for the pseudowords across expectancy conditions. (See Table 7.)

The second interaction, involving the SOA and response type variables $F(1, 62) = 5.99, p < .05$, indicated that whereas subjects made more errors on word targets at the long SOA compared to the short SOA (.086 at the long SOA versus .077 at the short SOA), the reverse was true for pseudoword targets. Accuracy for pseudoword targets increased as a function of SOA (.099 at the short SOA versus .064 at the long SOA). An examination of the error and reaction time data for this interaction, shown in Table 8, reveals a pattern suggestive of speed-accuracy tradeoff for pseudowords over levels of SOA. When subjects had little time between target and prime, their responses to pseudowords tended to be faster and less accurate in
Table 7

Average Response Latencies (in msec) and Proportion of Errors as a Function of Expectancy Condition and Response Type in Experiment 1. Analysis for Rhyming.

<table>
<thead>
<tr>
<th>Expectancy Condition</th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Errors</td>
</tr>
<tr>
<td>Expect-Rhyme</td>
<td>804</td>
<td>.097</td>
</tr>
<tr>
<td>Expect-Nonrhyme</td>
<td>838</td>
<td>.066</td>
</tr>
</tbody>
</table>
Table 8

Average Response Latencies (in msec) and Proportion of Errors as a Function of SOA and Response Type in Experiment 1, First Task Only. Analysis for Rhyming.

<table>
<thead>
<tr>
<th>SOA</th>
<th>Yes (Words)</th>
<th>No (Pseudowords)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Errors</td>
</tr>
<tr>
<td>250 msec</td>
<td>820</td>
<td>0.077</td>
</tr>
<tr>
<td>1250 msec</td>
<td>822</td>
<td>0.086</td>
</tr>
</tbody>
</table>
comparison to when they had more time between target and prime. With 1250 msec between presentation of prime and target, subjects responded more slowly and accurately to pseudoword targets.

Summary and Discussion

Although the analyses of Experiment 1 were complicated by task order effects and by the possibility that the XXXXX-primed control conditions may not have provided a truly neutral control baseline, the basic results can be summarized as they relate to the predictions of the model on which the experiment was based.

In the analysis of responses to expected targets versus controls, there was no evidence for automatic facilitation for rhyming word targets at the short SOA. This analysis yielded no significant interactions that differentiated between expected rhymes and expected nonrhymes or between surprise rhymes and surprise nonrhymes at the short SOA, although the individual cell means did show small amounts of facilitation for expected rhymes (7 msec) and surprise rhymes (15 msec) relative to their XXXXX-primed controls.

The same analysis also yielded the predicted effect of facilitation (32 msec) for all expected word targets at the long SOA, regardless of whether they rhymed with primes. The expected inhibition effect for surprise targets at the long SOA was not observed in the word data, however, although the pattern of data indicated that responses to
surprise word targets were slightly slower than they were to controls. The failure to observe a reliable inhibition effect relative to the neutral control may not be unusual (e.g., Becker, 1980; Martin & Jensen, 1988).

Becker (1980) demonstrated with semantically related targets that if subjects generate a candidate set as part of a strategy, the size of the candidate set can have an influence on whether inhibition is observed in paradigms such as the one used by Neely (1976). When the candidate set generated by subjects is large, inhibition effects for unrelated targets are observed because of the extra time it takes to search the set.

Becker’s account of inhibition is plausible within the framework of Experiment 1. Subjects in the expect-rhyme condition, for example, were told explicitly that targets would rhyme with each of two primes, which were announced at the beginning of each list. With this information, subjects could have generated or selectively activated candidate sets of rhyming words. The candidate sets in this experiment were undoubtedly larger than those in Becker’s experiment (antonyms of targets), however, there were only two possible sets per list and these were consistent over a number of trials until the next set of primes was announced. Because unexpected word targets always belonged to the opposite candidate set, the subject’s search would be constrained to the opposite set, making the subject’s search task...
functionally equivalent to the search of the two candidate
sets required in the neutrally primed condition, and that
would explain why no inhibition was observed for word
targets relative to controls at the long SOA.

Therefore, although the expected effect of inhibition
was not observed at the long SOA, the facilitatory effect of
expectancy at the long SOA demonstrates that subjects did
generate the expectation strategy, and given sufficient
time, were able to use their expectancies to facilitate
their responses without inhibiting non-targets.

The results of Experiment 1 do not support Hillinger's
(1980) claim of automatic facilitation along the
phonological dimension. These findings are strengthened by
recent work by Martin and Jensen (1988), who, in a series of
five experiments also failed to find evidence in support of
automatic facilitation for graphemically similar and
dissimilar rhyming targets when factors were controlled for
such as amount of processing time, whether or not subjects
responded to primes, and whether or not the rhyming word
belonged to a common spelling-sound group or to an uncommon
one. Using Hillinger's stimulus materials, Martin and
Jensen were also unable to replicate the results of the 1980
experiment. Over the five experiments they conducted,
however, the general facilitation pattern for rhyming
targets was positive, but of small magnitude.
With the original Millinger (1980) results called into question, the only other lexical-decision studies in which reliable rhyming facilitation has been reported have been Shulman et al. (1978), and Colombo (1986, Experiment 2). As discussed in the review of the literature, the magnitude of the rhyming facilitation effect first observed by Meyer, Schvaneveldt, and Ruddy (1974), was not statistically reliable. The rhyming facilitation effect in the Shulman et al. study, observed in the presence of both pseudoword and nonpronounceable nonword distractors, can be explained on the basis of the presentation conditions. Primes and targets were presented simultaneously and subjects made lexical decisions to both, and thus the visual similarity between target and prime could have been influential in producing the priming effect.

