1-1-1993

When bluebeards fly : a role for "assembled" phonological representations in the activation of meaning.

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Recommended Citation

Lesch, Mary Frances, "When bluebeards fly : a role for "assembled" phonological representations in the activation of meaning." (1993). *Doctoral Dissertations 1896 - February 2014*. 3797.
https://scholarworks.umass.edu/dissertations_1/3797

WHEN BLUEBEARDS FLY: A ROLE FOR "ASSEMBLED" PHONOLOGICAL REPRESENTATIONS IN THE ACTIVATION OF MEANING

A Dissertation Presented

by

MARY FRANCES LESCH

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 1993

Department of Psychology

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ABSTRACT

WHEN BLUEBEARDS FLY: A ROLE FOR "ASSEMBLED" PHONOLOGICAL REPRESENTATIONS IN THE ACTIVATION OF MEANING

SEPTEMBER 1993

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The present studies addressed the issue of whether the phonological mediation of visual word recognition proceeds through an assembled or an addressed representation. In Experiment 1, subjects judged whether pairs of words were semantically related. Both homophone and "false homophone" stimuli were used. The set of "false homophones" consisted of words with the following characteristics: (1) They have neighbors that share its orthographic body but not its pronunciation (BEARD - HEARD) and (2) when an alternate pronunciation of the body is attached to the pronunciation of the onset, another word is produced (e.g., if BEARD were pronounced like HEARD, then the word "bird" would result). Experiment 1 demonstrated that reaction times in a semantic relatedness judgment task were longer to homophones (e.g., SAND - BEECH) and "false homophones" (e.g., ROBIN - BEARD) of a semantic associate than to visually similar controls. Subjects also made more errors to homophone pairs than to visually similar controls. Since the false homophone pairs were related through a phonological representation not specified in the word's lexical entry, it was concluded that the phonological representation responsible for the effect was an assembled representation.

In a second experiment, a parafoveal preview paradigm was used in order to determine whether the phonological representation integrated across fixations in reading is an assembled or an addressed representation. As in Experiment 1, subjects made semantic relatedness decisions to the stimulus pairs. In the most interesting condition, it was expected that a "biasing" preview (one that specified the spelling-to-sound correspondence that, when applied to the false homophone, would produce the phonological representation of a word related to the other member of the to-be-judged pair) would increase reaction times to the false homophone targets. The failure to observe the expected "biasing" effect is discussed in terms of the characteristics of a neighborhood based on the onset and following vowel cluster of the preview. While the expected preview effect was not observed, the effect of the target words essentially replicated those of Experiment 1. These results argue that phonological mediation proceeds through an assembled phonological representation.

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CHAPTER 1

GENERAL INTRODUCTION

What function, if any, does phonological information have in reading? More specifically, is the written word recoded into a phonological representation in order to be recognized? That phonology does have a role in the reading process and, more specifically, in visual word recognition is suggested by the fact that the symbols of most writing systems (graphemes) represent, to varying extents, the sounds of the language (phonemes or syllables). Furthermore, children come to the task of learning how to read with a relatively well-developed knowledge of spoken language. Therefore, it seems that the task of learning to read corresponds to the task of learning how to associate visual signals (written words/graphemes) with the corresponding auditory signal (the sounds of spoken words).

Proponents of phonological mediation argue that visual word recognition proceeds from spelling to sound to meaning (e.g., Van Orden, 1987)[1]. Typically, this process has been associated with visual word recognition in beginning and poor readers -- it is assumed that more skilled readers can bypass phonology (e.g., Seidenberg, 1985). For skilled readers, it has been assumed that visual word recognition proceeds predominantly through "direct access" -- meaning is accessed on the basis of the visual/orthographic representation of the word. On this view, in skilled reading, phonological mediation serves as a back-up route that only has an effect on the visual word recognition process in instances in which the extraction of visual information is slowed down. For example, Seidenberg (1985) suggests that, in skilled reading, an effect of phonology is restricted to the recognition of low frequency words. It is assumed that word frequency influences the rate at which visual information is extracted such that visual information is extracted more slowly for low frequency words. The slower extraction of visual information from the stimulus allows more time for phonological information to exert an influence.

Theories like Seidenberg's suggest a minor role for phonological information in visual word recognition in skilled reading. However, it seems counterintuitive that skilled readers would ignore phonological information when it is so readily available from a word's printed form. Furthermore, since speech remains the primary means of communication throughout life, it may be that visual word recognition would continue to benefit from the use of phonological information, even in skilled reading. An interesting finding that relates to this suggestion is that some deaf individuals recode written words into signs (Treiman & Hirsh-Pasek, 1983).

The theory of visual word recognition implied by the above discussion assumes that there are two routes to the lexicon -- a direct access route and a phonological mediation route. Direct access proceeds on the basis of an orthographic representation while the phonological mediation route accesses the lexicon on the basis of a phonological representation. Beyond suggesting two means of accessing the lexicon, dual route theories posit that there are two means of obtaining a phonological representation: (1) by accessing its entry in the lexicon or (2) by a computation from its orthographic representation. An interesting question to ask regarding the "computation" of phonology from orthography is: At what level are the associations between the visual form and the phonological form made? Classic dual route theories (e.g., Coltheart, 1978; 1980; Meyer, Schvaneveldt, & Ruddy, 1974) claim that the computation of a phonological code proceeds through the application of grapheme-to-phoneme correspondence rules and is not subject to lexical influence -- a claim that has caused some difficulty for dual-route theory (see Humphreys & Evett, 1985). However, the translation from orthography to phonology could occur at many different levels ranging from the level of the individual grapheme and phoneme (what has typically been termed "assembled phonology") up to the level of the word ("addressed phonology"). Indeed, it has been suggested that there is a class of words for which the phonological representation must be obtained at the level of the word -- that is, the phonological representation must be retrieved from the lexical entry for the word. These words are termed "exception" words because they form exceptions to the spelling-to-sound correspondence rules of the language. For example, "have" is considered an exception word because it is pronounced differently than other words that are spelled similarly (e.g., "save", "gave", "wave"). Therefore, it is argued, the correct pronunciation for these words can only be obtained from the lexical entry. The pronunciation/phonological representation of "regular" words, on the other hand, can be "assembled" on the basis of the regularities in the spelling-to-sound correspondences of the language because they are pronounced similarly to words that are spelled similarly (e.g., "must"). Finally, it is argued that the pronunciation of "nonwords" must be assembled because nonwords do not have lexical entries.

Effects of Regularity and Consistency

If phonological mediation proceeds through the application of grapheme-to-phoneme correspondence rules, then it should be possible to find an effect of spelling-to-sound regularity on word identification. The research on spelling-to-sound regularity provides mixed evidence for phonological mediation. Although many studies (e.g., Gough & Coskey, 1977; Stanovich & Bauer, 1978) have replicated the original Baron and Strawson (1976) finding that regular words are named more quickly than irregular words, Seidenberg, Waters, Barnes, and Tanenhaus (1984) found that the effect of spelling-to-sound regularity was restricted to low frequency words (see also Andrews, 1982; Backman, Bruck, Hebert, & Seidenberg, 1984; Seidenberg, 1985; Waters, Seidenberg, & Bruck, 1984). The results of studies employing the lexical decision task are even more inconsistent. Stanovich and Bauer (1978) obtained the effect while Coltheart, Besner, Jonasson, and Davelaar (1979) did not. The restriction of a spelling-to-sound regularity effect to low frequency words seems to support the contention that the phonological mediation route is only a "backup" for the faster direct access route.

An issue related to the regularity of a word is "consistency". Glushko (1979) suggested that "consistency" is more important than regularity. "Consistency" is defined over the body (vowel and following consonants) of the word whereas "regularity" typically refers to the vowel. According to Glushko (1979), a word could be regular and inconsistent at the same time. For example, while HEAD might be considered irregular and BEAD might be considered regular, neither of them can be considered consistent because they have orthographic "neighbors" that are pronounced differently than they are. According to Glushko (1979), the pronunciation of a word (or a nonword) is determined by analogy to its orthographic neighbors with a word's "neighborhood" being determined primarily by the body of the word (e.g. SAVE, GAVE, RAVE are all neighbors). The conversion process from orthography to phonology that is suggested by analogy theory is inconsistent with that posited by traditional dual access theory (e.g., Coltheart, 1978) in that it allows for lexical influence and it requires an orthographic unit larger than the grapheme (the body).

Like the research on regularity, the research on consistency has not been all that consistent. Glushko (1979) found that subjects took longer to pronounce a nonword such as FEAD than to pronounce a nonword such as FEAL. The explanation for this effect goes as follows: FEAD has orthographic neighbors that have irregular spelling-to-sound correspondences (e.g., DEAD) while FEAL does not. This inconsistency in the vowel sound (/i/ vs. /E/) across words sharing the same body (EAD) results in the longer naming time for FEAD. Seidenberg et al. (1984) found consistency effects that were restricted to low frequency words. Stanhope and Parkin (1987; see also, Seidenberg et al., 1984) found that naming times for inconsistent regular words (e.g., BEAD) are slower relative to naming times for consistent regular words (e.g., MUST) only if an irregular neighbor (e.g., HEAD) has already been encountered in the list.

In summary, the research on regularity and consistency has provided somewhat inconsistent results. Overall, the results seem to support a dual route model that argues that the phonological route to the lexicon serves merely as a back-up route to the direct access route. The finding of effects of regularity and consistency that are restricted to low frequency words is one such result -- lower frequency words are recognized more slowly than high frequency words, therefore there is sufficient time for phonological information to build up and exert an influence on the word recognition process. Although these results may seem to argue against a major role for phonology in visual word recognition, another way to interpret the data is that they suggest that the mechanism postulated by dual route theory to compute the phonological representation is incorrect. The data, as inconsistent as they may be, at least suggest that units other than graphemes are involved in the process and that there is some lexical influence.

Evidence for the Rime as a Functional Unit in Visual Word Recognition

In spoken language, some theorists view the syllable as having a hierarchical structure consisting of an onset and a rime. The onset consists of the initial consonant or consonant cluster while the rime consists of the vowel and any subsequent consonants. There is a great deal of evidence that the onset and rime are perceptually salient units in speech (see Treiman, 1989), but what evidence is there that the rime is a functional unit in visual word recognition? In written language, the rime corresponds to Glushko's (1979) "body".

Some evidence comes from studies examining the pronunciation of nonwords. As indicated previously, Glushko (1979) found that the consistency of a nonword's body/rime influences its pronunciation. Treiman and Zukowski (1988) asked subjects to pronounce nonwords like FRIETH, CHIEND, and CHIETH. They were interested in how often the phoneme /E/ would be assigned to "ie". This assignment occurred more often for nonwords like CHIEND than for nonwords like FRIETH or CHIETH suggesting that rime units are used to a greater extent in the determination of pronunciation than initial consonant-vowel units or vowel units alone. A similar effect was obtained in spelling.

In order to examine the question of whether there are orthographic units in written language corresponding to the onset and the rime, Treiman and Chafetz (1987) used an anagrams task in which subjects were presented with segments of words and were asked if any words resulted from the combination of any of these segments. Words were more easily found when they resulted from the combination of an onset and rime unit than when they resulted from other types of segments. A similar result was obtained using the lexical decision task -- subjects were faster to respond to words that were divided at their onset/rime boundary (e.g., CR//ISP) than to words divided somewhere else (e.g., CRI//SP).

Bowey (1990) also found evidence that onsets and rimes are functional units in written language. Bowey (1990) used a partial identity priming procedure in which it is assumed that word recognition is facilitated by the prior presentation of a prime corresponding to a representation which is functional in the word recognition process. Bowey (1990) compared primes that corresponded to the rime unit of a following target word (e.g., "ail" followed by "hail") to primes that did not correspond to the rime unit of a following target word (e.g., "ray" followed by "pray"). The prime was presented for 120 msec and then masked. The target was then presented in the same location as the prime. The results indicated that word-final bigrams and trigrams speed naming times only when they correspond to the rime unit. In a final experiment, it was found that word-initial bigrams provide facilitation only when they form the onset of a word. Although these results support the idea that the onset and the rime are functional units in written word recognition, it should be noted that the stimuli in Bowey's (1990) experiments were restricted to low frequency words.

The research concerning the effects of regularity and consistency suggested that other units, in addition to the grapheme and the phoneme, are involved in the "computation" of a phonological representation. Based on the research just discussed, the rime seems to be a likely candidate.

