PHONOLOGICAL RECODING IN THE LEXICAL DECISION TASK.

Karin Elisabeth Patrizia Carter, B.Sc.

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University of York

Department of Psychology.

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ABSTRACT

The finding that nonwords (pseudohomophones) that sound like real words when pronounced take longer to be rejected in a lexical decision task than nonhomophonic nonwords has been used to support the argument that lexical access is mediated by a phonological or speech-based code. A series of six experiments explored the pseudohomophone effect as it has been suggested that previous demonstrations of the effect might be due to the greater visual similarity of pseudohomophones to words than the nonhomophonic control nonwords. Overall pseudohomophones were not responded to more slowly than their matched control nonwords. The phonological similarity of pseudohomophones to words had no reliable effect on the response times lending further support to the view that earlier demonstrations of the pseudohomophone effect had failed to adequately control the visual similarity of nonwords to real words.

Two other pieces of evidence for phonological recoding in the lexical decision task were examined. In Experiment 7 regular and irregular words were presented in a lexical decision task. If speech coding does take place prior to lexical access, then regular and exception words should be responded to differently. Reaction times to accept irregular words which do not conform to the grapheme-phoneme correspondence rules of English were no longer than those of regular words which are consistent with such rules and so should be recognized more easily. In the final experiment high and low-frequency homophones (BLEW/BLUE) and frequency matched control words were presented in the context of nonhomophonic nonwords. The results failed to show a homophone effect. The absence of any effects of phonological coding in the lexical decision task was discussed in the context of current theories of word processing. Dual-route theories which propose a nonlexical processing route were tentatively rejected on the basis of the evidence discussed.

INTRODUCTION

The central aim of this thesis was to test whether a phonological code is used in reading individual words. The term phonological recoding is taken to mean that the visual representation of a given letter string is translated into a speech-like code. This phonological code is then used to access the readers' mental lexicon; a dictionary like store containing a word's meaning, spelling and pronunciation.

The experimental paradigm used to investigate this question is the lexical decision task. In this task the subject is required to indicate whether a series of visually presented letter strings are real words or not. It is presumed that in such a task the subject searches their lexicon in order to check whether a corresponding lexical entry which matches the letter string presented is present.

In Chapter 1, some of the previous evidence in favour of phonological coding occurring pre-lexically is reviewed from three major sources, words, nonwords and an aquired reading disorder. Overall the evidence for pre-lexical phonology is equivocal. One major piece of evidence is the pseudohomophone effect. This is the finding that nonwords that sound like a real words (e.g. BRANE, which sounds like BRAIN) take longer to be rejected in a lexical decision task than nonwords that are not homophonic with a real word (e.g., PRANE). The extended response times shown to such nonwords have typically been interpreted as evidence that a speech-based code activated the lexical entry of the corresponding word. Pseudohomophones are then rejected some time later following the failure of a spelling check.

In Chapter 2, three experiments are reported in which the influence of physical characteristics and context are used to explore the pseudohomophone effect. It has been claimed that the pseudohomophone effect might be due to the greater visual similarity of pseudohomophones to words than the nonhomophonic nonwords. This claim was assessed in Experiment 1. Four types of nonwords of varying visual and phonological similarity to real words were presented in a lexical decision task to a group of skilled readers. A significant difference in reaction time was found between pseudohomophones and other nonwords that were less similar to real words, but there was no difference in the subjects' response times to pseudohomophones and control words matched for visual similarity, although there was a trend in this direction. This trend was also reflected in significantly higher error rates shown to pseudohomophones. An explanation was offered in terms of case of presentation. In this experiment upper-case characters had been used, which are more difficult to process. Slower processing may have given time for phonological effects to manifest themselves.

This proposal was tested in Experiment 2. The same pseudohomophones and visual control nonwords as were used in Experiment 1 were presented to two new groups of subjects. One group saw the stimuli in upper-case, and the other group saw them, in lower-case. Overall pseudohomophones were not responded to more slowly than their matched control nonwords. The interaction of nonword type and case was weakly supported. Pseudohomophones presented in upper-case were rejected more slowly than the matched control nonwords. The results give only very weak support to the view that a pseudohomophone effect would be more easily found with the stimuli presented in upper-case.

In Experiment 3, the effect of context was explored while using a new set of stimuli. In this experiment it was predicted that pseudohomophones would take longer to reject when a higher proportion of nonhomophonic nonwords were included. Phonological recoding is claimed to be an optional process subject to such factors as the nature of the nonwords, therefore subjects could adopt a phonological strategy when the costs involved in terms of errors are relatively few. The results did not support the predicted interaction of nonword type and context.

In Chapter 3, three experiments explored whether the effects of a number of visual variables would influence the finding of a pseudohomophone effect. It has been argued that the pseudohomophone effect might be a small effect that can be magnified by using double pseudohomophones, that is pseudohomophones that sound like an English homophone (e.g., BLOO sounds like BLUE and BLEW). Experiment 4 examined whether double pseudohomophones influence the pseudohomophone effect. The results did not support the claim that a pseudohomophone effect will be more easily obtained by using double pseudohomophones.

In Experiment 5, pseudohomophones and visual control nonwords were again compared following the generation of a new set of stimuli in which the items differed in two or more letter positions from a target word. This manipulation was to reduce the visual similarity of the nonwords to words. As the stimuli visually bore little resemblance to words it was expected that subjects might adopt a phonological strategy. The results of the study were negative. Once again the phonological similarity of pseudohomophones to words had no effect on the response times lending further support to the view that earlier demonstrations of the pseudohomophone effect had failed to adequately control the visual similarity of nonwords to real words.

Experiment 6, tested the proposal that the presence of homophones amongst the word set may be important for producing a reliable pseudohomophone effect. The results failed to support claims that the pseudohomophone effect is more easily found in the context of homophones.

Chapter 4 explored the possibility that individuals may differ in their reliance on phonological recoding. The claim has been made that individuals can be divided into two polar groups, the "Phoenicians" who rely more heavily on phonological processing and "Chinese" style readers who do not. A preliminary spelling-pronunciation test was conducted in order to select subjects who were either good (Phoenicians) or poor (Chinese) at using phonological rules. The Chinese and Phoenicain style readers were then tested in two lexical decision experiments.

In Experiment 7(a) the two groups groups of subjects produced indistinguishable responses in a test of the pseudohomophone effect and in Experiment 7(b) the two groups did not respond differently to irregular and regular words. The results were interpreted as further evidence in support of the claim that the pseudohomophone effect is an effect of visual similarity rather than phonological similarity. If this were not the case Phoenician style readers would be expected to have shown an enhanced pseudohomophone effect. The absence of a regularity effect was consistent with current research.

In Chapter 5, a final experiment (Experiment 8) examined the reported effects of homophony (e.g., BLEW/ BLUE) on lexical decision response time. It has been reported that the lower frequency member of a homophonic pair of words takes longer to be rejected than frequency matched nonhomophonic words. This was interpreted as evidence that words undergo speech coding prior to lexical access. Experiment 8 explored whether this effect was dependent on the kind of nonword stimuli used. High and low-frequency homophones with frequency matched control words were presented in the context of nonhomophonic nonwords. The results showed that there was frequency effect; high-frequency words were responded to more rapidly than low-frequency words. However, there was no difference in the reaction times between homophones and control words across either high or low-frequency stimuli. The results implied that earlier demonstrations of the homophone effect were not reliable.

In Chapter 7 a general summary of the findings are presented together with their theoretical implications. Overall there was no evidence for phonological coding in the lexical decision task. The absence of such evidence raised the question of whether the lexical decision task is a good measure of the processes involved in reading single words. It was concluded from a review of other recent studies that the lexical decision task may reflect additional post-lexical processes and may therefore provide a poor measure of the processes involved in lexical access in normal reading.

CHAPTER 1.

PHONOLOGY IN READING.