The results of the Colombo (1986, Experiment 2) experiment are not so easily explained. (See p. 90 for a more detailed account of Colombo's experiments.) Colombo, using Italian subjects and stimulus lists, observed inhibition for high-frequency rhyming targets at 320 msec SOA and facilitation for low-frequency rhyming targets. This result was partially replicated using English stimulus materials by Lupker and Williams (1987), who observed only the inhibition effect for high frequency rhyming targets; low-frequency targets were not facilitated. These contradictory findings, along with those of Martin et al.
(1988), cast doubt about the robustness of the rhyme priming effect, and argue for placing it in a class with the COUCH-TOUCH effect—elusive and subject to task variables, and thus a strategic option available to the subject. The results of Experiment 1 confirm that subjects can use rhyming information strategically, and although they suggest that expecting rhyme targets may be a little easier (though not significantly so) than expecting targets to rhyme with the opposite prime, there was no evidence to support automatic activation along a phonological network during the visual word recognition task that was presented.

The task order effects for word targets observed in Experiment 1 did, however, reveal some interesting differences between rhyming and nonrhyming targets and about how learning that takes place in the first task can affect the second task. Experience with repeated, expected rhymes as targets in the first task seems not to affect their surprise value very much (and may actually attenuate it) when they are encountered as surprise items in a subsequent task in which subjects are instructed to expect targets to rhyme with the opposite prime. Conversely, experience with repeated cross-pairings of prime and rhyme-target pairs (the expect-nonrhyme condition) increases the surprise value of surprise nonrhymes when they are encountered in a list of expected rhymes.
One possible explanation for these differences in the pattern of responding to surprise rhyming targets and nonrhyming targets is that the expect-nonrhyme task was more difficult to learn or execute than the expect-rhyme task. Intuitively, expecting a rhyme is easier (at least it involves fewer steps) and more natural than shifting attention to a second prime in memory and expecting the target to rhyme with the second prime.

When subjects learned the expect-nonrhyme task first, they had to devote attention both to learning the task in general as well as to the difficult aspects of learning, in effect, two new rhyme patterns for each list they saw (e.g., that TREE and FINE go together and WINE and SEE go together). Perhaps the added attention given to the new pattern (expecting mismatches on the rhyming dimension) caused subjects to overlearn or to be more aware of the opposites-rhyme expectancy pattern.

Rhyming patterns, on the other hand, are encountered frequently in daily life, and are more practiced and accepted as natural in comparison to the opposites-rhyme pattern. Because rhymes "slide by" attention more easily, they are less likely than the nonrhymes (cross-rhymes) to cause interference from having been practiced in the previous list. In one sense, one could argue that the rhyme pattern is more automatic than the nonrhyme pattern,
however, the claim would not be substantiated within the framework that formed the basis of this experiment.

The enhanced inhibition effect for surprise nonrhymes in the second task could also be attributed to the carryover of strategies from the first task to the second. Becker (1980) demonstrated that whether subjects received an antonym priming task first or a category superordinate-subordinate priming task first affected the pattern of facilitation and inhibition on the subsequent list. He hypothesized that the two different types of list encouraged different strategies based on the size of the candidate set the subject had to search. In the case of antonyms, subjects engage in a specific prediction strategy, which leads to a pattern of facilitation dominance for expected targets. In the case of categories, subjects engage in a more generalized expectancy strategy, which leads to a pattern of inhibition dominance for unexpected targets. Results of his experiments confirmed that the strategy subjects engaged in in the first task affected the pattern of performance in the second task.

Experiment 1 is different from Becker's (1980) experiments in at least one significant way. Unexpected items in Becker's second task were not item types that had been practiced in the first list. The general principle of strategic carry over, however, may also have played a role in the results of Experiment 1.
Experiment 2 was conducted to explore the time course of the rhyme priming effect. Although Experiment 1 failed to find evidence for automatic facilitation for rhyming targets at the short (250 msec) SOA, the task-order analysis did reveal a tendency for surprise nonrhyme targets to be inhibited when they were encountered as part of the subjects' second task, i.e., after they had been the expected targets in the first set of lists. Because this inhibition was generalized over both levels of SOA, it could be concluded within the Posner and Snyder (1975) framework that strategic processing was occurring even at the short SOA of Experiment 1, although this explanation does not seem likely in view of the work of Neely (1977) and others who have used this paradigm to demonstrate automaticity effects in semantic priming.

An alternative explanation of the results could be that the consistent mapping of the opposite-rhyme pattern in the first task caused the pattern to become temporarily "automatic" through perceptual learning. The only problem with this explanation is the fact that the consistent
mapping caused inhibition for surprise nonrhymes and no inhibition, perhaps even facilitation, for surprise rhyming words in the second task. It is possible that the SOAs chosen in Experiment 1 were adequate to demonstrate automatic priming effects for semantically related targets as in Neely's experiments, but inadequate to demonstrate priming for orthographically similar rhyming targets, because the time courses for the two priming effects are different.