Effects of Phonology in Semantic Categorization and Associative Priming

Recently, Van Orden (1987) found evidence for the phonological mediation of visual word recognition using a semantic categorization task. Van Orden (1987) found that subjects made more false positive errors to foils that are homophonic to category exemplars (e.g. ROWS for the category A FLOWER) than to spelling controls (e.g. ROBS). This result was obtained under brief exposure duration conditions and in conditions in which the foils could be clearly seen. Van Orden, Johnston, and Hale (1988) obtained similar results using pseudowords (for example, JEAP is misclassified as A VEHICLE more often than JELP). Furthermore, their results indicated that matched word and nonword homophones produced virtually identical error rates. This result is inconsistent with the view that phonological mediation serves as a back-up to the direct access route because it indicates a failure to find an effect of stimulus familiarity. On the basis of this result, Van Orden and colleagues (1987; Van Orden, Johnston, & Hale, 1988) argued that phonological coding plays a role in the recognition of all printed words and proposed a verification model of visual word recognition to account for their data. According to this model, candidate lexical entries are activated exclusively on the basis of a phonological representation. Candidate lexical entries are then subjected to a verification check. Whether a homophone of an exemplar "slips through" the verification procedure is seen to be a function of the frequency of the actual exemplar -- readers are more likely to have complete spelling knowledge concerning high frequency words.

Van Orden's model is also capable of explaining the finding that a regularity effect is restricted to low frequency words because the mechanism by which associations between orthographic features and phonological features are acquired is sensitive to the covariance of these features across words. A consistent covariance across many words results in faster performance and overlearning can compensate for a disadvantage due to inconsistency. Therefore, inconsistency shouldn't matter as long as a word is very familiar (high in frequency).

Another line of evidence concerning the role of phonology in visual word recognition comes from associative priming from pseudohomophones and homophones. Lukatela and Turvey (1991) followed pseudohomophone primes (e.g., TAYBLE) by a target word that was related to the word that corresponded to the phonological representation of the pseudohomophone (e.g., CHAIR). Pseudohomophone primes led to faster naming of the target words than did spelling controls (e.g., TARBLE), suggesting that the phonological representation of the pseudohomophone activated the lexical entry of the corresponding real word which in turn activated its semantic associates. A similar result was obtained by Lesch and Pollatsek (1993) using real homophones as primes (e.g., BEECH as a prime for SAND). Interestingly, the homophone effect was obtained when the prime word was pattern-masked after a short exposure duration (50 msec) but not when it was pattern-masked after a longer exposure duration (200 msec). Furthermore, these results were obtained with a prime-target SOA of 250 msec. These results argue that the meanings of words are accessed on the basis of the automatic activation of phonological information and that verification "kicks in" within about 200 msec to disambiguate homophones. While Fleming (1993) obtained evidence for phonologically mediated priming using a lexical decision task, the size of this effect was much smaller than the effect of direct priming. This is consistent with Lesch and Pollatsek's (1993) failure to find a phonologically mediated priming effect in their long exposure duration condition -- both findings indicate that the verification process rapidly inhibits incorrect spellings.

Eye Movement Research

Some other evidence for a central role for phonology in visual word recognition comes from eye movement research. Pollatsek, Lesch, Morris, and Rayner (1992) used the boundary technique developed by Rayner and colleagues (e.g., Rayner, 1975; Rayner, McConkie, & Zola, 1980) to determine whether phonological information is integrated across fixations. In this paradigm, the subject's eye movements are monitored and a "preview" appears in the parafovea. Subjects are instructed to move their eyes to the "preview" upon its appearance. When the eyes cross an invisible boundary, the preview is replaced by the target word (subjects are generally unaware of the display change and of the identity of the preview). In one experiment, the subject was required to name the target word. Pollatsek et al. (1992) found that the time required to name a target word was shorter when a homophone of that word was presented as a preview in the parafovea than when a visually similar control served as a preview. They also extended these results to the silent reading of text: A homophone preview shortened fixation time on a target word relative to a control preview matched on visual similarity to the target word. Therefore, it does seem that phonological information is integrated across fixations.

The Phonological Representation: Accessed or Computed?

The semantic categorization studies (Van Orden 1987; Van Orden, Johnston, & Hale, 1988) and the associative priming studies (Lesch & Pollatsek, 1993; Fleming, 1993) discussed above argue that visual word recognition is phonologically mediated, but they leave open the issue of whether the phonological representation responsible for these effects is accessed directly from a lexical entry or whether it is computed. However, the Lukatela and Turvey (1991) results seem to suggest that the phonological representation is assembled. The above discussion concerning regularity and consistency effects suggests the possibility that all the phonological representations supported by a letter string are computed: Inconsistent words are named more slowly than consistent words because a to-be-recognized word activates a "neighborhood" of entries in the lexicon that share its body. For inconsistent words, the pronunciation associated with some of these words will rhyme with the pronunciation of the to-be-recognized word while others will specify a pronunciation that is not consistent with that of the to-be-recognized word. This conflict results in slowed pronunciation times.

A study by Lukatela, Turvey, Feldman, Carello, and Katz (1989) provides some evidence that, in Serbo-Croatian, all possible phonological representations associated with a letter string are computed automatically and prelexically. In Serbo-Croatian there is a simple one-to-one correspondence between graphemes and phonemes and there are two partially overlapping alphabets (Cyrillic and Roman)[2]. These characteristics of the language make it possible to construct letter strings that only result in words if both alphabets are applied. For example, the letter string HAPEB results in a phonological representation corresponding to a word only if the phoneme /n/ is assigned to H by the Cyrillic alphabet, the phoneme /p/ to the P by the Roman alphabet, and the phoneme /v/ to B by the Cyrillic alphabet. HAPEB differs from a real word by only one letter while, if both alphabets are applied, it shares all its phonemes with a real word (NAPEV) (Lukatela & Turvey, 1991). If lexical access is assumed to occur on the basis of a visual representation, then letter strings like HAPEB and letter strings like BETAP -- that also differ from a real word in only one letter but can't sound like a real word -- should result in an equal number of false positive responses in the lexical decision task. Lukatela, Turvey, Feldman, Carello, & Katz (1989) found that, when preceded by a neutral context word, letter strings like BETAP produced about 3% false positive responses while letter strings like HAPEB produced 31% false positive responses. When HAPEB letter strings were preceded by a context word associatively related to /napev/, false positive response rates almost doubled (55%). These results suggest that all the phonological representations that the letter structure allows are computed prelexically and that the lexicon is accessed through phonological representations. This suggestion raises an interesting question: In an orthographically "deep" language such as English, which is characterized by somewhat inconsistent mappings from orthography to phonology, are all the phonological representations that are allowed by a letter string computed automatically? For example, when one sees a letter string like BEAD which contains an inconsistent vowel that is sometimes pronounced /i/ and sometimes /E/, are both the phonological representations /bid/ and /bEd/ accessed, and hence are both the words "bead" and "bed" activated?

NOTES

1. More recently, Van Orden and his colleagues (Van Orden, Pennington, & Stone, 1990) have departed somewhat from the traditional phonological mediation account. They now suggest that phonological codes are activated in parallel with other linguistic codes and that effects of phonology in visual word recognition arise from the phonological representation's enhanced capacity to cohere with semantic subsymbols. This "enhanced capacity" is due to the relationship between phonology and meaning in spoken language. See Van Orden et. al (1990) for a more complete explanation.

2. Actually, matters are not quite so simple. However, Lukatela et al. (1989) used materials for which this description is true.

CHAPTER 2

EXPERIMENT 1

Introduction

If visual word recognition is phonologically mediated and all the phonological representations allowed by a letter string are computed automatically, then presentation of letter strings like BEAD should result both in the activation of the meanings associated with the actual phonological representation of the word (/bid/) and the meaning "bed" associated with the phonological representation that results if an alternative spelling-to-sound correspondence is applied (/bEd/). In the present experiment, a semantic relatedness task was used. Recently, Van Orden (personal communication) found that subjects have difficulty making semantic relatedness judgments to homophone foils paired with "broad" categories (categories that are not very predictive of the actual exemplar) (e.g., AN ANIMAL-BARE). In the present experiment, words like BEAD were presented paired with words semantically associated with the "alternative" phonological representation (e.g., PILLOW) and subjects were asked to decide as quickly and as accurately as possible whether the two words are related. This will be termed the "false homophone" condition. Since there is a great deal of evidence suggesting that the rime is a functional unit in visual word recognition, the set of false homophones consisted of words that: (1) have neighbors that share an orthographic body but not its pronunciation (BEAD - HEAD) and (2) when an alternate pronunciation of the body is attached to the pronunciation of the onset, a word is produced (e.g., if BEAD were pronounced like it's neighbor HEAD, then the word "bed" would result). Therefore, in the present experiment, it is spelling-to-sound correspondences defined over the body/rime of the word that are applied in order to produce the alternative phonological representations of the false homophones.

The experimental design included three other conditions: (1) an "appropriate" condition in which the actual word corresponding to the alternative phonological representation is presented along with its semantic associate (PILLOW - BED), (2) "visually similar" -- a word as visually similar to the appropriate word as the false homophone is presented along with the semantic associate of the appropriate word (PILLOW - BEND), and (3) "different" -- a word visually and semantically unrelated to the appropriate word presented along with the semantic associate of the appropriate word (PILLOW - HOOK). The subject was supposed to respond "yes" (related) in the appropriate condition and "no" (unrelated) in the other three conditions. See Table 1 for the experimental conditions.

If visual word recognition is phonologically mediated through the activation of all phonological representations supported by a letter string, then it would be expected that subjects would sometimes incorrectly accept false homophones (BEAD) as being related to the semantic associate of the appropriate word (PILLOW) because it is assumed that the alternative phonological representation (/bEd/) activates the semantic associates of the corresponding real word (BED). Since the false homopones were both phonologically and visually similar to the appropriate words, it is necessary to compare the error rates to the false homophones (BEAD) with the error rates to the visually similar controls (BEND) in order to differentiate an effect of phonology from an effect of visual similarity, although it should be noted that the visually similar controls are also somewhat phonologically similar to the appropriate associates. If there is an effect of the phonology of the false homophones, then it would be expected that there would be higher error rates in the false homophone condition than in the visually similar condition. There should also be an effect of shared phonology on the reaction times -- it was expected that subjects would take longer to correctly reject false homophones than to correctly reject visually similar and different words. The different words should be relatively easy to reject as being unrelated to the semantic associate as they were phonologically and visually dissimilar to the appropriate associate and would not be expected to activate semantic representations consistent with the semantic associate. Again, a comparison of the reaction times in the false homophone condition with the reaction times in the visually similar condition will allow for the differentiation of an effect of phonology from an effect of visual similarity. It should also be noted, however, that the visually similar condition might also be expected to have higher error rates and longer reaction times than the different condition by virtue of its visual similarity to the appropriate condition.

In an attempt to replicate the findings of Van Orden (personal communication), homophones were used in conditions equivalent to those described above (appropriate, homophone, visually similar, and different). In the appropriate condition, a homophone is presented along with its semantic associate (SAND - BEACH) while in the homophone condition, the other member of the homophone pair is presented with the homophone's associate (SAND - BEECH). In the visually similar condition a word as visually similar to the appropriate homophone as the other member of the homophone pair is, is presented with the homophone's associate (SAND - BENCH). And finally, in the different condition, a word unrelated visually or phonologically to the homophone is presented with the homophone's associate (SAND - FLUID).

Although the semantic categorization and priming studies discussed above provide strong evidence for the phonological mediation of visual word recognition, a finding of increased error rates or increased response latencies in the false homophone condition in the present experiment would provide even stronger evidence for phonological mediation because the phonological mediation would occur through a phonological representation that is incorrect for the given word -- that is, it cannot be directly accessed from a representation in the visual lexicon. Therefore, the effect could not be explained in terms of the post-lexical activation of phonology.

The results of the Van Orden (1987) study, for example, could be explained in terms of the post-lexical activation of phonology: Since the category name was presented prior to the homophone target, it is possible that the category name (A FLOWER) primed its semantic associate (ROSE), the phonological representation of which (/roz/), then activated the other member of the homophone pair (ROWS) in the visual lexicon. Hence there would be a higher level of false positive responding to homophone foils (see Jared & Seidenberg, 1991). In other words, it may be the phonological representation obtained from the lexical entry of the exemplar ROSE (which is primed by the category name) that activates the lexical entry for ROWS -- not a phonological representation that is activated prior to the activation of meaning. Such an explanation is less plausible in the false homophone condition of the present experiment. Furthermore, if phonological mediation occurs through a phonological representation that is incorrect for a given word, it would suggest that the phonologically mediated route to the lexicon has a more central role in visual word recognition than classic dual route theories suggest.

Method

Subjects

The 40 subjects, who were members of the University of Massachusetts community, received money or experimental credit for their participation. All were native English speakers and had normal or corrected-to-normal vision.