1.1 Introduction.

Reading is the process whereby we understand written language. It is generally assumed that information about the words which we read is retrieved from a "mental lexicon". The lexicon is rather like a dictionary (Triesman 1963), where a word's previously learned meaning, spelling and pronunciation are stored. The question that we want to consider, is to what extent a speech code derived from the printed letter string is used to gain lexical access? The possible use of a speech code prior to lexical access is to be distinguished from post-lexical phonology, where a speech code is retrieved from the lexicon after it has been accessed e.g. the following symbols %, $, & can all be assigned a pronounciation as a consequence of post-lexical phonology. The possible use of a speech code to gain lexical access, and so retrieve the reader's knowledge about a word's meaning, has been a central concern in studies of word recognition in skilled readers.

1.1.1 History.

The study of speech recoding in reading has a long history: "To read, in effect is to translate the writing into speech" (Egger,1904 cited in Huey, 1908/1968). The suggestion that visual information in reading is transformed into a speech code has come from a number of sources. There is the powerful introspective evidence of silent reading frequently being accompanied by "inner speech". Huey wrote that:

> "Although it is foreshortened and incomplete speech in most of us, yet it is perfectly certain that the inner hearing or pronouncing, or both, of what is read, is a constituent part of the reading of by far the most of people, as they ordinarily and actually read" (pp 117-118).

Direct evidence for inner speech has come from electromyographic studies, where the electrical activity of the skin lying over the muscles concerned with speech are recorded. Edfeldt (1959) reviewed the experimental literature and found that electrical activity in both the vocal and mylohyoid muscles increases in reading in all people, although good readers show less evidence of silent speech than do poor readers. Readers of all ability however, engage in more silent speech as text difficulty increases. The electromyographic (EMG) studies are, nevertheless, difficult to interpret, as muscle tone in general increases as the difficulty of the task increases. Furthermore, proponents that equate silent speech, as revealed by electromyographic recordings, with speech coding, are ensnared by the observation that inner speech is much slower than even the longest estimates of reading comprehension times (Gough,1972). There is also the further problem that inner speech detected in EMG studies may reflect the use of speech after lexical access has been completed.

The link between speech processes and reading has been seen as a natural one for the beginning reader. For example, Gough and Cosky (1977) argued in favour of speech coding on the grounds of cognitive economy. The beginning reader already has a foundation for understanding speech, so by translating the written word into a speech code, they would achieve an efficient way of decoding it. However, even if this argument were accepted, it may be that in the skilled reader such recoding is unnecessary.

1.2 Theories of Prelexical Phonological Recoding.

The basic question is, if prior to lexical access words are recoded into a speech code, how might this recoding be accomplished? A number of proposals have been put forward as to how this might take place (Gough, 1972; Rubenstein, Lewis and Rubenstein, 1971; Marshall and Newcombe, 1973; Morton, 1979; Coltheart, 1978/1980/1985):

(1) Grapheme-Phoneme Correspondences (GPC's). One possibility is that the word is broken down into segments reflecting single phonemes (that is the distinctive sounds that distinguish words with different meanings e.g., DOG has 3 letters and 3 phonemes D/O/G, whereas SHEEP has 5 letters and only 3 phonemes SH/EE/P). Grapheme-phoneme correspondence rules could then be used to assign phonemes to the corresponding graphemes (that is a letter or cluster of letters corresponding to a phoneme);

(2) An alternative unit from which to derive a speech code is the syllable, e.g. BATTER can be broken down into two syllables BAT/ TER;

(3) Finally the whole word might be entered into a phonological lexicon and this representation could then be used to access the word's meaning and spelling.

Another option is that a speech code is unecessary for lexical access and that it proceeds from the visual representation alone, the so called "direct" route (Baron, 1973; Bower, 1970; Kolers, 1970; McClelland and Rumelhart, 1981). Probably the most popular theoretical position is that readers use both forms of internal representation to achieve lexical access (e.g. Coltheart, 1978, 1980). The strict view that speech coding is an obligatory precurser is untenable, as logographic writing systems such as Chinese can still be read. The experimental literature suggests that readers have access to both forms of internal representation. This has given rise to a class of theories known as dual-access models (Foster and Chambers, 1973; Meyer, Schvaneveldt and Ruddy, 1974; Allport, 1977, 1979; Frederickson and Kroll, 1976; Marshall, 1976; Coltheart, 1978, 1980; Marcel and Patterson, 1978; Morton and Patterson, 1980). These models share a number of features in that they distinguish between two proceses; one that is visually mediated and an indirect path, that uses phonology, as a precursor to entering the lexicon. These processes are independent and proceed in parallel, with a number of theorists e.g. Foster and Chambers,(1973) and Coltheart, (1978) postulating that visual access proceeds more rapidly.

Coltheart (1978/1985) proposed a dual-route theory by which oral reading can take place. He argued that normal adult readers have available two separate and independent methods by which printed words can be assigned pronunciations. A word may be pronounced either by the "direct route", where the visual representation of the stimulus is encoded and mapped on to its stored representation within the lexicon or by an "indirect route", where the visual representation is encoded into a phonological code through a process of spelling-to-sound rules. With the direct route the phonology of the entire word is retrieved and knowledge of the item's spelling and meaning can also be referenced. The indirect route allows a pronunciation to be generated without any direct knowledge of words, in this way unfamiliar words and nonwords can be sucessfully pronounced.

Coltheart (1978/1985) suggested that the phonological code is derived through the operation of grapheme-phoneme correspondence rules (GPC's) described by Venezky (1970). The word is segmented into functional spelling units (that is spelling units which correspond to individual phonemes for example M, P and EA). These units are then translated using a series of "context sensitive rules" into the corresponding phonemes with the most common correspondence being assigned.

An alternative class of theories reason that GPC's are unecessary; lexical analogy models propose that both words and nonwords enter the visually addressed lexicon. The neighbourhood of visually similar lexical entries and their phonological representations are activated depending on their resemblance to the presented stimuli. Although the unit has not been specified, Glushko (1979) has pointed to the number of shared letter clusters especially those at the end of the word to be influential. The activation is dispatched more quickly for real words, than that for nonwords, partly as a result of stimulating a word's particular entry, and in addition the resting activation of a word's entry is an inverse function of its frequency.

According to this theory, the pronunciation of a letter string, is generated from the net effect of a number of subsegments of phonological representation that have been stimulated. The pronunciation of nonwords is slower as it relies on several sources of information. Glushko is not very clear as to how the decision process takes place, but the less inconsistency between the activated representation and other competing representations the faster the decision process can take place.

Another and more explicit version of the activation and synthesis model has been advanced by McClelland and Rumelhart (1981). Their model provides a detailed mechanism to explain the effects of neighbours which are an important feature of Glushko's model (1979). This model postulates three levels of representation: features, letters and words. At each level, every item is represented by a node. These nodes have different resting values of excitation, thereby accomodating such effects as frequency. Communication between neighbouring nodes occurs by a process of spreading activation that is both of an excitatory and inhibitory nature. The stages of processing occur in a parallel as well as cascade fashion, that is current activity started in one level is not completed before "spilling-over" and stimulating the activity in the next level. The flow of activity is described as being in cascade because activity at higher levels begins before processing at lower levels is complete. There is interactive feedback across adjacent levels. Information at each level feeds into the next stage thereby building up a representation. A visually presented letter string activates nodes at different levels. As the activation of certain features grows those letter nodes consistent with that information are stimulated, in turn, letter nodes pushed beyond their resting values of excitation arouse nodes for words that are consistent with those letters and suppress inconsistent word nodes. The word nodes enhance the consistent letter nodes through a process of feedback. Within a level the nodes compete with each other by active suppression, it is through the summation of activation and inhibition that the representation of letters and words are isolated. Although the model of McClelland and Rumelhart does not include a level for pronouncing words, a simple extension could include stored knowledge about pronunciation, which would then be executed following visual analysis. The pronunciation could be determined either from the identified word or synthesized from the partial activation of the neighbourhood of excited nodes.