Experiment 2 was conducted to determine whether the rhyme priming or the rhyming inhibition effect observed by Colombo (1985, 1986) could be observed at very short SOAs, 75 and 100 msec, where the probability of strategic processing is more remote than at the 250 msec SOA. Because Experiment 2 was exploratory in nature, no specific predictions about response patterns were made, although the framework of Experiment 1 suggests that if the time course of the rhyme priming effect is earlier than that of the semantic priming effect, automatic facilitation of rhyming targets will be observed as inhibitionless facilitation at one of the short SOAs, or as an overall main effect for rhyming. It was expected that there would be no inhibition effects as products of conscious strategic processing at either of the short SOAs in Experiment 2.
Method

Subjects

An additional 32 undergraduate subjects from the subject pool described in Experiment 1 were given one hour's class credit for their participation. All were native speakers of English with normal or corrected-to-normal vision.

Materials

Materials were the same as those described for Experiment 1.

Design

The design of Experiment 2 was identical to the design of Experiment 1.

Procedure

The procedure was the same as that described for Experiment 1, except that the SOAs were changed from 250 and 1250 msec to 75 and 100 msec, respectively, for the short and long values. This manipulation reduced the total length of the experiment from 50 minutes to about 35 minutes.

Data Analysis

The reaction-time data and error data were analyzed as in Experiment 1.
Results

Response Latency Data

Preliminary Analysis of Experimental Conditions

Mean response latencies for all task orders of Experiment 2 are presented in Table 9. The task-order analysis of expected versus surprise targets (data aligned for rhyming) revealed a main effect of response type, \( F(1, 30) = 75.95, \ p < .001 \), with responses to word targets faster than responses to pseudoword targets. There was no main effect for rhyming (target relationship), nor was there a main effect of task order, although a four-way interaction between the task-order, expectancy condition, prime-target relationship, and response type variables approached significance, \( F(1, 30) = 3.53, \ p > .05 \).

The only other reliable effect from this preliminary analysis was an interaction between expectancy condition and prime-target relationship, \( F(1, 30) = 9.01, \ p < .01 \). This interaction, shown in Figure 10, appeared as a main effect of target relationship in the analysis for expectancy, \( F(1, 30) = 9.01, \ p < .01 \), indicating that responses to expected targets were faster than responses to surprise targets. Further analyses of the expectancy condition \times \ target relationship interaction at each level of the expectancy condition variable in the rhyming analysis revealed that the 35 msec difference between expected rhymes and surprise nonrhymes was reliable, \( F(1, 30) = 6.97, \ p < .05 \), but that
Table 9

Average Response Latencies (in msec) to Rhyming, Nonrhyming, and Neutral Control Targets in Experiment 2. Analysis for Rhyming

Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Expect-Rhyme</th>
<th>Expect-Nonrhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Relationship</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>801</td>
<td>784</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>822</td>
<td>832</td>
</tr>
<tr>
<td>Control</td>
<td>791</td>
<td>781</td>
</tr>
</tbody>
</table>

Condition Expect-Nonrhyme

<table>
<thead>
<tr>
<th>Condition</th>
<th>Expect-Rhyme</th>
<th>Expect-Nonrhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Relationship</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>836</td>
<td>804</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>802</td>
<td>789</td>
</tr>
<tr>
<td>Control</td>
<td>806</td>
<td>774</td>
</tr>
</tbody>
</table>
Table 9 (continued)

Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)

<table>
<thead>
<tr>
<th>Target Relationship</th>
<th>Condition Expect-Rhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhyne</td>
</tr>
<tr>
<td></td>
<td>833  811  822  872  861  866</td>
</tr>
<tr>
<td></td>
<td>829</td>
</tr>
<tr>
<td>Control</td>
<td>806  778  792  858  843  850</td>
</tr>
</tbody>
</table>

Condition Expect-Nonrhyme

|                     | Rhyne                  | Nonrhyme               |
|---------------------|------------------------|
|                     | 819  821  820  892  918  903 | 836  822  829  903  894  898 |
|                     | 824                                |
| Control             | 806  800  803  888  869  878            |
Figure 10. Mean reaction time to rhyming and nonrhyming targets as a function of expectancy condition in Experiment 2, task-order analysis, data aligned for rhyming.
the 13 msec difference between expected nonrhymes and surprise rhymes was not, $F(1, 30) = 2.33, p > .05$.

**Cost-Benefit Analysis: Comparisons between Experimental and Control Conditions**

**Expected conditions versus controls.** Following the data analysis plan of Experiment 1, a comparison of expected responses to control responses was conducted. This analysis yielded main effects of response type, $F(1, 30) = 91.84, p < .001$, SOA, $F(1, 30) = 20.29, p < .01$, and of prime-target relationship (expected versus control), $F(1, 30) = 13.44, p < .01$. Subjects responded faster to words than to pseudowords, their responses to all targets were faster at the 100-msec SOA, and, surprisingly, responses to XXXX-primed control targets were 16 msec faster than they were to expected targets primed by words.

The analysis also resulted in an interaction between task order, expectancy condition, and response type, $F(1, 30) = 4.91, p < .05$. Subjects were generally faster on the second task that they completed, but the effect was most prominent for pseudoword targets. The practice effect was less pronounced for words when expect-nonrhyme was the first task, and performance was actually 3 msec slower for targets in the second task when the expect-rhyme task was first.

Because of the task-order effects, the first-task-only data were also analyzed. The main effects of response type, SOA, and prime-target relationship were also observed in
this analysis. Responses to words were faster than responses to pseudowords, $F(1, 30) = 4.91, p < .05$, responses to all targets at the 100-msec SOA were 12 msec faster than they were at the 75-msec SOA, $F(1, 30) = 5.74, p < .05$, and responses to XXXXX-primed controls were 12 msec faster than responses to expected targets.