Materials and Design

A set of 36 words were selected that are characterized by "inconsistent" spelling-to-sound correspondences in that they have "neighbors" that have the same body, but are pronounced differently (See Appendix A for the stimulus materials). These words are such that, when the spelling-to-sound correspondences of a neighbor with an alternative pronunciation are applied to the word, a phonological representation corresponding to another real word is produced (e.g., "bead" could be pronounced like "head" to produce the phonological representation /bEd/). These words appeared in the false homophone condition. The 36 words corresponding to the alternative phonological representation of the false homophones appeared in the appropriate condition (e.g., BED). Since the homophones and the false homophones were often visually similar as well as phonologically similar to the appropriate words, a visual similarity rating system was used in order to asses visual similarity. In this rating system, visual similarity ranges from 0 to 1, with 1 indicating an exact match. Estimates of visual similarity were calculated as the average of the following two indices: (1) the fraction of letters shared between the two words in and out of position and (2) the fraction of shared letters that occur in the same position within the two words. The mean visual similarity between the appropriate words and the false homophones was .59 (SD = .15). 36 "visually similar" words were designed to be as visually similar to the appropriate words as were the false homophones (e.g., BEND). The mean visual similarity between the appropriate words and the visually similar words was .61 (SD = .16). The different words were designed to be unrelated visually and semantically to the appropriate words (e.g. HOOK). Visually similar and different words were equated in terms of word length (M = 4.42 letters, SD = 0.73) and approximately equated in terms of frequency (Francis & Kucera, 1982). Visually similar words had a mean frequency of 34.22 per 1,000,000 words (SD = 56.10), whereas different words had a mean frequency of 39.47 (SD = 62.56). It was not possible to match the false homophones and their visually similar controls in terms of visual similarity and frequency -- false homophones had a mean frequency of 97.58 (SD = 189.12). (The higher frequency of the false homophones should, if anything, work against the predicted inhibition effect for them relative to the controls).

A set of 36 homophone pairs were also selected (most of these stimulus materials were adapted from Lesch & Pollatsek, 1993). One member of each pair was assigned to the appropriate condition while the other member was assigned to the homophone condition. These assignments were made such that an equal number of the lower and higher frequency members of the homophone pairs served in the appropriate and homophone conditions, respectively. The homophones had a mean frequency of 21.22 (SD = 35.45). The mean visual similarity between the appropriate words and the homophones was .64 (SD = .12). Visually similar and different words were designed as described above. The mean visual similarity between the appropriate words and the visually similar words was .64 (SD = .12). Visually similar and different words were approximately equated in terms of word frequency. Visually similar words had a mean frequency of 45.64 (SD = 78.18) while different words had a mean frequency of 47.06 (SD = 107.52).

A set of filler stimuli was constructed so as to be comparable to the experimental stimuli except that there were no false homophone or homophone conditions. There were appropriate, visually similar, and different conditions (some of these materials were adapted from Lukatela & Turvey, 1991 and Lesch & Pollatsek, 1993).

For the false homophone, homophone, and filler stimuli, words judged as being associated with the appropriate words served as semantic associates.

There were 144 trials in the experimental session: 72 experimental trials and 72 filler trials. None of the semantic associates or associated target words were repeated for a given subject and for each semantic associate, only one of the four associated target words (appropriate, homophone/false homophone, visually similar, or different) was presented. There were four stimulus lists and the experimental conditions were counterbalanced across the stimulus materials over subjects.

Procedure

Subjects were seated at a distance of 63.5 cm from a Megatek Whizzard CRT display which has P-31 phospor and temporal resolution within 2 ms. At this distance, three characters subtended 1 degree of visual angle.

Presentation of stimuli was controlled by a Vax 11/730 computer. All words were printed in upper case.

A trial was initiated by the appearance of a "+" that served as a warning and fixation point. After a fixed stimulus onset asynchrony (SOA) of 250 ms, two words appeared on the screen. The semantic associate (e.g., PILLOW) appeared centered in the same location as the cross while the target word (e.g., BED, BEAD, BEND, or HOOK) appeared to the right. Subjects were instructed to look at the word appearing in the location of the cross first and then to look at the second word and judge whether the two words were semantically related in some way. They indicated their response by pressing one of two response keys. They were instructed to make their decision as quickly and as accurately as possible. Subjects did not receive feedback as to the accuracy of their responses.

Results and Discussion

Response times greater than 3000 ms and response times which lay three standard deviations above the mean for a given condition for a given subject were excluded from data analysis. Two sets of reaction time data were analyzed: one before the removal of seven stimulus items (three false homophone items and four homophone items) and one after the removal of those items. These items were missing more than 50% of the data (due to errors) in one or more conditions and were therefore adding considerable variability to the response time data. The means from both sets of analyses are presented in Table 2, but the statistics reported below are from the data set with the problematic items removed. As can be seen from Table 2, however, the pattern of results is the same in both analyses. Although Table 2 includes the means from the appropriate condition, it should be noted that this condition was not included in any of the analyses of variance reported below since the correct response in this condition was "yes" while the correct response in the other conditions was "no".

The response time data were subjected to a 4 X 2 X 3 analysis of variance with counterbalancing list as a between subjects factor, stimulus type (homophone or false homophone) as a within-subject factor, and target condition (false homophone/real homophone, visually similar, and different) as a within-subject factor. The means from this analysis are presented in Table 2. The counterbalancing list factor was not significant, $F(3,36) = 2.34$, $p = .09$. There was a significant effect of target condition, $F(2,72) = 20.26$, $p < .001$, and a marginally significant difference between false homophone and homophone stimuli, $F(1,36) = 2.75$, $p = .06$. None of the interactions were significant.

The error data were subjected to a 4 X 2 X 3 analysis of variance with counterbalancing list as a between subjects factor, stimulus type (homophone or false homophone) as a within-subject factor, and target condition (false homophone/real homophone, visually similar, and different) as a within-subject factor. The means from this analysis are presented in Table 2. There was no effect of counterbalancing list, F(3,36) = 2.11, p = .12. There were more errors in the homophone conditions than in the false homophone conditions, F(1,36) = 20.89, p < .001. There was also a significant effect of target condition, F(2,72) = 14.76, p < .001, and a significant stimulus type X target condition interaction, F(2,72) = 10.21, p < .001.

Since there was a main effect of stimulus type on error rates, and the stimulus type factor was marginally significant, separate analyses of variance were performed for the false homophone stimuli and the homophone stimuli. As the counterbalancing list factor was not significant in the overall analysis, it was collapsed in all other analyses.

Homophone Analyses

Since the predictions for the homophone stimuli are somewhat more straightforward than those for the false homophone stimuli, the analyses for the homophone stimuli will be presented first. As was discussed earlier, there is a great deal of evidence suggesting that, in visual word recognition, both meanings associated with the phonological representation of a homophone are initially activated. In particular, Van Orden (personal communication) has found that subjects have difficulty making semantic relatedness judgements to homophone foils paired with "broad" categories (categories that are not very predictive of the actual exemplar) (AN ANIMAL - BARE). It is assumed that subjects had difficulty because the phonological representation of the homophione (BARE) activates both meanings associated with that representation (the "naked" meaning and the "large furry animal" meaning). Furthermore, it was expected that homophones would be more likely to show the effect (increased response latencies or increased error rates) since both assembled and addressed phonological representations may be available (the false homophone effect would occur solely through an assembled representation).

Reaction Time Data. The response time data were subjected to a one-way analysis of variance with target condition (homophone, visually similar, different) as a within-subject factor. There was a main effect of target condition, F(2,78) = 11.31, p < .001, by subjects, but not by items, F < 1. Of greater interest were several planned comparisons. The homophone condition was 106 ms slower than the different condition. This difference was significant by subjects, F(1,39) = 14.38, p < .001, but not by items, F < 1. The homophone condition was also 95 ms slower than the visually similar condition which was significant by subjects, F(1,39) = 15.48, p < .001, but not by items, F(1, 31) = 1.13, p = .30. The visually similar condition did not differ significantly from the different condition (F's < 1 by subjects and by items), which argues that the difficulty in rejecting homophone targets was not due to their visual similarity to the appropriate targets but to their phonological identity.

Error Data. The error data were subjected to a one-way analysis of variance with target condition as a within-subjects factor. There was a main effect of target condition, F(2,78) = 15.03, $p < .001$, by subjects, and F(2,70) = 11.90, $p < .001$, by items. As can be seen in Table 3, subjects made more errors in the homophone condition than in either of the other two conditions: There were 15% more errors in the homophone condition than in the different condition, F(1,39) = 24.87, $p < .001$, by subjects, and F(1,35) = 20.15, $p < .001$, by items. More importantly, subjects made 11% more errors to homophone targets than to visually similar targets, F(1,39) = 11.00, $p < .01$, by subjects, and F(1,35) = 10.93, $p < .01$, by items.

To summarize, subjects took longer to correctly respond in the homophone condition than in any other condition. It should be noted that while the reaction time differences were significant over subjects, they were not significant over items. However, the loss of reaction time data due to high error rates (22% in the homophone condition and 11% in the visually similar condition) may partially explain this lack of reliability. Furthermore, homophone pairs were more often incorrectly judged as being related than were visually similar controls and these differences in error rates were significant by both subjects and items. These results essentially replicate those of Van Orden (personal communication) and suggest that visual word recognition proceeds from spelling to sound to meaning -- that is, meaning is accessed on the basis of a phonological representation. Again, it is assumed that the phonological representation of the homophone activates both meanings associated with that representation. Therefore, given BEECH, both the "tree" meaning and the "sand" meaning are activated; thus the difficulty in responding "no" to the pair SAND - BEECH.

False Homophone Analyses

As was discussed previously, there are two means of obtaining a phonological representation: An addressed phonological representation can be obtained directly from a word's lexical entry while (2) an assembled phonological representation can be computed/assembled on the basis of spelling to sound correspondences. In this experiment, the use of homophone stimuli does not allow for the determination of the type of phonological representation responsible for the effect since both addressed and assembled phonological representations are, in theory, available. The use of false homophone stimuli, however, does allow for a discrimination between the two types of phonological representation. In this experiment, "false homophones" have been defined as words that are characterized by inconsistent spelling to sound correspondences such that, if an alternative spelling to sound correspondence is applied (one other than that specified in the word's lexical entry), the phonological representation of another real word results. If subjects take longer to respond to pairs of words that are related only through an "alternative" phonological representation (e.g. PILLOW - BEAD, where BEAD could be pronounced like DEAD to produce "bed"), then that would be evidence that assembled phonology has a role in the activation of meaning because the alternative phonological representation is not specified in the word's lexical entry -- it cannot be an addressed representation.

Reaction Time Data. The response time data were subjected to a one-way analysis of variance with target condition (false homophone, visually similar, different) as a within-subject factor. There was a main effect of target condition, $F(2,78) = 8.69$, $p < .001$, by subjects, and $F(2,64) = 4.73$, $p < .05$, by items. Of greater interest were several planned comparisons. The false homophone condition was 80 ms slower than the different condition, $F(1,39) = 16.93$, $p < .001$, by subjects, and $F(1,32) = 9.67$, $p < .01$, by items. The false homophone condition was 55 ms slower than the visually similar condition, $F(1,39) = 6.42$, $p < .05$, by subjects, and, $F(1,32) = 4.65$, $p < .05$, by items. The visually similar condition, however, did not differ significantly from the different condition, $F(1,39) = 2.07$, $p = .15$, by subjects, and $F < 1$, by items, which argues that the difficulty in rejecting false homophone targets was not due to their visual similarity to the appropriate targets but to their relationship to their semantic associates through the alternative phonological representation.

Error Data. The error data were subjected to a one-way analysis of variance with target condition as a within-subjects factor. The three stimulus items that were removed from the reaction time analysis were also removed from the error analysis as it seemed that they may plausibly be semantically related (HORSE - FOWL, BLACK - WITCH, and RIFLE - GANG). There was a main effect of target condition that was significant by subjects, $F(2,78) = 4.33$, p

$< .05$, but only approached significance by items, $F(2,64) = 2.52$, $p = .09$. As can be seen in Table 3, subjects made fewer errors in the different condition than in either of the other two conditions. These differences were significant by subjects, $F(1,39) = 9.27$, $p < .01$, and $F(1,39) = 13.67$, $p <.001$, for the false homophone and visually similar conditions, respectively. The items analysis essentially replicated the subjects analysis: The 4% difference between the false homophone and the different conditions was marginally significant, $F(1,32) = 3.86$, $p = .06$, while the the 5% difference between the visually similar and different conditions was significant, $F(1,32) = 6.52$, $p < .05$. There was no difference between error rates in the false homophone and the visually similar conditions, F's < 1 by subjects and by items.