An alternative analogy model (that is one whereby the similarities between words are exploited in order to produce a pronunciation for a letter string) has been put forward by Marcel (1980) and Kay and Marcel (1981). They proposed that a printed letter string is subjected to all possible segmentations with morphemes (that is the smallest meaningful unit of language) in particular being marked. The letter string is parsed simultaneously from left to right with the initial letter forming the first segment. As each additional letter is parsed it is bracketed with earlier letters to create a potential segment. These brackets are not overidden by subsequent brackets, therefore the word "detect" would have the following bracketed segments:

d...de...det...dete...detec...detect

Those letters that remain unbracketed also form a potential segment for instance:

d...etect, de...tect, det...ect, dete...ct, detec...t

The parsed segments address matching segments in the same position of other words within the visual input lexicon. Following this access to the lexicon by a word or morpheme the pronunciation can be retrieved from the output lexicon. In the case of nonwords and unfamiliar words the pronunciation is produced by blending the segments, with the predominant correspondences (that is those which occur in most instances) being assigned when alternative pronunciations are encountered, as in the case of -AVE. The pronunciation produced as a result of segment blending is overridden in the case of known words which have a complete lexical address.

The dual-route model has, in the light of recent experiments, been updated and modified to accomodate these proposals and findings concerning the use of analogies (Patterson and Morton 1985). In the original model the GPC's were thought to operate on the commonest correspondence between graphemes and phonemes but this could not predict, or account for, Glushko's (1979) demonstation that less frequent correspondences are assigned on occasion to inconsistent nonwords. Campbell and Besner (1981) have also shown that the assignment of phonemes varies as a function of context and position within a sentence, and according to the basic dual process model there is no interaction between words. In addition the orthographic unit in the dual-route model is the grapheme and, as a result, the model does not take account of morphemic boundaries within words as well as any regularity that might occur between larger clusters of letters. Kay and Lesser (1985) have found that the terminal consonant clusters influenced the pronunciation assigned to nonwords, showing that units larger than the graphemic unit are used. These results are at odds with the dual process model as it originally stood.

Patterson and Morton (1985), have outlined a modified model of nonlexical phonology, the orthography-to-phonology correspondence (OPC) system. Within the nonlexical OPC system they proposed that there are two subsystems. The grapheme-to-phoneme correspondence system in which a single grapheme (or grapheme cluster) maps on to a corresponding phoneme. There is in addition to this system a body segment system which allows units larger than graphemes to map on to phonology. Bodies correspond to the terminal vowel-consonant segment of monosyllabic words. They differ from the GPC system which has a simple one-to-one mapping of graphemes to phonemes in that they have a more complicated one-to-many mapping of rules. Patterson and Morton described a number of different types of body segments; the differences reflected the properties of irregular and regular pronunciations for such segments in words. Within the nonlexical OPC system the two subsystems operate in such a way that the production of a nonlexical OPC code arises from either the GPC subsystem or the body subsystem. They further proposed that the GPC subsystem provides the nonlexical code on about seventy per cent of occasions with the body subsystem being selected on the remaining thirty per cent of occasions.

The lexical and nonlexical codes tend to overlap in the time it takes them to arrive at the output system but the lexical code has a slight edge in terms of speed of arrival. On arrival a code is processed and eventually pronounced. If before the processing of the first code is complete another code is received at the output system a delay in the pronunciation is incurred while the two codes are compared. If the lexical and nonlexical codes match the processing of the pronunciation code is resumed with only a short delay as a result of the interuption. If the two codes do not match a lexical check follows which will further delay the final production of a pronunciation.

In the OPC system the consistency effect arises from the processing mismatch between consistent and inconsistent words by the lexical and nonlexical routes. Consistent words will produce matching phonological codes by the nonlexical and lexical routes therefore no delay would be expected in the production of a pronunciation. However, inconsistent words will yield different phonological codes since the bodies of such words have more than one correspondence, for example, the regular inconsistent word COVE has a body segment "OVE" which is pronounced differently in many irregualar words such as LOVE and DOVE. A delay in responding to these types of words follows as aresult of the mismatch between the two codes.

Kay and Marcel (1981) and Kay (1985), have argued that the modified dual-route theory has become increasingly complicated in comparison to analogy theory where the idea of separate processes is dispensed with. However, despite the apparent economy of analogy theory it is as yet not clear how the words are represented in this store -that is, whether they are already stored as segments or whether the whole word is subject to segmentation. Overall the modified dual-route model has become increasingly complex and the strong notion of independent processing routes has been somewhat relaxed. The routes are still separate but some interaction between them is allowed to occur at a late stage.

1.3 Evidence in Favour of Prelexical Speech Coding.

The question that must now be considered is what evidence there is in favour of pre-lexical speech coding. Two tasks have been used extensively to study this question, the lexical decision task (LDT) and the pronunciation latency task (PLT). In a lexical decision task a subject is presented with letter strings visually. These letter strings may form legitimate English words, or be non words such as SLINT. The nonwords used may vary in their pronounceability (GRATF) and conformity to orthographic rules (NGKA). The subject is required to make a positive response to those strings which are real words and a negative response to those that are not legitimate English words. The dependent measure is reaction time. Similarly in the pronunciation task, subjects respond by pronouncing the visually presented stimuli, and the latency to initiate a response is recorded.

1.3.1 Pseudohomophones.

Rubenstein, Lewis and Rubenstein (1971) hypothesized that if letter strings undergo phonological coding prior to lexical access, then the recognition times of letter strings should vary depending on their phonological characteristics. The first experiment of Rubenstein et al., looked at the lexical decision times of nonwords that varied in pronounceability. They presented 30 orthographically and phonologically illegal nonwords that were, they argued, unpronounceable (e.g. TUBW, although the point of pronouncability is questionable), and 135 pronounceable, orthographically and phonologically legal (e.g. STRIG) nonwords. In addition 245 words were intermixed. These stimuli were presented to 45 subjects. They found that orthographically and phonologically legal nonwords like STRIG took longer to reject than illegal nonwords that were pronounceable (RATN) or unpronounceable (TUBW). The unpronounceable nonwords were rejected most quickly.

In their second experiment they compared the lexical decision times of pseudowords that were homophonic (e.g. BURD) with another word (e.g. BIRD, these will now be called pseudohomophones) against nonhomophonic nonwords (ROLT). The pseudohomophones were divided into two categories according to the properties of the word they represented, either high-frequency (300-500 Lorge magazine count) or low-frequency (30-50 Lorge magazine count). Rubenstein et al., selected 19 high-frequency pseudohomophones, 20 low-frequency pseudohomophones and 17 nonhomophonic nonwords. The pseudohomophones were homophonic with one English word. These were presented together with 338 words to 44 subjects. Their results showed that nonhomophonic pseudowords were rejected faster than the pseudohomophones. The frequency of the word they represented was found to have no effect on reaction time.

To explain these results Rubenstein et al., proposed that in word recognition letter strings undergo obligatory speech recoding. It is this code that is used to search the lexicon and it is compared serially in an exhaustive frequency ordered search. Following a phonological match between the target and a lexical entry a further check is made between their spellings. If a phonological match is not found, the search continues until all items in the lexicon have been checked, and then a negative response can be made. According to this model, in the first experiment the unpronounceable nonwords were rejected fastest as they never initiated a search of the lexicon because subjects failed to recode these letter strings into a speech code. The longer reaction times for pronounceable nonwords indicates that these letter strings could only be rejected as nonsense following a search of the internal lexicon failing to find a match. Pseudohomophones are successfully recoded and do match a phonemic representation in the lexicon, for example the letter string BREYN, would match the word BRAIN, but could only then be rejected following a spelling check. Performing a spelling check has a time cost, and pseudohomophones in comparison to nonhomophonic pseudowords are rejected more slowly following the failure to find an appropriate match.

The experiments of Rubenstein et al., (1971) were criticized on statistical grounds by Clark (1973) as only the subjects and not the materials were treated as a random factor. Clark argued therefore, that the findings could not be generalized to other materials. However, when he reanalysed the results of Rubenstein et al., with both the materials and subjects treated as random factors, he found with this more conservative analysis that the pseudohomophone effect was still reliable.