One possible explanation for the faster responses to the XXXXX-primed targets compared to expected targets is that at the shorter SOAs in Experiment 2, subjects are unable to use the word primes strategically to facilitate processing. Instead, the word primes slow down the lexical decision to the target by requiring more processing time than the repeated XXXXX-primes, which are more easily ignored, and which may therefore serve as an additional alerting stimulus. When the target appears, subjects may still be processing the word primes and this would result in a cost in reaction time to the subsequent targets. Jonides and Mack (1984) have given similar arguments against the use of supposedly neutral control primes such as XXXXX, claiming that because they may require less processing than targets, the neutral primes may actually underestimate facilitation effects (and therefore also overestimate inhibition effects).

**Surprise conditions versus controls.** The analysis of surprise targets versus controls revealed that subjects responded faster to words than to pseudowords, $F(1, 30) =$
171

74.30, \( p < .001 \), and they responded 40 msec faster to control targets than they did to surprise targets. Both the main effect for response type, \( F(1, 30) = 54.49, p < .001 \), and the apparent inhibition effect for surprise targets, \( F(1, 30) = 6.81, p < .05 \), were observed also in the first-task-only analysis. In the first-task only analysis, responses to surprise targets were 25 msec slower than responses to controls.

Summary. In summary, all the analyses of the reaction time data in Experiment 2 revealed a consistent advantage for responses to words over pseudowords. When expected targets were compared against controls, responses to supposedly neutral controls were faster than responses to expected targets, and both controls and expected targets were responded to faster at the 100-msec SOA. When surprise targets were compared to the XXXXX-controls, the controls were again responded to faster than the surprise targets. When the expected targets were compared to the surprise targets, in the absence of the control data, surprise nonrhymes were inhibited relative to expected rhymes.

Error Data

Error data for Experiment 2 are given in Table 10. Preliminary analysis of the error data for Experiment 2 indicated that overall, reaction times and errors were negatively correlated, although the correlation was slight, \( r (n = 48) = -.069 \). There was also a minimal negative
Table 10  
Proportion of Errors in Responses to Rhyming, Nonrhyming, and Neutral Control Targets in Experiment 2, Analysis for Rhyming

Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)

<table>
<thead>
<tr>
<th>SOA</th>
<th>Short</th>
<th>Long</th>
<th>Mean</th>
<th>Short</th>
<th>Long</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Condition Expect-Rhyme</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>0.088</td>
<td>0.086</td>
<td>0.087</td>
<td>0.084</td>
<td>0.064</td>
<td>0.074</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>0.043</td>
<td>0.148</td>
<td>0.095</td>
<td>0.116</td>
<td>0.053</td>
<td>0.084</td>
</tr>
<tr>
<td>Control</td>
<td>0.057</td>
<td>0.053</td>
<td>0.055</td>
<td>0.088</td>
<td>0.054</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Condition Expect-Nonrhyme</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhyme</td>
<td>0.053</td>
<td>0.074</td>
<td>0.063</td>
<td>0.021</td>
<td>0.043</td>
<td>0.032</td>
</tr>
<tr>
<td>Nonrhyme</td>
<td>0.054</td>
<td>0.054</td>
<td>0.054</td>
<td>0.057</td>
<td>0.056</td>
<td>0.057</td>
</tr>
<tr>
<td>Control</td>
<td>0.087</td>
<td>0.101</td>
<td>0.094</td>
<td>0.038</td>
<td>0.039</td>
<td>0.038</td>
</tr>
</tbody>
</table>
### Table 10 (continued)

**Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)**

<table>
<thead>
<tr>
<th>Target Relationship</th>
<th>Condition Expect-Rhyme</th>
<th>Condition Expect-Nonrhyme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhyme</td>
<td>Nonrhyme</td>
</tr>
<tr>
<td>0.070</td>
<td>0.062</td>
<td></td>
</tr>
<tr>
<td>0.109</td>
<td>0.076</td>
<td></td>
</tr>
<tr>
<td>0.089</td>
<td>0.069</td>
<td></td>
</tr>
<tr>
<td>0.048</td>
<td>0.048</td>
<td></td>
</tr>
<tr>
<td>0.063</td>
<td>0.052</td>
<td></td>
</tr>
<tr>
<td>0.055</td>
<td>0.050</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.104</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>0.032</td>
<td>0.058</td>
<td></td>
</tr>
<tr>
<td>0.068</td>
<td>0.058</td>
<td></td>
</tr>
<tr>
<td>0.136</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>0.116</td>
<td>0.049</td>
<td></td>
</tr>
<tr>
<td>0.126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.051</td>
<td>0.058</td>
<td></td>
</tr>
<tr>
<td>0.046</td>
<td>0.048</td>
<td></td>
</tr>
<tr>
<td>0.048</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>0.060</td>
<td>0.068</td>
<td></td>
</tr>
<tr>
<td>0.077</td>
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<td></td>
</tr>
<tr>
<td>0.037</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.074</td>
<td>0.088</td>
<td></td>
</tr>
<tr>
<td>0.081</td>
<td>0.070</td>
<td></td>
</tr>
<tr>
<td>0.074</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>0.072</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
correlation between reaction times and errors in the word data, \( r (n = 24) = -0.128 \), but for pseudowords the correlation was positive, \( r (n = 24) = 0.253 \).