To summarize, the pattern of reaction times for the false homophone stimuli was the same as that for the homophone stimuli: response times were longer in the false homophone condition than in the visually similar condition while response times in the visually similar condition did not differ significantly from those in the different condition. Again, the explanation of this result goes as follows: If visual word recognition is phonologically mediated and all the phonological representations allowed by a letter string are computed automatically, then presentation of a "false homophone" (e.g., BEAD) should result in the activation of the meanings associated with both the actual phonological representation of the word (/bid/) and the phonological representation that results if an alternative spelling-to-sound correspondence is applied (/bEd/). This activation of the semantic information associated with the alternative phonological representation (/bEd/) makes the false homophone pairs (PILLOW-BEAD) more difficult to reject as unrelated.

The error data for the false homophone stimuli differed from that for the homophones in that there were no more errors in the false homophone condition than in the visually similar condition. Therefore, for the false homophone stimuli, the effect of phonology seems to be limited to reaction time. It is not surprising that the effect of phonology is more robust for the homophones (in that it is manifested in both the reaction time and the error data) than for the false homophones. For the false homophones, the mediating phonological representation is not the correct representation for the word (it is not the phonological representation specified in the word's lexical entry). For the homophones, the mediating phonological representation is the same as the phonological representation specified in the word's lexical entry. In other words, the homophone effect may result from the cumulative effect of the activation of both addressed and assembled phonological representations while it seems that it is assembled phonology that is responsible for the effect of the false homophones. The finding of increased response latencies in the false homophone condition relative to the visually similar condition indicates the involvement of an assembled/computed phonological representation in visual word recognition since the phonological representation could not have been retrieved from a lexical entry. The pattern of results obtained is further evidence for the phonological mediation of visual word recognition particularly since the phonological representation that is the vehicle for the mediation in the false homophone condition cannot be lexical in nature, since it does not correspond to a correct representation for the given word -- therefore, it is difficult to explain the effect in terms of the post-lexical activation of phonology.

Analysis of Stimulus Characteristics. In order to examine the effects of stimulus characteristics on performance in the semantic relatedness judgement task, a multiple regression analysis was performed. Prior research suggests a number of characteristics of interest. For example, Andrews (1989); Forster, Davis, Schoknecht, & Carter (1987); and Grainger (1990) have all found neighborhood effects in lexical decision or naming tasks. More specifically, Jared, McRae, and Seidenberg (1990) have found that inconsistency effects in naming depend on the relative summed frequencies of the "friends" and "enemies" in a word's neighborhood but not on the relative number of friends and enemies. Jared et al. (1990) define a word's neighborhood in terms of the word body -- for example, "neighbors" of COME include SOME, DOME, and HOME. "Friends" of a word (e.g., COME) include those words in its neighborhood that are spelled similarly and are pronounced similarly (SOME) while "enemies" are those words that are spelled similarly but are pronounced differently (DOME and HOME). Based on this research, it seemed important to examine the number and summed frequencies of the friends and enemies of the false homophones. It also seemed possible that only a subset of the enemies would be of interest -- specifically, those enemies that specify the spelling to sound correspondence that, when applied to the false homophone, would result in the alternative phonological representation (e.g., pronouncing BEAD like HEAD would produce "bed"). This variable will be termed "enemies of interest".

There were a number of other variables that seemed potentially interesting: the frequency of the false homophone (BEAD), the frequency of the word corresponding to the alternative phonological representation of the false homophone (BED), and the degree of visual similarity between the false homophone and the word corresponding to the alternative phonological representation of the false homophone.

Correlations between the stimulus characteristics and the reaction times in the false homophone condition were calculated. The variable that correlated most highly with reaction time was the number of enemies of interest, r = .33. This is not surprising. If the false homophone effect is due to the activation of the alternative phonological representation, which in turn activates the semantic associates of that phonological representation, then one would expect that the number of enemies specifying the spelling to sound correspondence resulting in that alternative phonological representation would be important. It is interesting to note that the total number of enemies had a lower correlation with reaction time (.18) and that summed frequency of all enemies had a slightly negative correlation (-.14). This suggests that an alternative explanation of the results in terms of inconsistency -- that the false homophones take longer to respond to, not because the alternative phonological representation activates its semantic associates, but merely because of their inconsistency -- is unlikely. If it were only inconsistency that mattered, and not activation of meaning, then one would expect the total number of enemies to correlate more highly with reaction time. However, it is the number of enemies that specify the spelling to sound correspondence that results in the alternative phonological representation that matters. This seems to reinforce the interpretation of the data in terms of the activation of the meanings associated with the alternative phonological representation of the false homophone.

The next most highly correlated variable was the frequency of the word corresponding to the alternative phonological representation ($r = .30$). One possible explanation of this is that there is some "top-down" reinforcement of the alternative phonological representation -- that is, given ROBIN, subjects may expect BIRD so that, when they get BEARD, the activation of the alternative phonological representation "bird" is reinforced by the expectation. The higher the frequency of the word corresponding to the alternative phonological representation (BIRD), the more likely it is to be expected. It is important to make clear that this explanation presumes that the two types of information interact -- that the expectation acts upon an already activated alternative phonological representation. If it were the case that expectation completely explains the effect, then one would expect that expectation would exert a similar effect in the visually similar condition. As we already know, reaction times in the visually similar condition were not significantly different from those in the different condition. Furthermore, the frequency of the word corresponding to the alternative phonological representation correlates poorly with reaction times in the visually similar condition (.02) suggesting that the effect of the frequency of the word corresponding to the alternative phonological representation is dependent upon the activation of the alternative phonological representation of the false homophone.

Step-wise regression was used to select the best set of predictors of reaction time. This procedure resulted in the selection of two variables: (1) the number of enemies of interest and (2) the frequency of the word corresponding to the alternative phonological representation of the false homophone. Taken together, these two variables account for about 22% of the variance in the reaction times across stimuli in the false homophone condition, $F(2,30) = 4.15$, $p < .05$.

Before leaving this discussion, it is important to stress that these analyses are speculative -- there were too few items to expect reliable estimates of correlations. In spite of that, however, two variables, the number of enemies of interest and the frequency of the word corresponding to the alternative phonological representation, accounted for a significant amount of the variance in the reaction times in the false homophone condition.

Table 1

Examples of stimulus pairs for the experimental conditions in Experiment 1.

Stimulus Type	Experimental Condition			
	Appropriate	False/ Homophone	Visually Similar	Different
False Homophone	PILLOW-BED	PILLOW-BEAD	PILLOW-BEND	PILLOW-HOOK
Homophone	SAND-BEACH	SAND-BEECH	SAND-BENCH	SAND-FLUID

Table 2

Mean reaction times (in ms) in the semantic relatedness judgment task as a function of target type and preview condition. Numbers in parentheses are means before the removal of items.

	Target Condition			
Stimulus Type	Appropriate	False/ Homophone	Visually Similar	Different
False Homophone	1163 (1153)	1308 (1301)	1253 (1253)	1228 (1224)
Homophone	1158 (1153)	1356 (1376)	1261 (1271)	1250 (1263)

Table 3

Mean percent error rates in the semantic relatedness judgment task as a function of stimulus type and target condition.

	Target Condition			
Stimulus Type	Appropriate	False/ Homophone	Visually Similar	Different
False Homophone	8	7	8	3
Homophone	13	22	11	7

CHAPTER 3

EXPERIMENT 2

Introduction

Experiment 2 is concerned with a related, though somewhat different, issue than Experiment 1. While Experiment 1 provided evidence that phonological codes are used to activate meaning, Experiment 2 was concerned with the question of whether the phonological representation integrated across fixations in reading is an assembled or an addressed representation (or both). The function of the phonological representation integrated across fixations may, or may not, be the same as the phonological representation investigated in Experiment 1 -- in Experiment 1, the question of interest was whether assembled phonological represention have some role in the activation of meaning. In Experiment 2, the focus was on determining whether a phonological representation survives an eye movement. That is, is a phonological representation (assembled or addressed or both) involved in preserving the memory of a word from one fixation to the next?

In Experiment 2, a variant of the boundary technique developed by Rayner and colleagues (e.g., Rayner, 1975; Rayner, McConkie, & Zola, 1980) was used in order to determine whether the phonological code integrated across fixations in word identification and reading is a computed/assembled code or a code retrieved directly from a lexical entry. Subjects were presented with a word that served as a semantic associate in Experiment 1 in the fovea and with the previews in the parafovea. In Experiment 2, the semantic associates from Experiment 1 are never related to the target words with which they are paired (except possibly through a phonological representation) hence, "semantic associate", in quotation marks, will be used to acknowledge that they are not true semantic associates. Subjects were instructed to look at the word that appeared at fixation and then to move their eyes to the second word. When their eyes passed an invisible boundary, the preview was replaced by the target word. Thus the two words fixated were exactly as in Experiment 1 and in the same physical locations. As in Experiment 1, subjects were required to make a semantic relatedness judgment. The difference was that there was a preview of the target word in the target word's location before the subjects fixated the target word (prior to the eyes crossing the boundary).

The homophones, false homophones, and their controls from Experiment 1 served as the target words. Thus, for the homophone stimuli, there was a homophone target (e.g., BEECH, given the "semantic associate" SAND) and a visually similar control target (BENCH, given the "semantic associate" SAND). The preview conditions included: (1) "identical" -- the preview and target were the same word (BEECH - BEECH or BENCH - BENCH), (2) "true associate" -- the appropriate homophone served as the preview (e.g. BEACH - BEECH or BEACH - BENCH), (3) "visually similar" (e.g. BENCH - BEECH or BEECH - BENCH), (4) "different" (e.g. FLUID - BEECH or FLUID - BENCH).

For the false homophones, there was a false homophone target (e.g., BEARD, given the "semantic associate" ROBIN) and a visually similar control target (BOARD, given the "semantic associate" ROBIN). The preview conditions were: (1) "identical" (BEARD - BEARD or BOARD - BOARD), (2) "true associate" -- the word corresponding to the "alternative" phonological representation of the false homophone (BIRDS - BEARD or BIRDS - BOARD) served as the preview, (3) "biasing" -- a word that (a) shares the orthographic body of the target word, but not it's pronunciation (HEARD - BEARD) and (b) if the body of the target word were to be pronounced like the body of the biasing preview, a word semantically related to the foveal word (ROBIN) would result ("bird"). In the comparable condition for the visually similar controls, the visually similar control was previewed by a word that looks as much like it as the "biasing" word looks like the "false homophone" (HOARD - BOARD vs. HEARD - BEARD). (4) In the "different" condition a word unrelated (visually, phonologically, or semantically) to the target word served as the preview (LEVEL - BEARD or LEVEL - BOARD) (see Table 4 for an example of the experimental conditions).

The goal of Experiment 2 was to determine the type of phonological representation involved in the integration of information across saccades in reading. As mentioned earlier, prior research (Pollatsek et al., 1992) indicated that a preview that is homophonic with a target word provides more facilitation of naming time and fixation time than does a preview that is only visually similar, implying that the sound information provided by the preview in the parafovea facilitates processing of the foveal target word. The goal of the present experiment was to determine the nature of the phonological representation involved in the integration of information across saccades. It is important to make clear that, while previous experiments employing the boundary technique were interested in facilitation effects (information provided by the preview facilitates processing of the target word when it is actually fixated), in the present experiment, the effect of interest was an inhibitory effect -- it was expected that some of the previews would make a "no" decision in the semantic relatedness judgment task more difficult by activating representations consistent with the "semantic associate".

If the phonological representation that is integrated across fixations is an "assembled" representation, and if the body is important in the assembly process, then it would be expected that the presentation of a biasing preview (HEARD) would slow responses to the false homophone pairs (ROBIN - BEARD) because the preview should, in some sense, "prime" the alternative phonological representation of the target word ("bird"). A comparison of the conditions for the homophone stimuli will help to determine the relative contributions of three different types of information to the preview effect (1) visual, (2) phonological, and (3) semantic.

Method

Subjects

The 48 subjects, who were members of the University of Massachusetts community, received money or experimental credit for their participation. All were native English speakers and had normal uncorrected vision.

Materials and Design

Although many of the words from Experiment 1 served as stimuli in Experiment 2, the use of the boundary technique put one constraint on the selection of stimuli that prevented the use of the entire set -- prior research has indicated that the preview and target should be the same length in order to minimize disruption due to visual dissimilarity. Therefore, the target words that were used were those for which it was possible to match preview and target on word length. Occasionally, this was achieved by pluralizing the preview (e.g., the "true associate" preview BEDS served as a preview for the false homophone BEAD). Several new stimuli were added to the subset from Experiment 1 to produce 40 false homophone and 40 homophone targets. The 80 visually similar controls also served as targets. The false homophones and their visually similar controls were equally visually similar to the true associate previews (the words actually related to the foveal words) with mean visual similarity ratings of .63 (SD = .13) and .64 (SD = .12), respectively. The same was true of the homophone stimuli: The homophones had a mean visual similarity rating of .62

(SD = .16) while their visually similar controls had a mean visual similarity rating of .62 (SD = .15). See Appendix B for the stimulus materials.