Further criticisms however, came from Coltheart, Davelaar, Jonasson and Besner (1977). They argued that the pseudohomophone effect was not necessarily a phonological one, as the nonwords were not matched in their visual similarity to real words. Therefore, it is possible that the pseudohomophones may have looked more like English words than the nonhomophonic nonwords.

Coltheart, Davelaar, Jonasson and Besner (1977) carried out a partial replication of the experiment of Rubenstein et al. Their stimuli consisted of 78 words, half of the words were the less frequent member of a homophonic pair and the remainder were control words matched for frequency, length and part of speech. The nonwords constituted 39 double pseudohomophones, and 39 nonhomophonic visual controls. Each pseudohomophone sounded like an English homophone, e.g HOAL (sounding like whole and hole) and WAID (sounding like weighed and wade). The presentation of double pseudohomophones was a deliberate attempt by Coltheart et al., to magnify the effect. For according to the model of Rubenstein et al., the access procedure involves a serial search whereby unsuccessful spelling checks will produce longer reaction times. Therefore, more time costs will be incurred when two or more spelling checks are required. The visual controls were formed by changing one letter of the pseudohomophone e.g. HOAL to create a pronounceable nonhomophonic nonword was changed to JOAL, with the same number of syllables and letters. The 78 words and 78 nonwords were presented to 20 subjects in a random order. Coltheart, Davelaar, Jonasson and Besner (1977) found a significant pseudohomophone effect, that is the double pseudohomophones had longer rejection latencies than their matched visual controls, this effect generalized across both subjects and materials.

Martin (1982) has proposed that the pseudohomophone effect as reported by Coltheart et al., (1977), is a visual rather than a phonological effect. She argues that in order for pseudohomophones to sound like words they also tend to share more letters in common with that word, and so may be more visually similar to words than other nonwords. She proposed that the less similar a nonword is to words the more easily it will be rejected. The visual controls of Coltheart et al., (1977) for the pseudohomophones were created by changing one letter of the pseudohomophone for instance, WURLD, to result in a pronounceable nonword like MURLD. They proposed that the control nonword MURLD is still visually similar to a word. However, this procedure results in pseudohomophones differing from words by one letter and their visual controls by 2 letters from the same word. One way of checking the similarity of the pseudohomophones and visual control nonwords is to use an "N" measure suggested by Coltheart et al., (1977). This measure is calculated by counting the number of words that can be created from a nonword by changing one letter at a time while holding letter positions constant, e.g. BRANE has a N-count of 3 words, CRANE, BRINE and BRAND. Martin showed that in the experiment of Coltheart et al., the average N-count for the pseudohomophones was 5.7, while that for their matched controls was 3.4. This difference was statistically significant.

Martin went on to conduct an experiment where nonwords matched for N-count were compared to pseudohomophones. She found two words of similar frequency whereby a change in one word resulted in a pseudohomophone and a similar change in the other word formed a pronounceable nonhomophonic nonword, (e.g. WoRD and CoST > WERD and CEST). The stimuli were matched in their number of syllables and letters. The difference in N-count for Martin's pseudohomophones and visual controls was not significant. Martin found no difference in reaction times between pseudohomophones and nonwords that were matched for N-count, and so concluded thst when visual similarity to real words is controlled, phonological effects will not necessarily be found on nonword trials. On the other hand, nonwords of lower N-count which were therefore less word like, did show significantly faster reaction times when compared to the pseudohomophones.

Taft (1982), has also challenged the status of the pseudohomophone effect as evidence for the generation of a speech code in lexical access. In a similar fashion to Martin (1982), he controlled the stimuli so that orthographic similarity and homophony were not confounded. His pseudohomophone and control nonwords were matched in the same way to real words. Taft took pairs of words which shared an orthographic pattern (that is spelling pattern), but which were pronounced differently, for instance GHOST and FROST share the same orthographic pattern OST. By appropriately changing the orthographic pattern in both words, a pseudohomophone (GHOAST) and nonhomophonic nonword (FROAST), which have exactly the same relationship to a real word can be produced. If speech coding is taking place, pseudohomophones like GHOAST should take longer to be rejected than the nonhomophonic control nonwords like FROAST. If on the other hand, the effect is really a result of orthography, then no difference should be found between these two types of nonword.

The first experiment of Taft (1982) looked at the effect of orthographic similarity in lexical decision responses to nonwords and words. He presented 20 pseudohomophones (GHOAST), 20 nonhomophonic nonwords (FROAST), that were orthographically similar to a real word and 20 nonhomophones (PLOAT) that were not orthographically similar to a word. In addition the word stimulus set was made up of 15 homophonic words (e.g. PANE; they were always the less frequent member of a homophonic pair), and 15 nonhomophonic control words (e.g. JERK) matched for frequency and length. There were also 15 nonhomophonic words (e.g. GREET) that were orthographically similar to another word (e.g. GREAT), and 15 matched control words (CREST). The 120 words and nonwords were presented to 30 subjects in a lexical decision task.

Taft found that on analysing the reaction times for the nonwords, that there was no difference between pseudohomophones and matched controls but that reaction times to pseudohomophones were significantly slower than to nonwords that were not orthographically similar to words. It was shown that the orthographic similarity of nonwords to real words resulted in longer reaction times when compared to nonwords that were not orthographically similar to real words. This supports the argument of Martin (1982), that previous demonstrations of the pseudohomophone effect were a consequence of the pseudohomophones visual similarity to real words, rather than evidence for speech coding.

These recent results with nonwords fail to support the idea that a phonological code is used during lexical access. It is, however, possible that phonemic recoding does occur, but that it is under the optional control of the subject. This idea was advanced by McQuade (1981). She placed a small comparison group of 20 pseudohomophones and 20 control nonwords in two nonword enviroments. One was made up of only pseudohomophones such as GRONE and the other of nonhomophonic nonwords such as SLINT. Subjects in a lexical decision task responded with longer reaction times to pseudohomophones in the nonhomophonic nonword environment but the effect was abolished when the distractors were all pseudohomophones. These results were seen as support for the view that subjects are able to choose a speech-coding strategy depending on whether it would be beneficial or detrimental to making lexical decisions. However, McQuade did not consider the arguments concerning visual similarity of pseudohomophones to real words put forward by Martin and Taft. As the materials were not published it is impossible to be sure, but it is likly that the pseudohomophones were visually more similar to words than the control nonwords.

The objections of Martin and Taft to the pseudohomophone effect have not gone unchallenged. Besner and Davelaar (1983), carried out a successful replication of the pseudohomophone effect using Coltheart et al's., (1977) set of stimuli. Their stimuli were matched for the number of letters, number of syllables and overall number of orthographic neighbours (N-count). However, the pseudohomophones did differ in one respect from those of Martin's (1982). Besner and Davelaar's pseudohomophones were homophonic with an English homophone (that is a word with the same pronunciation but different spelling as that of another word e.g., FLORE is homophonic with FLOOR and FLAW) whereas Martin's stimuli were homophonic with only one English word. Besner and Davelaar (1983) like Coltheart et al., (1977) proposed that the pseudohomophone effect might be difficult to detect, and by using double pseudohomophones, it could be magnified

There are however, a number of problems with Besner and Davelaar's (1983) experiment. On analyzing the stimulus set it was found that amongst the matched control nonwords was one real word (SILD, a kind of fish) and up to eight pseudohomophones depending on ones pronunciation of the stimuli [KORM, (corm); HEGE, (hedge); CORZE, (cause); FIE, (fee); BAID, (bade); STOUK, (stook); BORT, (bought); and SLOO, (slew)]. With 23% of the nonwords consisting of either words or pseudohomophones it is somewhat surprising that Besner and Davelaar found such a strong pseudohomophone effect with this "contamination".

In terms of the number of letter changes needed to produce the control nonwords, the visual controls of Besner and Davelaar's are equivalent to those of Martin's approximate visual controls. Besner and Davelaar's stimuli might therefore, still be more visually different than the pseudohomophones are from real words (even when they have similar N-counts) and may have less common combinations of letters occurring in a string. This might mean that the visual controls of Besner and Davelaar would therefore be rejected as nonsense more quickly. Besner and Davelaar's result could then be explained purely as a visual effect and not as a result of speech coding being used to access the lexicon.