**Analysis of Errors in Experimental Conditions**

The analysis of errors in the expected conditions versus surprise conditions yielded no reliable main effects. Task order was involved in two two-way interactions, with expectancy condition, \( F(1, 30) = 17.36, p < .001 \), and with target relationship, \( F(1, 30) = 10.90, p < .01 \). Task order also entered into a three-way interaction with expectancy condition and response type, \( F(1, 30) = 6.82 \), and a four-way interaction with expectancy condition, SOA, and prime-target relationship, \( F(1, 30) = 5.64, p < .05 \), (data aligned for rhyming).

**Task-order effects.** The four interactions, like the task-order interactions of the reaction-time analysis, appeared to stem generally from two primary sources: effects of task familiarity, in which subjects made fewer errors in their second task, and effects that implied that having experienced the first task changed the way subjects responded to targets in the second task. In the interest of clarity and brevity, the task-order interactions will not be discussed in their entirety or in great detail, but rather the general patterns of the most interesting effects will be summarized.
One of the most interesting effects of practice was evidenced in a three-way interaction between task order, expectancy condition, and prime-target relationship in the analysis for expectancy, $F(1, 30) = 10.90, p < .01$. Notable in the pattern for this interaction was that error rates to surprise targets improved dramatically from the subjects' first task to their second task, regardless of which expectancy condition was encountered first. The interaction pattern also indicated that there was an increase in errors for expected rhymes when they were encountered as the second task (following expected nonrhymes). This was the only major deviation from the general pattern of reduced errors on the second task versus the first task. The reduction in errors for surprise targets could be a result of learning to inhibit a response bias to respond "no" to surprise targets by the second task, or it could be a result of having experienced the surprise items as expected items on the previous task.

A second interesting interaction involving the task order variable was the four-way interaction in the analysis for rhyming between expectancy condition, task order, target relationship, and SOA. This interaction was expressed in the analysis for expectancy as a three-way interaction between task order, prime-target relationship, and SOA, $F(1, 30) = 5.64, p < .05$. (See Table 11.) The general pattern of the three-way interaction indicated that when subjects
Table 11

Proportion of Errors as a Function of Task Order, Target Relationship, and SOA in Experiment 2: Analysis for Expectancy

Task Order 1 (Expect-Rhyme, Expect-Nonrhyme)

<table>
<thead>
<tr>
<th>SOA</th>
<th>Short</th>
<th>Long</th>
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</thead>
<tbody>
<tr>
<td>Target Relationship</td>
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<tr>
<td>Expected</td>
<td>.071</td>
<td>.065</td>
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<tr>
<td>Surprise</td>
<td>.058</td>
<td>.079</td>
</tr>
</tbody>
</table>

Task Order 2 (Expect-Nonrhyme, Expect-Rhyme)

| Target Relationship                  |
| Expected      | .057  | .073 |
| Surprise      | .087  | .061 |
had the task order expect-rhyme first, they made more errors to expected targets at the 75-msec SOA than to surprise targets, but at the 100-msec SOA they made more errors to surprise targets than to expected targets. The pattern of errors was the opposite for subjects who had the expect-nonrhyme task first. At the 75-msec SOA, subjects made more errors to surprise targets, but at the 100-msec SOA, they made more errors to expected targets.

**First-task-only analysis.** The first-task-only analysis of expected versus surprise error conditions resulted in one interaction that clarifies further the curious effects of errors to surprise targets over levels of SOA. The interaction between SOA, prime-target relationship and response type, $F(1, 30) = 4.43, p < .05$ (analysis for rhyming) was realized in the analysis for expectancy as a four-way interaction between expectancy condition, SOA, target relationship, and response type, $F(1, 30) = 4.43, p < .05$.

Although the three-way interaction in the analysis for rhyming yields the simplest interpretation of the data, the four-way interaction in the analysis for expectancy provides a more meaningful comparison relative to the experimental manipulations because it represents all the data points under investigation. (See Table 12).

The pattern of data that resulted from the four-way interaction in the analysis for expectancy revealed that
Table 12
Proportion of Errors as a Function of Expectancy Condition, SOA, Target Relationship, and Response Type in Experiment 2. Analysis for Expectancy

<table>
<thead>
<tr>
<th>Condition</th>
<th>Expect-Rhyme</th>
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<th>Expect-Nonrhyme</th>
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<tr>
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<td>0.087</td>
<td>0.084</td>
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<tr>
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<td>0.148</td>
<td>0.095</td>
<td>0.116</td>
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</tbody>
</table>

Condition Expect-Rhyme

<table>
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<th>Expect-Rhyme</th>
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<th>Expect-Nonrhyme</th>
<th></th>
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<tr>
<td>Surprise</td>
<td>0.043</td>
<td>0.148</td>
<td>0.095</td>
<td>0.116</td>
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</table>

Condition Expect-Nonrhyme
when the target was a word, subjects made more errors to expected rhymes than to surprise nonrhymes at the 75-msec SOA, but at the 100-msec SOA, subjects made more errors to surprise nonrhymes than to expected rhymes. The change in error rates in the expect-rhyme condition over levels of SOA can be attributed largely to errors on surprise nonrhymes. Whereas the percent of errors to expected rhymes changed by only .2% from the 75-msec SOA to the 100-msec SOA, the percent of errors to surprise nonrhymes increased from 4.3% to 14.0%, a change in magnitude of 10.5%.