There were 128 trials in the experimental session: 80 experimental trials and 48 filler trials. The 80 experimental trials consisted of 20 homophone trials, 20 false homophone trials, and 40 visually similar control trials (20 for the homophones and 20 for the false homophones) in order to ensure that the "semantic associates" and targets were not repeated in the session. All of the experimental trials required "no" responses while all of the filler trials required "yes" responses. There were eight stimulus lists, and the eight experimental conditions were counterbalanced across the stimulus materials over subjects.

Procedure

The equipment used and the procedures followed in Experiment 2 were the same as those used in Experiment 1 except that subjects' eye movements were monitored and the boundary technique was used in order to vary the type of information available parafoveally. The eye movement recording system was a Stanford Research Institute Generation V Eyetracker interfaced to a VAX 11/730 computer and a Megatek Whizzard vector-graphics display using a P-31 phosphor. During the experiment, a bitebar was used in order to maintain a fixed head position. At the beginning of the experiment, the eye-tracking system was calibrated for the subject. At the beginning of each trial, a "check calibration" pattern came on with five fixed target crosses and a calibration cross that moved in synchrony with the eye. If, while fixating one of the target crosses, there was a discrepancy between the calibration cross and the fixed cross, the subject was recalibrated.

When it was determined that the equipment was properly calibrated and that the subject was fixating the central cross, a trial was initiated by the experimenter. During each trial, two words appeared on the screen. One word appeared centered in the same location as the cross while the other word appeared to the right centered 2.5 degrees (or 7.5 character spaces) from fixation. Subjects were instructed to look at the word appearing in the location of the cross first and then to look at the second word. When the subject's eyes crossed an invisible boundary two character spaces to the right of fixation, the parafoveal preview was replaced by the target word and the foveal word disappeared. Since this display change (from preview to target) took no more than 3 ms and was programmed to occur during an eye-movement (when vision is suppressed), subjects were seldom aware that any display change had occurred. As in Experiment 1, subjects were asked to judge whether the two words (the word presented at fixation and the target word) were semantically related in some way. They were instructed to make this decision as quickly and as accurately as possible and to press one of two buttons to indicate their response.

Results and Discussion

Reaction times greater than a 3000 ms cutoff and response times which lay three standard deviations above the mean for a given condition for a given subject were excluded from data analysis. One of the false homophone stimuli (FOWL) was not included in any of the analyses because it was determined that it was plausibly semantically related to the word presented at fixation (HORSE).

Reaction Time Analyses

Homophone Stimuli. The response time data were subjected to an 8 X 2 X 4 analysis of variance with counterbalancing list as a between subjects factor and target type (homophone or visually similar control) and preview condition (identical, true associate, visually similar, and different) as within-subjects factors. The condition means from this analysis are presented in Table 5. First, there was a significant effect of target type, $F(1,40) = 20.55$, $p < .01$, by subjects, and $F(1,39) = 8.55$, $p < .01$, by items, with homophone targets taking 57 ms longer to reject than their visually similar controls. This replicated the central finding for homophones in Experiment 1. Second, the main effect of preview condition was also significant by subjects, $F(3,120) = 7.18$, $p < .001$, but not by items, $F(3,117) = 1.56$, $p = .20$. There was also an effect of counterbalancing list, $F(7,40) = 2.86$, $p < .05$.

False Homophone Stimuli. The means from the analysis of variance are presented in Table 6. Subjects were 33 ms slower to reject false homophones than to reject visually similar controls which was significant by subjects, $F(1,40)$

= 9.10, $p < .01$, but not by items, $F < 1$. Thus, the central result of Experiment 1 was replicated. The effect of target type interacted with counterbalancing list, $F(7,40) = 3.13$, $p < .01$. The effect of preview condition was also significant, $F(3,120) = 8.46$, $p < .001$, by subjects, and, $F(3,114) = 4.04$, $p < .01$, by items, and the interaction of this effect with counterbalancing list approached significance, $F(3,120) = 1.59$, $p = .06$. The interaction between target type and preview condition approached significance by subjects, $F(3,120) = 2.40$, $p = .07$, but not by items, $F(3,114) = 1.62$, $p = .19$. The main effect of counterbalancing list was marginally significant, $F(7,40) = 2.13$, $p < .06$.

Error Analyses

Homophone Stimuli. The analysis of variance indicated that there was an effect of target type such that subjects made 11% more errors when the target was a homophone than when it was a visually similar control, $F(1,40) = 44.65$, $p < .001$, by subjects, and $F(1,39) = 16.87$, $p < .001$, by items. The means from this analysis are presented in Table 7. The effect of preview condition was marginally significant, $F(3,120) = 2.59$, $p = .06$ by subjects, but not by items, $F(3,117) = 2.05$, $p = .11$. An inspection of the means in Table 7, suggests that there was a tendency for subjects to make more errors in the identical and true associate preview conditions than in the other preview conditions (particularly in the case of the homophone stimuli). Although there was no main effect of counterbalancing list (F < 1), this factor interacted with preview condition, F(21,120) = 1.73, p < .05, by subjects.

False Homophone Stimuli. Although the analysis of variance for the false homophone stimuli indicated that none of the factors approached significance, there was some hint of higher error rates in the true associate preview conditions and slightly higher errors rates for false homophones than controls (see Table 8).

Assessment of Preview Effects

Homophone Stimuli. Several planned comparisons with respect to preview conditions were of interest. As indicated earlier, it is important to make clear that it was expected that the preview might have two different kinds of effect: (1) faster lexical access of the target word due to shared information between preview and target and (2) inhibition due to more evidence for the true semantic associate. More specifically, shared graphemic or phonological information between the preview and target may facilitate lexical access of the target. On the other hand, features shared between the preview and the "semantic associate" may make the decision that the target is unrelated to the "semantic associate" more difficult.

In order to assess the effect of changing the sound from preview to target, the true associate and visually similar preview conditions for the homophone targets were compared. The true associate previews were visually similar and phonologically identical to the target while the visually similar preview was as visually similar to the target as was the true associate preview, but was not phonologically identical (BEACH - BEECH vs. BENCH - BEECH). Reaction times to homophone targets were 27 ms slower in the visually similar preview condition than in the true associate preview condition. However, this difference was not significant either by subjects, F(1,40) = 1.10, p = .30, or by items, F < 1. Subjects made 6% more errors in the true associate preview condition than in the visually similar preview condition. This difference was marginally significant by subjects, F(1,40) = 3.71, p = .06, but not by items, F(1,39) = 1.93, p = .17. Although the differences were not significant, the pattern of reaction time differences suggests that a homophonic preview in the parafovea facilitated processing of the foveal target word.

A second issue is whether the semantic features of the orthographic form of the preview matter. In order to assess the effect of the meaning of the preview, conditions in which the meaning of the preview was consistent with that of the "semantic associate" (e.g., BEACH - BEECH and BEACH - BENCH, given SAND) were compared with conditions in which the meaning of the preview was not consistent with that of the "semantic associate" (e.g., BEECH - BEECH and BEECH - BENCH, given SAND). While this contrast was not significant, an examination of the means in Table 5 suggests that there is a hint of an effect of the meaning of the preview: There was a 12 ms difference between the identical and true associate preview conditions for the homophones; however, this difference did not approach significance: F's < 1, by subjects and by items. The visually similar controls were 7 ms slower when the preview had the right sound and the right meaning than when it only had the right sound. Subjects also made 3% more errors on the visually similar controls when the true associate served as the preview than when the other member of the homophone pair served as the preview, though this difference was not significant, F(1,40) = 2.52, p = .12, by subjects. The contrast testing the effect of the meaning of the preview on error rates did not approach significance by subjects or by items.

The visually similar preview condition allows for an assessment of the contribution of visual information to the integration process (it should be noted, however, that the comparison involved words that are also phonologically similar). For the homophone targets (BEECH), the visually similar control (BENCH)served as the visually similar preview. For the visually similar controls (BENCH), the homophone of the exemplar (BEECH) served as the preview. From Table 5 it can be seen that the visually similar preview condition was 39 ms slower than the identical condition for the homophone targets and 28 ms slower for the visually similar targets. Neither of these differences approached significance F(1,40) = 1.48, p = .23, by subjects, and F < 1, items, for the homophone targets and F(1,40) = 1.34, p = .25, by subjects, and F < 1, by items, for the visually similar controls. A comparison with the identical condition provides some measure of the effect of decreasing the degree of overlap between preview and target. A comparison with the different condition, on the other hand, provides some measure of the facilitation resulting from shared information. The 50 ms difference between the visually similar preview and the different preview for the homophones was marginally significant by subjects, $F(1,40) = 3.83$, $p = .05$, but not by items, $F < 1$. The 45 ms difference for the visually similar controls was significant by subjects, $F(1,40) = 4.11$, $p < .05$, but not by items, $F = 1$. Although either the identical or the different preview condition may be used as a baseline in order to assess the effect of the other preview conditions, the identical condition is probably the better baseline since the visual similarity between the identical condition and the homophone and visually similar controls was better controlled than that between the different condition and the homophone and visually similar controls.

To summarize, the finding of longer response latencies and higher error rates to homophone targets than to visually similar controls replicates one of the main results of Experiment 1. Furthermore, although there was a great deal of variability in the data, the pattern of preview effects is consistent with prior research (e.g., Pollatsek, et al., 1992): The pattern of data suggested that changing the sound from preview to target matters -- the visually similar condition, in which visual similarity, but not phonology, was preserved was responded to 27 ms slower than the true associate condition, in which both phonology and visual similarity was preserved. While this effect on the reaction times seemed to be independent of the semantic features of the phonological representation, there was some suggestion in the error rates that the decision process was facilitated by the absence of the "right" sound (a phonological representation corresponding to the "semantic associate"). Finally, there was some hint in the data that the semantics of the visual form of the preview matters -- response times were somewhat slower when the true associate (BEACH, given SAND) served as the preview than when the other member of the homophone pair (BEECH) served as the preview.

False Homophone Stimuli. An examination of the preview effects for the false homophones should help to determine whether the phonological representation integrated across fixations is an addressed or an assembled representation. It was of interest whether the same previews would effect processing of the two types of target (false homophones and their visually similar controls) differently. If the phonological representation that is integrated across fixations is an "assembled" representation dependent on the body, then it would be expected that the presentation of a biasing preview (HEARD) would slow responses to the false homophone pairs (ROBIN - BEARD) because it would be expected that the preview HEARD would "prime" the phonological representation associated with its body and this, in turn, would prime the alternative phonological representation of the target word ("bird"). Thus, there are two reasons why response times in the biasing condition for the false homophones would be expected to be slower than the identical condition: (1) inconsistent phonology across preview and target (HEARD - BEARD) and (2) priming of the alternative phonological representation of the target word.

Response times in the visually similar control condition, on the other hand, should not be slowed as much as the biasing condition for the false homophones since BOARD and HOARD are phonologically similar and there should be no priming of a phonological representation that would result in a "yes" response in the semantic relatedness judgment task. As can be seen in Table 6, for the false homophone targets, the biasing condition was actually 14 ms faster than the identical condition although this difference didn't approach significance either by subjects or by items (both F's < 1). For the visually similar controls, the biasing condition was 57 ms slower than the identical condition which was significant by subjects, F(1,40) = 5.39, p < .05, but only approached significance by items, F(1,38) = 3.06, p = .08. The difference between these two differences was significant by subjects, F(1,40) = 5.46, p < .05, but not by items (F < 1).

The effect that was obtained was exactly opposite that which was predicted -- the biasing preview had a more negative effect on the semantic relatedness decision to the visually similar controls than to the false homophones. One possible explanation for the failure to obtain the expected result is related to the nature of the overlap between preview and target. Prior research has shown that overlap in the first two or three letters results in about as much facilitation as when the preview and target are identical (Rayner, McConkie, & Ehrlich, 1978; Rayner et al., 1980), however, if the overlap is limited to the first letter, or to all but the first letter, there is almost no facilitation

(Rayner et al., 1980). In the present experiment, the biasing previews overlapped with the targets at the level of the body (vowel and subsequent consonants) -- that is, in most cases, they overlapped in all but the first letter. The Rayner et al. (1980) results thus suggest that the body of the preview may not be an operative unit in preview benefit and that, therefore, the above predictions, which were based on the assumption that the body of the preview would influence the processing of the target words, were misguided. However, it should be noted that Pollatsek et al. (1992) observed a difference between homophones and visually similar controls even when the first letter was different suggesting that there are some circumstances in which shared word endings have an effect (see also Inhoff, 1989).