An alternative account of the apparent inconsistencies in the demonstration of the pseudohomophone effect has been put forward by Dennis, Besner and Davelaar (1985) in terms of context sensitivity. Context effects have been shown to affect the pseudohomophone effect by McQuade (1981), she found that a low proportion of pseudohomophone in a list would produce a pseudohomophone effect in the lexical decision task but that this effect disappeared when the proportion of pseudohomophones was increased. Similarly the homophone effect (the finding that low-frequency words that have the same pronunciation but different spelling to another higher frequency word, take longer to be accepted as real words e.g. BLEW and BLUE than frequency matched nonhomophonic words) demonstrated by Davelaar et al., (1978) was found to depend on the background context. Dennis, Besner and Davelaar (1985), found a significant pseudohomophone effect using Martin's (1982) pseudohomophones and visual controls when they were presented with control words half of which were homophones. This pseudohomophone effect was not elicited however, when the homophones were absent in another experiment. Dennis et al., argued that pseudohomophones have the property of sounding like a real word (or several words) without the corresponding spelling and this characteristic can be used to identify a letter string as a nonword, when homophones are absent or occur only occasionally amongst the stimulus word set. However, this evidence for making negative responses is lost in the presence of homophones which have several alternative spellings for the same sounding word. Hence the reaction times to pseudohomophones in the presence of homophonic words are lengthened.

Their pseudohomophone effect was, however, significant only across subjects and not across materials. Similarly their homophones were significantly slower across subjects but not across stimuli. These results are therefore tenuous and for Dennis et al., to propose that homophones contribute to the finding of a pseudohomophone effect, their findings would need to be replicated with a new set of stimuli, and shown to generalize across both subjects and materials.

1.3.1(a) Summary and Conclusions.

A large number of experiments have been reported demonstrating that pseudohomophones like BURD (sounding like BIRD), take longer to be rejected in the lexical decision task and show more errors, compared to matched pronounceable nonhomophonic nonwords such as DURD (e.g., Rubenstein, Lewis and Rubenstein, 1971; Frederikson and Kroll, 1976; Coltheart et al., 1977; Cohen and Freeman 1978;Barry, 1981; Pring, 1981; McQuade, 1981; Marcel and Patterson, 1977; Besner and Davelaar, 1983). However, a significant number of investigators have failed to report a pseudohomophone effect (Martin, 1982; Taft, 1982; Andrews, 1982; Dennis, Davelaar and Besner, 1984). The status of the pseudohomophone effect is at the present time unclear. On inspecting these studies it would appear that those where the pseudohomophones have been carefully controlled for their visual characteristics do not reveal an effect. On the other hand, a number of other factors, such as whether the pseudohomophones are double or single and the context in which the experimental stimuli occur, have been alleged to influence the occurence of the effect. A prudent conclusion would be that there is no unambiguous evidence that the pseudohomophone effect in the lexical decision task is a phonological effect. This effect therefore can no longer be accepted as good evidence in favour of speech recoding in the lexical decision task.

1.3.2 Spelling Regularity.

Words in the English language have been classified as either regular or irregular in their pronunciation, following the application of spelling-to- sound correspondence rules (Wijk, 1966; Venezky, 1970). Regular words such as DOG have a pronunciation that is correctly indexed via spelling-to-sound correspondence rules, whereas irregular words such as PINT have pronunciations that violate such rules and are therefore incorrectly indexed. If the word PINT was regular it would be pronounced so as to rhyme with TINT. A working hypothesis was adopted by Baron and Strawson (1976) who argued that if speech coding does take place prior to lexical access, then regular and exception words would be responded to differently. An alternative hypothesis based on the influence of neighbouring words with similar spelling patterns but dissimilar pronunciations would also predict a processing advantage for regular words over exception words. This hypothesis will be examined in the next section (1.3.2a). Baron and Strawson predicted that regular words would take less time to read than irregular words because the irregular words would be incorrectly indexed by spelling-to-sound rules. If however, readers do not rely on such a speech code no effects of regularity would be expected.

Baron and Strawson (1976), had subjects rapidly read ten lists of regular and irregular words, as defined by Venezky's (1970) rules of pronunciation. Regular words were consistent with the rules of English orthography or the correct pronunciation could be derived from several consistent analogies. The correct pronunciation of exception words however, could not be elicited via these rules or analogies. The lists composed of regular words were read faster than lists of exception words when frequency and word length were matched.

There is nonetheless a difficulty for this type of task, because the production processes are confounded with the decision time. It is possible that irregular words take longer to articulate than regular words and this could give rise to the difference in reading times. It is also possible that the time needed to retrieve and then launch the motor command for a given word (production latency) may differ between irregular and regular words. The study of Baron and Strawson (1976) also included error times which makes the interpretation of their results even more difficult.

Reliable regularity effects however, have been demonstrated in the pronunciation of single words. Fay and Edgmon (cited in Gough and Cosky, 1977) presented irregular and regular words to subjects in a pronunciation task. The words were similarly matched on the number of letters, syllables, form class, initial letter and phoneme as well as frequency. They found that latencies to irregular words were significantly longer than to regular words, however, the 27 msec difference was considerably smaller than the 166 msec difference found by Baron and Strawson (1976). This suggests that articulation latencies may have contributed to, and inflated, the regularity effect demonstrated by Baron and Strawson.

The small but significant regularity effect demonstrated by Fay and Edgmon (1977) has been questioned by Stanovitch and Bauer (1978). They argued that Fay and Edgmon did not measure the production latencies of their stimuli and this could account for the difference they obtained. But they too observed a regularity effect of 18 msec, when there were no differences in the production latencies of regular and exception words. In another experiment the regularity effect disappeared when the subjects were forced by a response deadline technique to respond faster than usual. This is consistent with the idea that lexical access mediated by a speech code proceeds at a slower rate than the direct visual route.

Demonstrations of the regularity effect (Baron and Strawson, 1976; Stanovitch and Bauer, 1978; Glushko, 1979; Underwood and Bargh, 1982), have generally based their classification of regularity on type counts such as those produced by Wijk, (1966) and Venezky, (1970). This is where the number of words with a sequence of letters with a particular correspondence (e.g., OSE) occuring in a given position are counted. This particular method ignores the frequency of the word and the most typical correspondence is considered as the regular one, any other correspondence is consequently considered to be irregular. This can be demonstrated in the example of CAVE and HAVE, there are many more words with the AVE correspondence rhyming with CAVE than with HAVE, and as result regularity based on type counts consider the pronunciation of CAVE to be the regular one despite HAVE being one of the most frequently used words in the English language (Kucera and Francis 1967). As irregularity has frequently been predicted on the basis of these rules, Parkin (1984) examined whether words that were irregular at the letter level according to Venezky's (1970) grapheme-phoneme rules but regular when larger groups of letters were considered, would give rise to a regularity effect.

The subject's task in Parkin's experiment was to name two types of exception words. The first, were true exceptions such as MONK and PINT, where the spelling-to-sound correspondences were either very unusual or unique, but whose orthographic structure (that is the spelling pattern) was not exceptional. The second type were mildly inconsistent in their spelling-to-sound correspondences and were composed of two categories; (a) were irregular at the level of grapheme to phoneme correspondences but regular at a higher level rule e.g., HEALTH; (b) were words with common divergent correspondences e.g., USH, as in PUSH and RUSH. The stimuli were presented in lower-case with the pronunciation latencies of the exception words being compared with those of matched regular words. True exception words were shown to have significantly longer latencies than their matched controls however, this did not hold true for the mildly inconsistent exception words.