Error rates for responses to words in the expect-nonrhyme condition showed a similar pattern of stability over SOA for expected nonrhyme targets. Subjects made only .05% fewer errors to expected nonrhymes at the 100-msec SOA than they did at the 75-msec SOA. However, in contrast to the lower error rates observed for surprise nonrhyming targets in the expect-rhyme condition at the 75-msec SOA, subjects made more errors to surprise rhymes at the 75-msec SOA than they did to expected nonrhyme targets. At the 100-msec SOA, subjects made fewer errors to surprise rhyming targets than to expected nonrhymes, although the magnitude of this difference was not as great as the magnitude of the differences at the 75-msec SOA. This interaction was also reliable when the word data were analyzed separately, $F(1, 30) = 8.85, p < .01$. 
As was evidenced in the four-way interaction between task order, expectancy condition, SOA, and rhyming relationship in the task-order analysis, it appears that for some reason, subjects had difficulty with surprise rhyming word targets at the 75-msec SOA and with surprise nonrhyming word targets at the 100-msec SOA. In addition, the low error rates for surprise nonrhymes at the 75-msec SOA indicate that for some reason, subjects found surprise nonrhymes easier than expected rhymes at the 75-msec SOA.

The pattern of data for errors to pseudowords revealed that across levels of SOA, subjects generally made fewer errors at the 100-msec SOA, although subjects in the expect-nonrhyme condition made slightly more errors to expected targets at the 100-msec SOA than at the 75-msec SOA. In addition, subjects in both expectancy conditions made more errors to surprise pseudoword targets than to expected pseudoword targets at the 75-msec SOA, and subjects in the expect-nonrhyme condition also made more errors to surprise rhymes than to expected nonrhymes at the 100-msec SOA. Subjects in the expect-rhyme condition, however, actually made fewer errors to surprise nonrhymes at the 100-msec SOA.

A separate analysis of the pseudoword data revealed that the interaction was not reliable, and that only the main effect of more errors to surprise targets was significant, \( F(1, 30) = 4.63, p < .05. \)
With one major exception, there was a general trend across word and pseudoword conditions for subjects to make fewer errors on surprise targets at the 100-msec SOA compared to the 75-msec SOA. The notable exception was that of surprise nonrhyming word targets in the expect-rhyme condition, which had a very high average error rate (14.8%) at the 100-msec SOA and a low error rate (4.3%) at the 75-msec SOA.

The error data, which were characterized by a number of complex task order effects not found in the reaction-time data, were also characterized in the first-task-analysis by wildly fluctuating error rates for surprise targets as a function of SOA in each expectancy condition. The reasons for the fluctuation are unclear. Thus, whereas SOA appeared not to be a major factor in the reaction time analysis of expected versus surprise targets, it played an important role in the pattern of errors.

**Summary of the Error Analysis**

To summarize and simplify, the error analysis of expected versus surprise targets was evidenced by a number of interactions involving the task-order variable, some of which provided evidence for a reduction in errors in the second task as a result of practice, and others that implied that having experienced the first task changed the way that subjects responded to targets in the second task. The first-task-only analysis revealed that SOA was an important
factor influencing the error patterns in both the expect-rhyme and expect-nonrhyme conditions. SOA had its greatest effect on surprise rhyming and nonrhyming targets, and this was particularly true for the word data. The most interesting finding was the radical increase in errors to surprise nonrhyming words from the 75- to the 100-msec SOA contrasted with the radical decrease in errors to surprise rhyming words from the 75- to the 100-msec SOA.

**Summary and Discussion**

If it is assumed that the XXXXX-primed controls are a valid neutral baseline at the very short SOAs, the results of Experiment 2 indicate that all word-primed targets, whether they were expected or surprises, rhymes or nonrhymes, were inhibited relative to controls at short SOAs (75 and 100 msec). In the first-task-only analysis of the reaction time data, expected targets (regardless of rhyming status) were 12 msec slower than controls, and surprise targets were 25 msec slower than controls. In contrast to the findings of Colombo (1985, 1986), inhibition was observed for all surprise targets relative to controls, regardless of whether they were surprise rhymes or surprise nonrhymes.

If the XXXXX primes are not considered valid controls, however, and the data seem to support this argument, there was no reliable evidence based on the analysis of expected versus surprise targets for automatic facilitation of
rhyming targets. In addition, there was evidence for inhibition of unexpected targets relative to expected targets (especially for expected rhymes and surprise nonrhymes), and this result was generalized over both levels of SOA. This finding gives credence to the conclusion that the inhibition was in conjunction with a conscious expectancy strategy, even at the short SOAs.

It is interesting to note that although the reaction time data in Experiment 2 did not reveal as clear an argument for conscious strategic processing as in Experiment 1, reaction times to words in the second experiment averaged around 818 msec, which is about the same as the 820 msec average in Experiment 1, but considerably higher than the average reaction time of around 650 msec that is normally observed for words in lexical decision. The long reaction times in this and the first experiment may partly reflect the effects of the strategy instructions, which provides further evidence that subject expectations may have played a role overall in Experiment 2. In a baseline experiment, in which the same materials and SOA values were used as in Experiment 1, the average reaction time to word targets was around 780 msec when subjects were not given explicit expectancy instructions.

Experiment 2 also demonstrated further the problem of the appropriateness of the XXXXX prime as a neutral baseline for measuring the relative magnitude of facilitation and
inhibition. The curious reaction time results, in which responses to expected targets were inhibited relative to controls, were interpreted as an indication that at the short SOAs of Experiment 2, subjects were able to use the XXXXX prime as an additional alerting stimulus because the XXXXX prime did not interfere with the processing of a subsequent word target in the same way that a word prime does.