The failure to obtain the expected result in the biasing condition for the false homophones thus may be explained to some extent by the fact that word beginnings seem to be more important than word endings in preview benefit. However, there seems to be something else going on. The biasing preview condition for the false homophones was no slower than the identical preview condition (and was actually somewhat faster). Even if the inconsistency in phonology across a shared orthographic body does not slow reaction times in the biasing condition, reaction times should be slowed on the basis of the differing first letters alone. Therefore, it seems that the biasing preview is somehow providing some sort of facilitation for the false homophones.

One possibility is that the onset of the word (the initial consonant) influences the pronunciation assigned to the following vowel. Some evidence for this comes from studies of nonword naming. For example, Kay (1987) found that words like POOK and WOOK are assigned different pronunciations based on their relationship with real words with the same initial consonant and vowel -- "oo" following a "p" is most commonly pronounced as in POOL while "oo" following "w" is most commonly pronounced as in WOOD. Taraban and McClelland (1987) found that a word prime sharing an initial consonant and vowel with a following nonword target influences the pronunciation assigned to the vowel in the nonword (e.g., DEAF - DEAG). While these studies suggest that the onset has some influence on the assignment of a pronunciation to the following vowel, there is evidence for the greater salience of the word-body for stimuli presented at fixation (discussed earlier). However, it is possible that the use of the boundary technique may have elevated the importance of the onset because the word-initial information of the parafoveally presented previews is so salient. If this is so, then the onsets of some of the biasing previews may have facilitated processing of the target by "priming" the pronunciation of the following vowel cluster (which is shared across preview and target) (e.g., "ea" following "h" is normally pronounced as in "heal" so that, when HEAD previews BEAD, the HEA- may predict that the vowel is pronounced as it should be ("bead" and not "bed"). In order to examine this hypothesis further, Spearman rank correlation coefficients were computed in order to assess the relationship between reaction times in the biasing preview condition for the false homophones and the characteristics of a neighborhood based on the onset and the following vowel of the preview (HEA-). Words that shared the initial consonant and vowel and that were the same length as the preview were included in the neighborhood. The rank correlation between the number of these "onset" enemies of the biasing preview (words specifying some other pronunciation of the vowel) in the neighborhood and the reaction times in the biasing preview condition for the false homophones was marginally significant, rho(37) = -.31, p = .05. This correlation indicates that reaction times in the biasing preview condition tended to decrease as the number of "onset" enemies of the biasing preview increased -- the more evidence there is against the actual pronunciation of the preview, the less effective the preview will be in biasing the target word towards a phonological representation consistent with the "semantic associate".

One problem in interpreting this correlation in terms of an effect of the preview is that the previews and targets in the biasing preview condition are quite similar in that they share the same body (e.g., HEAD - BEAD). In order to test the possibility that the correlation reflects an effect of the target word rather than an effect of the preview, the Spearman rank correlation coefficients between number of "onset" enemies of the biasing preview and reaction times in the other three preview conditions were computed. It should be noted that only the preview varied across the false homophone preview conditions -- the target word remained the same (e.g., BEAD, BEDS, HEAD, and HOOK all previewed the target word BEAD). Therefore, if the correlation reflects an effect of the target word, then number of "onset" enemies of the biasing preview should correlate similarly with reaction times in all four preview conditions (because the target word is the same). As can be seen in Table 9, this was not the case. The number of "onset" enemies of the biasing preview correlated poorly with reaction times in the other three preview conditions. The correlations were .05, -.03, and -.10 for the identical, true associate, and different preview conditions, respectively.

Therefore, the results of this correlational analysis support the idea that the correlation between the number of "onset" enemies of the biasing preview and reaction times in the biasing preview condition reflects an effect of the preview rather than an effect of the target. The negative correlation between number of "onset" enemies of the biasing preview and reaction times in the biasing preview condition is consistent with the idea that the effectiveness of the biasing previews was somewhat determined by the characteristics of a neighborhood based on the beginnings of words. The finding that the characteristics of the preview's neighborhood influences its effectiveness is evidence for a role of assembled phonology -- it is an effect of a neighborhood based on subunits of a phonological representation.

In an attempt to further clarify the relationship between number of "onset" enemies of the biasing preview and reaction times in the biasing preview condition, the number of "onset" enemies were divided into two categories: (1) number of "onset" enemies of the biasing preview that are friends of the target and (2) all other "onset" enemies. It was expected that the enemies of the biasing preview that are also friends of the target might play a greater role in limiting the effectiveness of the biasing preview -- the more evidence that the target word is pronounced the way it should be, the easier it should be to classify the target word as being unrelated to the "semantic associate". The correlations did not support this hypothesis. The number of enemies of the biasing preview that are also friends of the target correlated poorly with reaction times in the biasing preview condition, rho = .13, while there was a significant negative correlation between the number of "other" enemies and reaction times in the biasing preview condition, rho = -.36, $p < .05$. Therefore, it seems that the more neighbors that suggest a pronunciation other than those associated with the preview or the target, the easier it is to decide that the target word is not related to the "semantic associate". Before leaving this discussion, it should be noted that there are several possible measures of neighborhood size. The measure used here did not take into account at least one potentially important source of information: The frequency of the tokens. Therefore, the results reported here should be viewed as suggestive.

Another preview effect of interest is the effect of the true associate preview on reaction times to the false homophones and their visually similar controls. An examination of the means suggests that the true associate preview affected the false homophones and their visually similar controls similarly. The difference between the identical condition and the true associate condition was 35 ms for the false homophones and 37 ms for the false homophones. This difference was not significant for the false homophones, $F(1,40) = 1.24$, $p = .27$, by subjects, and $F < 1$, by items, or for the visually similar controls, $F(1,40) = 2.33$, $p = .13$, by subjects, and $F(1,38) = 1.91$, $p = .17$, by items. The overall difference, collapsing over target type, was not significant by subjects, $F(1,40) = 2.48$, $p = .12$. The interaction between preview condition and target type was not significant either by subjects or by items (F's < 1). The similar effect of the true associate preview on the false homophones and their visually similar controls suggests that the effect of the true associate preview may be due to phonological and graphemic differences and, thus, that there is little in the way of semantic pre-processing of the preview. More specifically, if the difference were due to the semantic pre-processing of the preview, then one would expect a larger effect for the false homophone targets since, as was indicated by the results of Experiment 1, the false homophone activates the meaning of the "semantic associate".

To summarize, as was the case with the homophones, the false homophone results replicate those of Experiment 1 -- there were longer response latencies to the false homophones than to the visually similar controls. However, the pattern of preview effects was not as expected: The visually similar control for the biasing condition slowed response time to the target more so than did the biasing preview condition for the false homophones. It was suggested that the failure to obtain the expected effect in the biasing preview condition could be due to the effect of a neighborhood of words based on word-initial letters.

Analysis of Stimulus Characteristics

The results of Experiment 2 replicated the major results of Experiment 1: Homophones and false homophones took longer to correctly reject than their visually similar controls. Homophones were also much more often incorrectly accepted as being related to the "semantic associate". The addition of the preview manipulation to the design of Experiment 2 was intended to get at the nature of the phonological representation involved in the integration of information across saccades. Specifically, the biasing preview condition was designed to determine how important assembled phonology is to the preview effect. It was expected that the biasing preview would "bias" the false homophone towards its alternative phonological representation resulting is slower correct rejection times. However, the result was exactly opposite that which was predicted -- the biasing preview slowed reaction times to visually similar controls but not to the false homophones. In order to explore the role of stimulus characteristics in this somewhat anomalous result, Spearman correlation coefficients between response time in the biasing preview condition for the false homophone targets and several variables of interest were calculated. It should be noted that, in this analysis, the neighborhood of the biasing preview was determined in reference to the word body. The two variables that correlated most highly with response time were the number of "body" friends of the biasing preview (the "enemies of interest" from Experiment 1) and summed frequency of the "body" friends of the target (which sometimes equals the summed frequency of the enemies of the preview). The two correlations were .40 and .47, respectively (see Table 9). Both of these correlations were significant at $p < .05$. The results of a regression analysis indicated that these two variables account for a significant amount of the variance (34%) in the response times across stimuli in the biasing preview condition for false homophone targets, $F(2,36) = 9.43$, $p < .001$. The effect of the number of friends of the biasing preview seems consistent with the results of Experiment 1 -- the more friends the preview has, the more likely it will bias the target word towards the alternative phonological representation and lead to difficulty in rejecting the false homophone. In order to determine whether the correlation actually reflects an effect of the preview and not an effect of the target, the number of friends of the biasing preview was correlated with reaction times in the other three preview conditions (see Table 9). None of the correlations approached significance (all p's > .10). The lack of a correlation in the identical preview condition seems inconsistent with the results of the analysis of stimulus characteristics in Experiment 1. That analysis indicated an effect of the number of enemies of interest (which corresponds to the number of friends of the biasing preview). The slight indication of a correlation with the reaction times in the different condition was also of interest -- it suggested the possibility that the correlation with reaction times in the biasing preview condition does not reflect an effect of the preview (or at least not the effect suggested). In order to assess whether there was a common underlying basis for the two correlations, Spearman's rho was calculated to assess the relationship between the reaction times in the biasing preview condition and the reaction times in the different preview condition. The reaction times in the two conditions correlated poorly (.04), suggesting that the nonsignificant correlation between the number of friends of the biasing preview and reaction times in the different preview condition reflects something different than what the correlation between the number of friends of the biasing preview and reaction times in biasing preview condition reflects.

The effect of the summed frequency of the friends of the target is somewhat more difficult to interpret than was the effect of the number of friends of the biasing preview. One possibility is that the two variables provide a measure of the size of the neighborhood and that size of the neighorhood (total friends and enemies) and composition of the neighborhood (friends of the preview) interact to produce changes in the effectiveness of the preview. Large neighborhoods could facilitate processing of the preview -- partially activated neighbors may add to the activation of sublexical components of the preview and consequently strengthen preview activation, but this assumes that lateral inhibition at the lexical level does not cancel out excitatory activation between lexical and sublexical units (see Andrews, 1989). Therefore, the preview is likely to affect the processing of the target word in the expected way if (a) there is a large neighborhood that facilitates the processing of the word and (b) the preview has many friends that specify the spelling-to-sound correspondence of interest (the spelling-to-sound correspondence that would bias the target word towards the alternative phonological representation). Essentially, the idea is that the faster the preview is processed, the more likely it is to have any effect at all -- the high number of friends of the preview helps ensure that the preview has the desired effect given that the preview has been processed sufficiently to begin with.

The correlations between the frequency of the friends of the target and the reaction times in the other three preview conditions (see Table 9) support the idea that the correlation with reaction times in the biasing preview condition is due to a combined effect of the preview and the target -- the correlations are quite different across the four preview conditions.

Table 4

Examples of stimuli appearing in the experimental conditions in Experiment 2.

		Preview - Target Conditions			
Stimulus Type	"Semantic Associate"	Identical	True Associate	Biasing/ Visually similar	Different
False Homophone					
Experimental	ROBIN	BEARD BEARD	BIRDS BEARD	HEARD BEARD	LEVEL BEARD
Control	ROBIN	BOARD BOARD	BIRDS BOARD	HOARD BOARD	LEVEL BOARD
Homophone					
Experimental	SAND	BEECH BEECH	BEACH BEECH	BENCH BEECH	FLUID BEECH
Control	SAND	BENCH BENCH	BEACH BENCH	BEECH BENCH	FLUID BENCH

Table 5

Mean reaction times (in ms) in the semantic relatedness judgment task for the homophone stimuli as a function of target type and preview condition.

Target Type	Preview Condition Identical	True Associate	Visually Similar	Different
Homophone	992	1004	1031	1081
Visually Similar	936	971	964	1009

Table 6

Mean reaction times (in ms) in the semantic relatedness judgment task for the false homophone stimuli as a function of target type and preview condition.

Target Type	Preview Condition			
	Identical	True Associate	Biasing	Different
False Homophone	974	1009	960	1080
Visually Similar	927	964	984	1018

Table 7

Mean percent error rates in the semantic relatedness judgment task for the homophone stimuli as a function of target type and preview condition.

Target Type	Preview Condition			
	Identical	True Associate	Visually Similar	Different
Homophone	23	23	17	18
Visually Similar	10	11	8	8

Table 8

Mean percent error rates in the semantic relatedness judgment task for the false homophone stimuli as a function of target type and preview condition.

Target Type	Identical	True Associate	Biasing	Different
	Preview Condition			
False Homophone	7	10	8	6
Visually Similar	5	7	7	10

Table 9

Correlations between characteristics of the biasing preview and reaction times in the four preview conditions for false homophone targets.