In order to counter criticisms that the regularity effect for the true exception words was due to differences in articulation difficulty Parkin presented the same stimuli to a new set of subjects in a second experiment. Here subjects were presented with a single word but were not required to respond until a cue was delivered following the offset of the stimulus. As soon as the cue appeared, they pronounced the word they had identified earlier. Parkin found no differences in the pronunciation latencies. Although Parkin controlled the articulatory onset time of regular and irregular words it may still be more difficult to retrieve the articulatory code prior to pronunciation of irregular words compared to regular words. Therefore, the larger response latencies to irregular words than regular words may reflect differences in retrieval time. It is not clear therefore that this effect reflects the processes involved in lexical access, rather than production processes. Parkin (1984) concluded that the regularity effect is limited to words with exceptional pronunciations. Words which are irregular at a minor correspondence level, or which have common alternative pronunciations are not distinguished by their response times from regular words.

The regularity effect is not always found in the lexical decision task. A substantial number of studies have shown that exception words are more difficult to read aloud than regular words (Baron and Strawson, 1976; Stanovitch and Bauer, 1978; Coltheart, Besner, Jonasson and Davelaar 1979; Glushko 1979, and Parkin, 1984). However this difference has not always been found in the lexical decision task. Stanovitch and Bauer (1978) found a regularity effect whereas Coltheart, Besner, Jonasson and Davelaar (1979), Andrews (1982) and Seidenberg et al (1984) did not. The effects of further moderating influences on the regularity effect have been investigated by Seidenberg, Waters, Barnes and Tanenhaus (1984). In their third experiment they investigated whether spelling-to-sound regularity was influenced by frequency. Four classes of words (high-frequency regular, low-frequency regular, high-frequency exception, low-frequency exception) were presented in a pronunciation and lexical decision task to different groups of subjects. There were no reliable differences in reaction time and onset latencies for the high-frequency regular and exception words in both of the tasks. For the low-frequency words a significant regularity effect across subjects and materials was found in the pronunciation task. There was no reliable difference between the low-frequency regular and exception words presented in the lexical decision task. Seidenberg et al concluded that the regularity effect was limited to lower frequency words that are orally read. They proposed that high-frequency words are recognized via a rapid lexical route and are not influenced by the effects of neighbours and spelling-to-sound regularity. Similar negative results for high-frequency words have been found by Mason (1978) and by Andrews, (1982) who only found a regularity effect with low-frequency words.

In their fourth experiment Seidenberg et al., (1984) examined whether the effects of spelling regularity had been confounded with orthographic regularity or as they defined it, "strangness" (e.g. the word YACHT, is the only word in the English with the terminal sequence of letters CHT). They compared regular, regular inconsistent (these words share the same spelling structure as other words but are pronounced differently e.g. GOES and DOES) and strange words in a pronunciation and lexical decision task. They found no differences between the high-frequency word classes in either task. The regular inconsistent words took longer to be responded to than the low-frequency regular words in the pronunciation task, but this effect was absent in the lexical decision task. Low-frequency strange words had longer response times in both the lexical decision task and the pronunciation task. They suggested that the inconsistent regularity effects in the lexical decision task were a result of irregular orthography rather than irregular spelling-to-sound correspondence. In the pronunciation task the effects of irregularity were confined to low-frequency words, therefore, studies which included more low-frequency words would be more likely to produce regularity effects than those which included fewer low-frequency words.

Waters and Seidenberg (1984) found that for low-frequency words the regularity effect could be elicited under certain circumstances in the lexical decision task; notably when the set of stimuli included a mixture of regular, irregular and strange words. The effect was absent, however when strange words were not included. Waters and Seidenberg proposed that the composition of the stimuli influenced the criteria by which subjects come to a decision that a letter string is a word or nonword. The presence of strange words they argue, slows down the decision process thereby allowing the effects of spelling regularity to influence response times. Results consistent with those of Waters and Seidenberg have been found by Waters, Seidenberg and Bruck (1984) in the lexical decision responses of adults and children.

Backman, Bruck, Herbert and Seidenberg (1984) examined the extent to which skilled and less skilled readers used spelling-to-sound information. This knowledge was tested through the subjects ability to read aloud words and nonwords with homographic spelling patterns, that is where several pronunciations (e.g., OSE as in lose, dose and hose) are associated with that sequence, in comparison to regular spelling patterns that are associated with a single pronunciation (e.g., UST as in must). Six groups of subjects were tested, 3 groups of average readers (grades

2, 3 and 4), 1 group of high school seniors and 2 groups of poor readers (grades 3 and 4). The subjects were presented with 4 types of words, (1) Regular words, where a single pronunciation could be formed from the orthographic sequence. (2) Exception words, where a correct pronunciation could not be derived from the words orthography. (3) Regular-inconsistent words, with a regular pronunciation e.g. GAVE but which share the same pattern with an exception word e.g. HAVE. (4) Ambiguous words like CLOWN and LOVE. These words have regular spelling patterns that are associated with two or more pronunciations. The words were of fairly high-frequency and were matched on this variable. Mixed in with the words were a number of nonword trials formed by changing the initial consonant of type 1, 3 and 4 words.

The authors found that the latencies and errors for words and nonwords declined with age for readers of average ability. The exception, regular-inconsistent and ambiguous words produced more errors than regular words in all groups except the most skilled. The mispronunciations were mainly errors of regularization, with the youngest group making proportionally fewer regularization errors than the other groups. This it was argued, reflected their poorer knowledge of spelling-to-sound rules. The poor readers were slower and less accurate than the good readers, with fewer of their errors being attributed to regularization in their responses to word and nonwords. The poorer readers' errors were like those of younger good readers (grade 2). It was suggested that poor readers showed a developmental delay in their spelling-to-sound knowledge. Overall the authors concluded that in the process of learning to read there is developmental shift in an individual's reliance on phonological information.

1.3.2 a Consistency Effects.

"Classifying words as 'regular' or 'exception' is more than a preliminary to stimulus selection. Instead, it presupposes a theory of reading" (Glushko 1979, p. 684). This is an important observation, for the pronunciation of a word with regard to other words with similar spellings was ignored in many previous experiments. When the pronunciation neighbourhood of a word is considered, a word may be broadly classified as being either consistent or inconsistent within this context rather than simply regular or irregular (e.g., MAIN is a regular consistent word as all words with the ending AIN are pronounced in the same way, and COST is a regular inconsistant word as not all words ending in OST are pronounced like cost e.g. MOST and POST).

In his third experiment Glushko compared three classes of word:

(1) Regular consistent- these words have regular spelling-to-sound correspondence (Venezky 1970), and the spelling pattern is pronounced only one way e.g., seed and gray.

(2) Regular inconsistent- these words have regular spelling-to-sound correspondences but the sequence of letters have more than one pronunciation e.g., seen and moth.

(3) Exception- these words have different pronunciations

when compared with words with the same sequence of letters e.g., foot and pint.

Glushko showed that exception words had longer latencies than regular consistent words. The interesting finding was that inconsistent regular words produced longer pronunciation latencies than consistent regular words. This consistency effect is at variance with a simple dual-route theory which would not predict a difference in the latencies of consistent and inconsistent words. According to that theory the pronunciation of a word is derived from the nonlexical route through the application of GPC's and directly from the lexical route, therefore both the consistent and inconsistent regular words would produce the same pronunciation in parallel. A delay would only be expected for exception words because the nonlexical route on applying regular correspondence rules would produce a pronunciation which is incompatible with that derived from the lexical route. This mismatch would result in a delay prior to the words pronunciation.

Glushko accounted for his results in terms of an activation and synthesis model (1979). The inconsistent words activate subsegments in the same position in other words with different pronunciations as well as exciting their own lexical entry, this interference results in a delay in the pronunciation latency despite the correct lexical entry being more salient. For similar reasons inconsistent nonwords would excite lexical entries with conflicting pronunciations, for instance the nonword HEAF would activate the regular word LEAF and the exception word DEAF, these conflicting pronunciations would result in a time cost. Exception words also suffer a disadvantage in their pronunciation latencies but for different reasons to those accepted by the GPC view. Exception words share a visual resemblance with a number of other words but they are pronounced differently. It is the interference between activated phonological information that prompts a delay in the final pronunciation latency.