The presence of inhibition (exhibited in both the reaction time and the error data) at very short SOAs presents a problem of interpretation for the two-factor framework of attention on which Experiments 1 and 2 are based. Effects of inhibition at SOAs of 75 and 100 msec would appear to be evidence for the operation of some sort of strategic processing, and would thus invalidate the claim that strategic and automatic processes can be contrasted by controlling the amount of processing time through a manipulation of SOA in the primed lexical decision task. The fact that the errors to both expected and control targets remained relatively stable over SOA, whereas errors to surprise targets fluctuated as a function of SOA is further evidence that subjects' expectations played a role in Experiment 2. The pattern of the error effects is puzzling, however, in that it is not a straightforward projection of what one would anticipate based on a simple model of violation of subject expectancies. It still
remains to be explained why surprise rhymes were inhibited and surprise nonrhymes were facilitated relative to expected targets at the 75-msec SOA and why the pattern reversed itself at the 100-msec SOA.
Strictly interpreted within the Posner and Snyder (1975) framework, the results of Experiments 1 and 2 did not provide support for Hillinger’s claim that rhyming facilitation is the result of automatic spreading activation along dimensions of phonological similarity. The results of Experiment 1 argue that priming of orthographically similar rhyming words can occur if conditions permit it, and that it seems to be the result of the application of a conscious expectancy strategy. In Experiment 1, the conditions amounted to sufficient time between the onset of prime and target (1250 msec) to apply an expectancy strategy and explicit instructions to expect primes and targets to rhyme. Together with Martin and Jensen’s (1988) failure to replicate Hillinger’s results, the results of Experiment 1 result suggest that the occurrence of the rhyming facilitation effect in lexical decision is heavily influenced by task demands.

Experiments 1 and 2 also raised some questions about the notion of automatic versus strategic processing as formulated in the two-factor theory of attention of Posner
and Snyder (1975) and as implemented in terms of a spreading activation theory of lexical processing by Neely (1976, 1977). Task-order effects beyond those that could be accounted for by facilitation with practice on the second task had an interesting influence on reaction time results to surprise word targets in Experiment 1. In addition, there was an equally intriguing influence of SOA on error rates to surprise rhyming and nonrhyming targets in Experiment 2. The fact that inhibition effects for surprise targets occurred at all in Experiment 2 presents a problem for an interpretation along the lines of a strict automatic-strategic dichotomy for lexical access defined in terms of speed of processing. This does not necessarily imply that Posner and Snyder's conceptualization of attention was in error. It implies only that the application of the concept to the lexical decision task may be inappropriate.

Antos (1979), using both a cost/benefit analysis and a speed/accuracy analysis, demonstrated that task variables, reflected in the subject's bias to respond "yes" to valid cues and "no" to invalid cues, were partly responsible for facilitation and inhibition effects for semantically primed targets in lexical decision. In his first experiment, invalid cues produced inhibition in reaction times at SOAs as short as 200 msec. Antos concluded:

The valid cue's effect on the speed of target processing is through both increased speed of lexical
access and early preparation of the response system. Inhibition produced by the invalid cue is not thought to be an inhibition of target based lexical access, but is thought to be due to having to inhibit using the cue-accessed memory. (p. 544)

Antos (1979) suggested that because of complex relationships between stimulus and response, "or for whatever reason," some tasks, namely the lexical decision task, may require a significant amount of attention at the task level, and the effects of attention could overshadow any automatic facilitation effects within the lexicon. He also suggested the possibility that the two types of facilitation he posited for lexical decision might not be tied to the automatic/attentional distinction.

Although Antos (1979) did not provide evidence or further discussion regarding the last point, research by McLean and Shulman (1978) addresses the issue. Using a primed letter matching task with an interpolated probe task, McLean and Shulman demonstrated that expectancy and attention, terms that many researchers (including Posner and Snyder) have used interchangeably, are not one and the same. McLean and Shulman found that attention plays a role early in the construction of expectancies, but once constructed, an expectancy can continue to exert its effect even though it is no longer valid and attention has been directed away from it (via an interpolated task).
MacLean and Shulman's (1978) finding could help to explain why inhibition effects were observed at the short SOAs as a result of task order in Experiment 1. Well-established expectancies in the form of response biases may have carried over from the first task to the second task. Because the expectancies could operate without the involvement of attention, their effects appeared at short SOAs, and in a sense, these expectancies became the "system defaults." In addition, the fact that the surprise items were proportionately fewer than the expected items may also have had the effect of sustaining the response criteria from the first task to the second, because subjects encountered too few instances that would cause them to adjust their response criteria.

Following Antos, other researchers have pursued the notion that factors other than those involved with lexical access can affect lexical decision times. After comparing subjects' reaction times to the same stimulus sets in tasks such as naming, lexical decision, and category verification, Balota and Chumbley (1984) argued that the frequency effects observed in lexical decision can be attributed largely to the decision stage of the task. Because the subject's task in lexical decision is to discriminate meaningful stimuli from nonword letter strings, Balota and Chumbley suggested that subjects use dimensions of familiarity and meaningfulness as criteria for determining the lexicality of
a target, implying that lexical access may not be necessary in the lexical decision task.

A number of researchers (Balota and Chumbley, 1984; Norris, 1986; Seidenberg & McClelland, 1989) have found a signal detection framework, originally developed by Atkinson & Juola (1973) to describe performance in the memory search task, useful for describing performance in the lexical decision task. Basically, the framework posits two distributions, one for words (signal) and one for nonwords (noise) that fall along a continuum of familiarity/meaningfulness. To the extent that nonwords resemble words in terms of orthographic and phonological similarity, the two distributions will overlap.