	Preview Condition			
Stimulus characteristic	Identical	True Associate	Biasing	Different
# enemies (onset)	.05	-.03	-.31	-.10
# friends of the preview	.07	.09	.40	.24
frequency of friends of the target	.21	-.26	.47	-.25

CHAPTER 4

GENERAL DISCUSSION

The present studies were concerned with the role of phonological information in visual word recognition. This issue is an important one because of its implications for the teaching of reading skills -- visual word recognition is a major component of the reading process. The importance of phonological information in the reading process is suggested by the finding that poor phonological processing skills correlate highly with reading disability (Pennington, 1991; Pennington, Van Orden, Smith, Green, & Haith, 1990) suggesting that a skilled reader is one who is able to process phonological information optimally. Our intuitions are also consistent with the suggestion that phonological information is important in visual word recognition -- it seems that if a language systematically encodes phonological information in its written form, then a reader should take advantage of it. Also, the continued primacy of spoken language throughout life suggests that visual language processing may benefit from shared representations or processes.

In Experiment 1 subjects were presented with pairs of words and were asked to judge whether or not the two words were related in meaning. It was found that subjects took longer to correctly reject pairs containing a homophone of a semantic associate (SAND - BEECH) than to reject pairs containing visually similar controls (SAND - BENCH). Subjects also made more errors to homophone pairs than to visually similar controls. These results essentially replicate those of Van Orden (personal communication) and suggest that the phonological representation of BEECH accesses both meanings associated with that representation -- the "tree" meaning and the "sand" meaning. While these results argue for a major role of phonology in visual word recognition, they do not address the issue of whether the phonological representation involved is an addressed or an assembled representation (the homophone result could be explained by the activation of either addressed or assembled phonology). An similar effect for the false homophones, on the other hand, would indicate that an assembled representation is involved.

Subjects took longer to correctly reject false homophone pairs than to reject pairs containing visually similar controls. False homophones were defined as words that: (1) have neighbors that share the same orthographic body but not the same pronunciation (BEARD - HEARD) and (2) when the spelling-to-sound correspondence of the neighbor (HEARD) is applied to the false homophone (BEARD), the pronunciation of another real word is produced (BEARD could be pronounced like HEARD to produce "bird"). The finding that false homophone pairs take longer to reject than visually similar controls indicates that the presentation of the false homophones resulted in the activation of both the actual phonological representation of the word and an alternative phonological representation consistent with a spelling-to-sound correspondence characteristic of a neighbor. It further suggests that phonological mediation proceeds through these representations. That is, the false homophone pairs (ROBIN - BEARD) were more difficult to reject because the "alternative" phonological representation ("bird") "primes" the meaning (ROBIN) associated with the actual word that corresponds to that representation (BIRD). Consistent with this interpretation was the finding that the best predictor of reaction times in the false homophone condition was the "number of enemies of interest" -- the number of enemies (e.g. HEARD) in the false homophone's (BEARD) neighborhood that specify the spelling to sound correspondence that would result in the alternative phonological representation ("bird"). The finding that phonological mediation proceeds through these "alternative" phonological representations argues that phonological mediation proceeds through a computed/assembled representation since the phonological representation responsible for the effect ("bird") could not have been obtained from the lexical entry for BEARD. One of the major difficulties of studying phonological activation during visual word recognition lies in determining whether this activation comes before or after lexical access. Since the effect of the false homophones is not due to a phonological representation that is specified within its lexical entry, it is difficult to explain this effect in terms of the postlexical activation of phonology.

Experiment 2 was concerned with a somewhat different, though related, issue: whether the phonological representation integrated across fixations in reading is an assembled or an addressed representation. While the differences between target words in Experiment 2 provided a replication of the basic results of Experiment 1, the effects of different previews failed to further elucidate the nature of the phonological representation involved in the integration process. However, the pattern of results for the homophone stimuli were consistent with those obtained by Pollatsek et al. (1992): There was a 27 ms preview effect attributable to shared phonology from preview to target (although it just failed to reach significance). There was also some indication of an effect of the semantic features of the preview. For the false homophones, the comparison that was of greatest interest was that between the biasing preview condition for the false homophones and the matched visually similar control condition. This comparison was intended to assess the extent to which assembled phonological codes are involved in the integration process. However, the result was exactly opposite that which was predicted -- the "biasing" preview HEARD failed to slow reaction times to BEARD given the "prime" ROBIN while the matched control preview HOARD did slow responses to BOARD.

There are several possible explanations for the failure to obtain the expected result in the biasing condition. One possibility is related to the nature of the overlap between preview and target. Prior research suggests that the preview benefit derives primarily from overlap in the preview and target in the first few letters (e.g., Rayner et al., 1980). In Experiment 2, the biasing previews overlapped with the targets at the level of the body (vowel and subsequent consonants). It is possible that the use of the preview technique may have emphasized the importance of the word-initial letters and the phonological codes derivable from them. The results of a correlational analysis suggested that a neighborhood based on the onset and following vowel cluster influenced the effectiveness of the biasing preview -- there was a significant negative correlation between "enemies of the preview" (words specifying some other pronunciation of the vowel) and reaction times in the biasing preview condition for the false homophones. This correlation suggests that the more evidence there is against the actual pronunciation of the preview, the less effective the preview will be in biasing the target word towards a phonological representation consistent with the "semantic associate".

A number of other paradigms may be better suited to the study of "priming" by shared word bodies. One possibility is to use the backward masking technique that has been employed by Perfetti, Bell, & Delaney (1988) and Perfetti and Bell (1991). Perfetti and colleagues have found that when a briefly exposed target word is followed by a pseudoword mask, the disruptive masking effect is reduced when the mask shares graphemic or phonemic information with the target word (subjects are better able to report the identity of the target word). Presumably, the pseudoword mask reinstates information activated during incomplete identification of the target. Perfetti and Bell (1991) obtained evidence of phonemic activation within the first 40 ms of word identification. It would be interesting to use this backward masking technique with false homophones as the targets and an inconsistent neighbor as the mask. Would subjects sometimes report having seen "bird" when BEARD is masked by HEARD? If so, then that would be evidence that the word body EARD initially activates both of its associated pronunciations.

Another possibility is to use Forster's (Forster and Davis, 1984) "masked priming" paradigm. In this paradigm, the sequence of events is as follows: a forward mask, a priming stimulus in lowercase letters, and target stimulus in upper-case letters. Since the forward mask and the target are both presented for 500 ms, and the prime is presented for only 60 ms, subjects are not generally aware of the prime. The "prime" is analogous to the preview of Experiment 2 except that the prime is seen foveally. It is of interest whether the biasing previews from Experiment 2 would have their expected biasing effect in a paradigm in which the "prime" (i.e., preview) is foveal and hence the word-initial letters might not be as important as they seem to be in the preview paradigm.

Although the analyses of the effects of stimulus characteristics undertaken in these studies were exploratory in nature, they suggested that the recognition of a word is influenced by the composition of its phonological neighborhood. In Experiment 1, the best predictor of reaction times in the false homophone condition was the the number of "enemies of interest" -- the number of words in the false homophones's neighborhood that specified the spelling-to-sound correspondence that would result in a phonological representation consistent with the "semantic associate". In Experiment 2, reaction times in the biasing preview condition for the false homophones were negatively correlated with the number of "onset" enemies of the preview (in a neighborhood defined in terms of the onset and vowel cluster) and positively correlated with number of friends of the preview and summed frequency of the friends of the target (in a neighborhood based on the word-body). The results of these analyses indicated that both onset and rime units may help to define a word's neighborhood. However, the onset seems far more important for words seen parafoveally. An effect on visual word recognition of spelling-to-sound correspondences at multiple levels is consistent with a model of word recognition in which a word is represented as a pattern of activation across a more distributed representation (e.g., Van Orden, Pennington, & Stone, 1990; Seidenberg & McClelland, 1989).

Van Orden (1987) proposed that the statistical regularities in language are "acquired" through covariant learning and that the orthographic representation of a word will activate a set of lingusitic features that covary with its orthographic features -- the stronger the covariance, the more active the features will be. This set of active linguistic features is the lexical representation of the word. The effects of phonology in visual word recognition arise from the phonological representation's enhanced capacity to cohere with semantic subsymbols. This "enhanced capacity" is due to the relationship between phonology and meaning in spoken language.

Although the present studies were concerned with the role of assembled and addressed phonological representations in the activation of meaning, models such as the one proposed by Van Orden (see also, Seidenberg & McClelland, 1989) make no distinction between the two types of representation -- the linguistic codes are computed each time a word is read. Therefore, there are no "lexical entries" to be accessed in order to obtain the meaning of a word -- the meaning of a word corresponds to a pattern of activation over a set of distributed units. In the present experiments, there was an effect of the false homophones on semantic relatedness judgments attributable to assembled phonology. Although the effect of the homophones could not be unequivocally attributed to assembled phonology since the phonological representation responsible for the effect could have been assembled _or_ addressed (it is the phonological representation specified in the homophone's lexical entry), the results are not inconsistent with the idea that the effect observed with the homophones is also an effect due to "assembled" or "computed" phonology. The larger effects observed with the homophone stimuli could be due to the covariation between orthography and phonology at the level of the word -- the false homophones do not have this extra source of activation.

The results obtained in the present experiments suggest a more central role for phonological mediation in the recognition of printed words than is suggested by classic dual route theories. Furthermore, they suggest that a "computed" phonological representation is involved in the activation of meaning. Future experiments should attempt to clarify the nature of the computation process with special attention to the levels of representation that are activated as part of that process.

APPENDIX A

STIMULUS MATERIALS FOR EXPERIMENT 1

The first column is the semantic associate. The second, third, fourth, and fifth columns are the appropriate, false homophone (or real homophone), visually similar, and different target conditions, respectively.

False Homophone Stimuli:

PILLOW	BED	BEAD	BEND	HOOK
HORSE	FOAL	FOWL	FOIL	MESS
FOOT	TOE	TOUGH	TOOLS	SHOCK
SOUR	SWEET	SWEAT	SWEPT	MOVIE
SOUND	TONE	TOWN	TORN	MYTH
SMART	DUMB	DOME	DIME	MASK
DEER	DOE	DEW	DEN	RIM
RIFLE	GUN	GONE	GANG	RENT
SCAB	SORE	SOUR	SORT	PLAN
NAP	DOZE	DOSE	DOPE	RACK
VERB	NOUN	KNOWN	NOON	SINK
TIE	SUIT	SOOT	SEAT	PARK
WORST	BEST	BEAST	BURST	PITCH
BLACK	WHITE	WEIGHT	WITCH	MOUND
BRUSH	COMB	COME	COMA	MULE
SHORT	TALL	TOLL	TILL	SICK
ROPE	CORD	CARD	CURD	STEW
ROBIN	BIRD	BEARD	BOARD	LEVEL
SHIP	FERRY	FURY	FAIRY	WIDTH
RAKE	HOE	HOW	HOT	YES
BUILDING	TOWER	TOUR	TONER	LEMON
IRON	COAL	COWL	COIL	SHED
LOVE	HATE	HEIGHT	HEARTH	PLAQUE
CANE	CRUTCH	CROUCH	CRUNCH	STREAK
DIED	BORN	BARN	BURN	KICK
EMPTY	FULL	FOOL	FEEL	LAND
PIT	HOLE	HOWL	HOLD	MEAN
SLEEVE	CUFF	COUGH	CLUES	SPARK
CAPE	SHAWL	SHALL	SHELL	PRIDE
SING	HUM	HOME	HAMS	WEED
JURY	COURT	CART	CURT	SKID
GOAL	SCORE	SCOUR	SCORN	WRIST
FUNERAL	HEARSE	HORSE	HOARSE	STRAND
COOL	WARM	WORM	WARP	STUD

BOAT	ROW	ROUGH	ROACH	SCRAP
MUFFIN	BUN	BONE	BIND	WRAP

Homophone Stimuli:

SAND	BEACH	BEECH	BENCH	FLUID
TREE	FIR	FUR	FAR	DAY
LETTER	MAIL	MALE	MALL	KNOB
STEP	STAIR	STARE	STARS	LUNCH
BLOOD	VEIN	VANE	VINE	MOTH
BOAT	SAIL	SALE	SALT	CROP
JAIL	BAIL	BALE	BALL	NEWS
STORY	TALE	TAIL	TALK	NEED
HEAD	HAIR	HARE	HARM	NEST
BUN	ROLL	ROLE	ROCK	PATH
SPIRIT	SOUL	SOLE	SOIL	PARK
MUSIC	LUTE	LOOT	LIST	FEAR
STREAM	CREEK	CREAK	CROOK	BLOOM
VOTE	POLL	POLE	POOL	TEST
MAJOR	MINOR	MINER	MANOR	PEDAL
DAY	NIGHT	KNIGHT	FLIGHT	BRANCH
WATER	RAIN	REIN	RUIN	BOOT
BREAD	DOUGH	DOE	DOOM	PAWN
CLOCK	TIME	THYME	TAME	LUST
CORN	MAIZE	MAZE	HAZE	SLUG
VIRTUE	VICE	VISE	VILE	NULL
MEAT	STEAK	STAKE	STALE	FLIRT
SHOE	HEEL	HEAL	HELL	LACK
MOON	SUN	SON	SIN	LEG
ACHE	PAIN	PANE	PANS	LUMP
PART	PIECE	PEACE	PEACH	STRAW
GARBAGE	WASTE	WAIST	WARTS	PUNCH
CLAM	MUSSEL	MUSCLE	MUSEUM	OCCUPY
LEFT	RIGHT	RITE	RIOT	BULB
SUGAR	FLOUR	FLOWER	FLOOR	TEETH
FRIEND	PEER	PIER	PIES	MOBS
HARP	LYRE	LIAR	LURE	HAWK
FENCE	GATE	GAIT	GASP	CROW
FRUIT	PEAR	PAIR	PAR	TON
RICH	POOR	PORE	PORK	LANE
DISCIPLE	PROPHET	PROFIT	PROTEST	HEALTHY

APPENDIX B

STIMULUS MATERIALS FOR EXPERIMENT 2

Each pair of lines represents one item. The first column is the word presented at fixation. The second column is the target word (false homophone, homophone, or visually similar control). Columns three to six are the associated preview conditions (identical, true associate, biasing/visually similar, and different).