Seidenberg, Waters, Barnes and Tanenhaus (1984) challenged the strength of the consistency effect found by Glushko. They noted that sequences of letters were repeated within the experiment which suggested to them that the consistency effects could have been confounded with the effects of priming. This possibility was tested in an experiment where the stimuli were presented such that exception words e.g., PINT either preceded or followed the regular inconsistent word STINT. A consistency effect was found when an exception word preceded the regular inconsistent word but failed to appear when the regular inconsistent word preceded its exception counterpart. These results cast doubt on the consistency effect demonstrated by Glushko.

More recently consistency effects in the naming task have been found across materials and subjects by Stanovitch and Bauer (1980), Andrews (1982) and by Seidenberg et al., (1984) for words of lower frequency, suggesting that the consistency effect is a reliable variable which was probably artificially magnified in Glushko's (1979) study by the presence of conflicting neighbours within the same list.

The dual-route model of word recognition has further been shown to be inadequate, following a series of pronunciation latency tasks involving nonwords carried out by Glushko (1979). He found that nonwords were not always assigned a pronunciation according to the most frequent grapheme-phoneme rules but were occasionally given infrequent pronunciations. In his first experiment Glushko presented regular and exception words like DEAN and DEAF together with nonwords holding consistent or inconsistent spelling patterns e.g. HEAN and HEAF in a naming task. A regularity effect (that is longer pronunciation latencies for irregular than regular words) was demonstrated. In addition an exceptional pronunciation was given to almost eighteen per cent of the inconsistent nonwords, so that a nonword like TAVE was not pronounced regularly like /tev/ but was instead pronounced as /taev/ with an irregular vowel assignment as in the word HAVE. These results are incompatible with dual-route theory where words and nonwords are pronounced through a set of spelling-to-sound rules and whereby the pronunciation of stored words do not contribute to the process.

In his second experiment Glushko presented 26 pairs of nonwords which were composed of letter sequences that were pronounced regularly or irregularly in English (a word was defined as irregular if it had an alternative pronunciation, his definition was not based on Venezky's spelling-sound rules). The nonwords were matched for initial consonant in order to reduce any difference in the time to initiate a response. In addition each vowel and terminal consonant was presented once only, to overcome any effects of priming. The monosyllabic nonwords were presented with filler nonwords in a naming task. He found that nonwords based on irregular spelling patterns were pronounced more slowly than nonwords based on regular spelling patterns. This observation is awkward for the dual-route theory as the difference in pronunciation latency between nonwords with consistent and inconsistent spelling patterns suggests that some interaction has taken place between the direct and nonlexical routes.

Kay and Marcel (1981), carried out a priming experiment in order to test the dual-process and analogy based theories. They found that inconsistent nonwords could be biased to be pronounced with either a regular or irregular correspondence depending on the prime that preceeded the target. These results are consistent with the idea that stimuli are pronounced by analogies and not according to the dual-process theories via independent lexical and nonlexical processes, whereby lexical information has no influence on the recognition of a word. Similar findings have been found by Rossen (1983) using semantic associations. She found that nonwords with ambiguous spelling patterns (that is, one that can be pronounced in more than one way) could be biased toward a particular pronunciation as a result of a preceding prime word that was semantically related to a lexical entry e.g. preceding VEAD with ALIVE increased the probability that the subject would pronounce the nonword to rhyme with DEAD rather than with BEAD.

Kay and Marcel's account can encompass both the regularity effect and consistency effect. As segments address matching phonological segments in the output lexicon exception and inconsistent words and morphemes will activate more conflicting phonological addresses than regular and consistent words and morphemes. This conflict in the case of exception and inconsistent words is overridden by the appropriate match for that word, but the conflicting phonology produces a delay in the pronunciation latency for exception and inconsistent words. For similar reasons nonwords which do not have complete lexical matches are subject to delays when conflicting phonological segments are activated, this conflict is resolved by assigning the pronunciation that occurs in most words with that segment.

1.3.2(b) Summary and Conclusion

In conclusion, it seems that the regularity effect is smaller than originally thought but nevertheless the finding is a robust one. The effect has proved variable in the lexical decision task in comparison to the pronunciation task; a number of factors have been uncovered which may have contributed to the ambiguous results. Larger spelling regularity effects are found for low-frequency words than for high-frequency words in the pronunciation latency task. Orthographically atypical words e.g. YACHT, seem to be relatively difficulty to process. Longer reaction times to such words have been found compared to regular words in both the lexical decision task and the pronunciation task. Those studies which failed to partial out this confounding factor may therefore have produced exaggerated regularity effects.

Skilled readers do apparently show a regularity effect under certain circumstances depending on the context in which the stimuli are presented. The dual-route theory has been supported by a number of studies where the effects of spelling-to-sound regularity have been demonstrated however, consistency effects are evident in both pronunciation latency tasks and lexical decision tasks. These results suggest that the traditional understanding of regularity needs to be revaluated, as the identification and pronunciation of letter strings is sensitive to both regularity and its consistency within the context of neighbouring words. The effects of phonological consistency are difficult to accomodate within the basic dual-route theory of word processing. The theory holds that nonlexical processing proceeds by the application of GPC's but there is evidence that nonword processing implicates the influence of lexical knowledge. However, within the modified account put forward by Patterson and Morton (1985) the effects of consistency can be accomodated. The effect arises as a result of lexical and nonlexical routes coding inconsistent words differently. In general the evidence from spelling-to-sound regularity experiments that a nonlexical route of word processing proceeds by the application of GPC's is much weaker than originally claimed.

1.3.3 Homophones.

Homophones such as BLUE and BLEW can be easily understood leading us to suppose that some visual information must have been used in gaining lexical access. However, Rubenstein, Lewis and Rubenstein (1971) were the first to demonstrate a homophone effect, that is, low-frequency homophones had longer reaction times than matched nonhomophonic low-frequency words. These results were interpreted as evidence that words undergo speech coding prior to lexical access. In their third experiment forty-four subjects were presented with 25 homophones such as SAIL and SALE (13 low-frequency and 12 high-frequency), and 24 nonhomophonic ones such as LAMP (12 low-frequency and 12 high-frequency). They found that only low-frequency homophonic words had longer reaction times than the nonhomophonic words, and that high-frequency words had significantly faster reaction times than low-frequency words. This is consistent with their proposal that lexical memory is searched in a frequency ordered fashion. Homophonic and nonhomophonic words of high-frequency for example RAIN and GIFT had faster reaction times than homophonic and nonhomophonic words of low-frequency for example REIGN and PEST. A low-frequency homophonic word such as REIGN will phonemically match the higher frequency entry RAIN and will be rejected following the spelling check. A time cost is incurred from this mismatch and the search continues until the correct entry for REIGN in the lexicon is found. The finding that low-frequency homophonic words are responded to more slowly and with more errors than control words is not predicted by direct access theories which have no basis to predict a difference between REIGN and PEST, which are both legal and pronounceable.

Clark (1973) criticized the third experiment of Rubenstein, Lewis and Rubenstein (1971) on the that the materials were not treated as a random factor. On reanalysing the materials Clark failed to repeat the homophone effect. Further negative results were found by Coltheart, Davelaar, Jonasson and Besner (1977) in a partial replication of the work of Rubenstein et al. They failed to find a homophone effect despite the homophones being the less frequent member of the homophonic pair.

Meyer, Schvaneveldt and Ruddy (1974) expressed doubts over Rubenstein, Lewis and Rubenstein's interpretation of their data. They argued that the graphemic and phonemic properties of the letter strings may have been confounded. homophones are more alike visually to their homophonic mates, (for example DEER and DEAR) than to other nonhomophonic words. Therefore the graphemic properties of the stimuli could explain the results of Rubenstein, Lewis and Rubenstein.

Baron (1973) tested the speech coding hypothesis in a phrase evaluation experiment, where the subjects task was to disambiguate homophones such as HAUL and HALL. Under the speech coding hypothesis, homophones are normally identified through the context in which they occur. Should this fail, than the subject must look at the spelling of the word in order to arrive at the correct meaning.