According to the model, the subject uses information about the amount of overlap in conjunction with the instructions for the lexical decision task (usually to respond as quickly as possible, while minimizing errors), and in the case of the present experiments, explicit expectancy instructions, to set response criteria that allow fast responding with a minimum of errors. Because the two distributions do not overlap completely, the subject is able to set two criteria, a high criterion for positive identification of words, and a low one for positive identification of nonwords, and this will allow rapid, correct responses (hits) to a number of word and nonword targets, with a minimum of false alarms (identifying a
nonword target as a word) or misses (identifying a word as a nonword).

Depending on the overlap of the word and nonword distributions in terms of familiarity/meaningfulness, however, there will be a "gray area," the area above the low criterion and below the high criterion, in which the similarity of the word and pseudoword targets requires that the subject conduct further analysis on the input string in order to arrive at a decision concerning its lexicality. This further analysis, which could take a number of forms, depending on the task stimuli (and the assumptions about the model of word recognition that the researcher adopts), exacts its price in the form of increased reaction times.

Waters and Seidenberg (1985) incorporated the signal-detection explanation to account for a number of seemingly incongruent effects involving spelling-sound relationships in the lexical-decision and naming tasks. Their explanation hinged on an interactive model of word recognition in which phonological information is available following the extraction of orthographic information. They hypothesized, and provided evidence in favor of the argument that phonological effects in lexical decision are produced only when processing of the stimulus continues past the time course of phonological code activation, and that these effects are absent when lexicality decisions can be based on early orthographic evidence. Factors such as the difficulty
of the stimuli (low-frequency items) and the subjects'
decoding skills (i.e., whether they were fast or slow
responders) were shown to be affected by phonology. Waters
and Seidenberg (1985) mention that factors such as context
(within which they presumably include priming) and subject
strategies affect lexical decisions post-lexically, but they
do not specify how this occurs within the time-course model.

Most recently, Seidenberg and McClelland (1989) have
implemented a parallel distributed model of visual word
recognition and pronunciation that incorporates some, but
not all of the notions of the time-course model. The
simulation accounts for many of the inconsistent results
observed empirically in lexical decision and naming
experiments without the need to posit or include lexical
units per se or separate orthographic and phonological
lexicons, and is therefore a major deviation from other
current models of word recognition.

Instead of lexical entries or logogen-like units, the
model computes for each input to be recognized a distributed
representation of orthographic and phonological codes in
parallel (a provision for the computation of meaning codes
is envisioned, but not yet implemented). The computations
are based on generalized information that the program has
"learned" about the orthographic structure of words and how
the orthographic structure correlates with the phonological
realization. This knowledge is represented in terms of
weights on connections between processing units in the model. The values of these weights are determined by the nature of the input (English orthography in the model) and feedback that occurred during the model's learning phase.

According to Seidenberg and McClelland (1989), "lexical information is computed on the basis of the input string in conjunction with the knowledge stored in the network structure, resulting in the activation of distributed representations. Thus, the notion of lexical access does not play a role" (p. 560). When a stimulus string is presented, orthographic, phonological, and semantic information are all activated in parallel, "each of which could provide information relevant to the decision process, depending on the conditions of the experiment" (p. 550).

Using only the orthographic and phonological components of the model (i.e., without recourse to computation of lexical meanings, which are not yet represented in the model), Seidenberg and McClelland (1989) have shown that their model can mimic subject performance on lexical decision and naming tasks for a number of different types of stimulus situations, demonstrating that both naming and lexical decision can be accomplished without referencing meaning. In doing so, they have also shown how subjects' response criteria (particularly in lexical decision) vary as a function of the stimulus set in an experiment, and how responses to variables such as frequency, orthographic-
phonological regularity, and contextual fit (including priming) vary also as a function of the subjects' response criteria.

Although priming effects have not been modeled, Seidenberg and McClelland (1989) explain that these effects of context obtain in part because of a difficult-to-inhibit tendency on the part of subjects to compare targets to the contexts in which they occur (even though not doing so and basing their decisions purely on the properties of the target could lead to faster reaction times), and in part as a function of the types of contextual information provided and the proportion of different types of stimulus items on the list. Thus, they conclude that "subjects respond intelligently to the information provided by the stimuli in the experiment and modify their response strategies to improve performance" (p. 550).

If Seidenberg and McClelland's (1989) account of word recognition is correct (or at least on the right track), then the question of whether rhyme priming is an automatic or a strategic effect becomes unimportant, because rhyme priming, along with a host of other effects, including semantic priming, belongs by current definition in the category "strategic." It seems somewhat counterintuitive to label as "strategic" processes that appear to occur subconsciously or without cognitive intervention as a means of adjusting to the performance constraints of a particular
task. Indeed, the purported inability of subjects to inhibit comparing targets and primes, which resulted in semantic facilitation effects reported as automatic by Neely (1976, 1977), would have to be re-cast as strategic. Perhaps, as Logan (1985) has suggested, characterizing complex performance in terms of simple, bipolar distinctions such as automatic-controlled (or automatic-strategic or automatic-conscious) may be not be fruitful scientifically. As our understanding of the visual word recognition process evolves, it might be prudent to adopt a new terminology to classify those processes, now termed "strategic," that seem to occur "automatically" in response to various task demands.
BIBLIOGRAPHY


### APPENDIX

#### STIMULI FOR EXPERIMENTS 1 AND 2

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<tr>
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