False Homophone Stimuli:

PILLOW	BEAD	BEAD	BEDS	HEAD	HOOK
PILLOW	BEND	BEND	BEDS	MEND	HOOK
HORSE	FOWL	FOWL	FOAL	BOWL	MESS
HORSE	FOIL	FOIL	FOAL	TOIL	MESS
SOUR	SWEAT	SWEAT	SWEET	TREAT	MOVIE
SOUR	SWEPT	SWEPT	SWEET	CREPT	MOVIE
SOUND	TOWN	TOWN	TONE	MOWN	MYTH
SOUND	TORN	TORN	TONE	HORN	MYTH
SMART	DOME	DOME	DUMB	SOME	MASK
SMART	DIME	DIME	DUMB	LIME	MASK
DEER	DEW	DEW	DOE	SEW	RIM
DEER	DEN	DEN	DOE	TEN	RIM
RIFLE	GONE	GONE	GUNS	DONE	RENT
RIFLE	GONG	GONG	GUNS	FANG	RENT
SCAB	SOUR	SOUR	SORE	POUR	PLAN
SCAB	SORT	SORT	SORE	PORT	PLAN
NAP	DOSE	DOSE	DOZE	ROSE	RACK
NAP	DOPE	DOPE	DOZE	COPE	RACK
VERB	KNOWN	KNOWN	NOUNS	CROWN	SINK
VERB	NORMS	NORMS	NOUNS	FORMS	SINK
TIE	SOOT	SOOT	SUIT	BOOT	PARK
TIE	SEAT	SEAT	SUIT	HEAT	PARK
BRUSH	COME	COME	COMB	HOME	MULE
BRUSH	COMA	COMA	COMB	SOMA	MULE
SHORT	TOLL	TOLL	TALL	DOLL	SICK
SHORT	TILL	TILL	TALL	BILL	SICK
ROPE	CARD	CARD	CORD	WARD	STEW
ROPE	CURD	CURD	CORD	TURD	STEW
ROBIN	BEARD	BEARD	BIRDS	HEARD	LEVEL
ROBIN	BOARD	BOARD	BIRDS	HOARD	LEVEL
RAKE	HOW	HOW	HOE	TOW	YES
RAKE	HOT	HOT	HOE	DOT	YES

BUILDING	TOURS	TOURS	TOWER	HOURS	LEMON
BUILDING	TONER	TONER	TOWER	LONER	LEMON
IRON	COWL	COWL	COAL	BOWL	SHED
IRON	COIL	COIL	COAL	BOIL	SHED
DIED	BARN	BARN	BORN	WARN	KICK
DIED	BURN	BURN	BORN	TURN	KICK
EMPTY	FOOL	FOOL	FULL	WOOL	LAND
EMPTY	FEEL	FEEL	FULL	PEEL	LAND
PIT	HOWL	HOWL	HOLE	BOWL	MEAN
PIT	HOLD	HOWL	HOLE	TOLD	MEAN
SLEEVE	COUGH	COUGH	CUFFS	TOUGH	SPARK
SLEEVE	CLUES	CLUES	CUFFS	BLUES	SPARK
CAPE	SHALL	SHALL	SHAWL	STALL	PRIDE
CAPE	SHELL	SHELL	SHAWL	SMELL	PRIDE
SING	HOME	HOME	HUMS	COME	WEED
SING	HAMS	HAMS	HUMS	RAMS	WEED
ALE	BEAR	BEAR	BEER	NEAR	SACK
ALE	BOAR	BOAR	BEER	ROAR	SACK
WELCOME	GREAT	GREAT	GREET	TREAT	LOUSE
WELCOME	GRANT	GRANT	GREET	SLANT	LOUSE
ENEMY	FEW	FEW	FOE	SEW	JOY
ENEMY	FED	FED	FOE	RED	JOY
GRIEF	WOW	WOW	WOE	LOW	SEA
GRIEF	WON	WON	WOE	TON	SEA
FACE	NEWS	NEWS	NOSE	SEWS	BAIT
FACE	NETS	NETS	NOSE	BETS	BAIT
CARNIVAL	FEAR	FEAR	FAIR	BEAR	SIDE
CARNIVAL	FOUR	FOUR	FAIR	TOUR	SIDE
LEAVES	WREAK	WREAK	RAKES	BREAK	MOURN
LEAVES	RACKS	RACKS	RAKES	BACKS	MOURN
COPY	CLOWN	CLOWN	CLONE	FLOWN	WOMAN
COPY	CLOSE	CLOSE	CLONE	PROSE	WOMAN
HOSPITAL	WORD	WORD	WARD	FORD	CHAP
HOSPITAL	WAND	WAND	WARD	HAND	CHAP
CAUTION	HEAD	HEAD	HEED	BEAD	SOON
CAUTION	HELD	HELD	HEED	WELD	SOON
BLACK	WEIGHT	WEIGHT	WHITES	HEIGHT	PROMPT
BLACK	WHINES	WHINES	WHITES	SPINES	PROMPT
SHORES	COSTS	COSTS	COAST	POSTS	FRAIL
SHORES	CASTS	CASTS	COAST	LASTS	FRAIL
COURT	SEW	SEW	SUE	DEW	LET
COURT	SET	SET	SUE	LET	LET
SHOE	LASS	LASS	LACE	BASS	JUST
SHOE	LAST	LAST	LACE	FAST	JUST

HARD	FORM	FORM	FIRM	WORM	CLASS
HARD	FARM	FARM	FIRM	HARM	CLASS

Homophone Stimuli:

SAND	BEECH	BEECH	BEACH	BENCH	FLUID
SAND	BENCH	BENCH	BEACH	BEECH	FLUID
TREE	FUR	FUR	FIR	FAR	DAY
TREE	FAR	FAR	FIR	FUR	DAY
LETTER	MALE	MALE	MAIL	MALL	KNOB
LETTER	MALL	MALL	MAIL	MALE	KNOB
STEP	STARE	STARE	STAIR	STARS	LUNCH
STEP	STARS	STARS	STAIR	STARE	LUNCH
BLOOD	VANE	VANE	VEIN	VINE	MOTH
BLOOD	VINE	VINE	VEIN	VANE	MOTH
BOAT	SALE	SALE	SAIL	SALT	CROP
BOAT	SALT	SALT	SAIL	SALE	CROP
JAIL	BALE	BALE	BAIL	BALL	NEWS
JAIL	BALL	BALL	BAIL	BALE	NEWS
STORY	TAIL	TAIL	TALE	TALK	NEED
STORY	TALK	TALK	TALE	TAIL	NEED
HEAD	HARE	HARE	HAIR	HARM	NEST
HEAD	HARM	HARM	HAIR	HARE	NEST
BUN	ROLE	ROLE	ROLL	ROCK	PATH
BUN	ROCK	ROCK	ROLL	ROLE	PATH
SPIRIT	SOLE	SOLE	SOUL	SOIL	PARK
SPIRIT	SOIL	SOIL	SOUL	SOLE	PARK
MUSIC	LOOT	LOOT	LUTE	LIST	FEAR
MUSIC	LIST	LIST	LUTE	LOOT	FEAR
STREAM	CREAK	CREAK	CREEK	CROOK	BLOOM
STREAM	CROOK	CROOK	CREEK	CREAK	BLOOM
VOTE	POLE	POLE	POLL	POOL	TEST
VOTE	POOL	POOL	POLL	POLE	TEST
MAJOR	MINER	MINER	MINOR	MANOR	PEDAL
MAJOR	MANOR	MANOR	MINOR	MINER	PEDAL
DAY	KNIGHT	KNIGHT	NIGHTS	FLIGHT	BRANCH
DAY	FLIGHT	FLIGHT	NIGHTS	KNIGHT	BRANCH
WATER	REIN	REIN	RAIN	RUIN	BOOT
WATER	RUIN	RUIN	RAIN	RUIN	BOOT
VIRTUE	VISE	VISE	VICE	VILE	NULL
VIRTUE	VILE	VILE	VICE	VISE	NULL
MEAT	STAKE	STAKE	STEAK	STALE	FLIRT
MEAT	STALE	STALE	STEAK	STAKE	FLIRT
SHOE	HEAL	HEAL	HEEL	HELL	LACK

SHOE	HELL	HELL	HEEL	HEAL	LACK
MOON	SON	SON	SUN	SIN	LEG
MOON	SIN	SIN	SUN	SON	LEG
ACHE	PANE	PANE	PAIN	PANS	LUMP
ACHE	PANS	PANS	PAIN	PANE	LUMP
PART	PEACE	PEACE	PIECE	PEACH	STRAW
PART	PEACH	PEACH	PIECE	PEACE	STRAW
GARBAGE	WAIST	WAIST	WASTE	WARTS	PUNCH
GARBAGE	WARTS	WARTS	WASTE	WAIST	PUNCH
CLAM	MUSCLE	MUSCLE	MUSSEL	MUSEUM	OCCUPY
CLAM	MUSEUM	MUSEUM	MUSSEL	MUSCLE	OCCUPY
FRIEND	PIER	PIER	PEER	PIES	MOBS
FRIEND	PIES	PIES	PEER	PIER	MOBS
HARP	LIAR	LIAR	LYRE	LURE	HAWK
HARP	LURE	LURE	LYRE	LIAR	HAWK
FENCE	GAIT	GAIT	GATE	GASP	CROW
FENCE	GASP	GASP	GATE	GAIT	CROW
FRUIT	PAIR	PAIR	PEAR	PART	FLIP
FRUIT	PART	PART	PEAR	PAIR	FLIP
RICH	PORE	PORE	POOR	PORK	LANE
RICH	PORK	PORK	POOR	PORE	LANE
DISCIPLE	PROFITS	PROFITS	PROPHET	PROTEST	HEALTHY
DISCIPLE	PROTEST	PROTEST	PROPHET	PROFITS	HEALTHY
WEEKS	DAZE	DAZE	DAYS	DAMS	BULB
WEEKS	DAMS	DAMS	DAYS	DAZE	BULB
EGG	YOKE	YOKE	YOLK	YORE	LUST
EGG	YORE	YORE	YOLK	YOKE	LUST
GROWN	MOWN	MOWN	MOAN	MOON	BAND
GROWN	MOON	MOON	MOAN	MOWN	BAND
SHIP	ARC	ARC	ARK	ARM	FIT
SHIP	ARM	ARM	ARK	ARC	FIT
ME	EWE	EWE	YOU	RAT	TIN
ME	RAT	RAT	YOU	EWE	TIN
WHEAT	WRY	WRY	RYE	CRY	SIT
WHEAT	CRY	CRY	RYE	WRY	SIT
FLOWER	ROWS	ROWS	ROSE	ROBS	DENT
FLOWER	ROBS	ROBS	ROSE	ROWS	DENT
DOLLARS	SENSE	SENSE	CENTS	MENDS	ROACH
DOLLARS	MENDS	MENDS	CENTS	SENSE	ROACH
PADDLE	ORE	ORE	OAR	OUR	TWO
PADDLE	OUR	OUR	OAR	ORE	TWO

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