Baron selected four kinds of phrases, (1) "IN THE HAUL" which he argued is phonologically correct but orthographically incorrect (strictly this could be quite sensible). (2) "IN THE HALL" which is phonologically and orthographically congruent. (3) "NUT AND BOUT", which is phonologically and orthographically incongruent and (4)

"NUT AND BOLT", which is phonologically and orthographically correct. The sets of phrases were based on a pair of homophones, with the control pairs carefully matched on letter number and letter positions that were present or absent. The subjects were presented with 8 pairs of each phrase type in a choice reaction time task. Six subjects made judgements of semantic legality. No differences were found. If speech coding were taking place, phonologically correct phrases but orthographically incorrect phrases like "IN THE HAUL" would be expected to have longer rejection latencies than phrases that were both phonologically and orthographically incongruent such as "NUT AND BOUT". The predicted difference in the reaction time data was not found, and Baron concluded that speech coding was not necessary for lexical access. However, significantly higher error rates were found for the orthographically incorrect but phonologically correct phrases, which would suggest that speech coding had taken place at some point and the absence of an effect on reaction time could have been due to a speed accuracy trade off. Moreover, no strong conclusions can be made from such a small sample of phrases which were highly familiar. The phrases were shown to the subjects prior to the start of the experiment and each phrase was subsequently repeated 16 times. When these factors are taken into account it is not surprising that only weak evidence for speech coding was obtained.

Evidence for the homophone effect has been mixed. Taft (1982) presented 15 less frequent members of a homophonic pair (PANE) together with 15 frequency matched nonhomophonic words (JERK) together within a context of nonwords which included pseudohomophones in a lexical decision task. Taft showed that homophones were rejected more slowly than their matched control words but this effect was only reliable in the by-subjects analysis. A study conducted by Coltheart, Davelaar, Jonasson and Besner (1977) failed to obtain the homophone effect originally found by Rubenstein et al (1971). However, the same group of researchers in the in the following year produced data that suggested that the type of nonword present influenced the reaction times to homophones. Davelaar, Coltheart, Besner and Jonasson (1978) carried out two parallel experiments, one using the low-frequency member of a pair of homophones and the other using the high-frequency member. The experimental design was such that there were three sections without there being a discreet change between sections. In the first third, subjects were presented homophones (either high or low-frequency depending on the group) and control words in the context of nonhomophonic nonwords such as SLINT. This was followed by 20 words presented in a predetermined order with first 10 nonhomophonic nonwords and then 10 pseudohomophones e.g., GRONE. The final section was again made up of homophones and control words in the context of pseudohomophones.

Davelaar, Coltheart Besner and Jonasson (1978) found a homophony effect, that is longer reaction times for low-frequency homophones in comparison to control words when the nonword distractors were orthographically legal and pronounceable e.g., SLINT. But the effect disappeared in the presence of pseudohomophone distractors such as

BRANE. High-frequency homophones were not differentially affected by the type of nonword distractor present. These results were interpreted as evidence for an optional speech coding strategy which subjects could bring into play when it was advantageous to do so. These results also provide a possible explanation for the weak homophone effect found by Taft (1982) in the context of pseudohomophones. Davelaar et al., (1978) proposed that subjects have simultaneous graphemic and speech coding procedures. The differential effects arise following the outcome of the first few trials. Lexical decisions in the presence of "slint" type nonwords are accurately identified using a speech coding strategy, but in the presence of "grone" type nonwords, a speech code would produce many errors and so the subject abandons this strategy in favour of a graphemic code. The homophone effect was found only on the low-frequency member of a pair and not the high-frequency member. The authors explained this as a result of a spelling check (This idea is the same as that of Rubenstein, Lewis and Rubenstein, 1971). Following lexical access by the speech code, a spelling check takes place so that pseudohomophones are not incorrectly accepted as words. In the case of homophones this check takes place serially in order of frequency, with high-frequency items being checked first, should this be unsuccessful as in the case of low-frequency homophones and pseudohomophones a further search and spelling check occurs or termination of the process results. This process necessarily takes time and is reflected in the longer reaction times for the low-frequency homophones. These results are consistent with a dual-route model of word recognition. However, the strong conclusions of Davelaar et al (1978) are based on a weak statistical foundation. The low-frequency homophone effect was significant only using a one tailed t-test.

1.3.3.(a) Summary and Conclusion.

In conclusion, the experimental results obtained using homophones provides only weak evidence for speech recoding. The reliability of the homophone effect is in doubt partly due to the many inconsistencies between studies and the apparent lack of significant results. Despite these negative findings there is some suggestive evidence that the homophone effect can be found when a phonological strategy is adopted by the subject.

1.3.4 Irrelevant Articulation.

Suppression involves occupying the articulatory system with some secondary speech activity. The role of articulation and its disruptive effects on phonology were originally investigated by inserting objects into the subjects mouth (Secor, 1900) or having them whistle. More recently it has been achieved by requiring the subject to repeat a word, nonword or string of digits at a rapid rate.

Studies of irrelevant articulation arose from studies in short-term memory (STM). Conrad (1964), observed intrusion errors in the immediate recall of strings of consonants (e.g., B, G, T), the misrecalled errors were more likly to be phonemically similar (P for a B) than dissimilar. Conrad and Hull (1964), also showed that visually presented acoustically similar consonants (G, T, P, C) were more difficult to recall than acoustically dissimilar (L, P, R, Y) consonants. Baddeley (1966) has shown similar effects using words. However, when a secondary task of irrelevant articulation was introduced subjects failed to demonstrate an acoustic similarity effect (Murray, 1968; Levy, 1971; Peterson and Johnson, 1971).

It is evident that irrelevant articulation disrupts the effects of phonology in memory experiments which involve visual presentation, but it may be presumptuous to take this finding and apply it to reading experiments without evidence that the processes responsible for speech coding are the same in short-term memory and reading tasks. In experiments on reading the problem arises in that the effects of phonology can occur either pre-lexically or postlexically. It is clear that irrelevant articulation can disrupt the execution of articulatory commands which are a consequence of post-lexical phonology there is no evidence that it disrupts prelexical phonology derived from the visual representation of print. Irrelevant articulation may affect reading for many reasons and speech recoding may be only one of these. Waters, Komoda and Arbuckle (1985) have argued that the observed performance decrements in the context of suppression may be due mainly to a reduction in the subject's processing capacity. They pointed out that in the studies conducted by Kleiman (1975) and Levy (1977), the greatest interference effects were shown on those tasks that were performed most poorly.

A widely cited initial experiment involving a secondary task was carried out by Kleiman (1975). He observed the effects of shadowing on three tasks (1) Phonemic decision: Do the following pair of words rhyme, "TICKLE PICKLE"? (2) Graphemic decision: Are the following pair of words visually similar, "HEARD BEARD"? (3) Synonomy decision: Do the following words have a similar meaning, "MOURNE GRIEVE"? He found that shadowing disrupted the subjects ability to detect rhymes (this was seen in their reaction times and error rates) to a greater extent than judgements of graphemic similarity and synomity; from this he argued that the shadowing task was therefore an effective means of disrupting speech coding. He proposed that graphemic judgements did not require a speech code, whereas decisions of synomity would require lexical access, and as the shadowing task had disrupted these decisions to a similar degree that speech coding was not a necessary part of lexical access.

In another experiment (3) he presented subjects with sentences which required comprehension, again he found that rhyme judgements were disrupted (e.g., Is there a word that sounds like cream in the following sentence: "HE AWAKENED FROM THE DREAM"?) to a larger degree than judgements about graphemic similarity (e.g., Is there a word spelled like bury in the following sentence: "YESTERDAY THE GRAND JURY ADJOURNED" ?) and category judgements (e.g., Is there a game mentioned in the following sentence: "EVERYONE PLAYED MONOPOLY" ?). Judgements about graphemic similarity and categories were influenced to a significantly lesser degree by shadowing than were rhyme judgements and acceptability judgements (e.g., Does the following sentence make sense; "PIZZAS HAVE BEEN EATING JERRY" ?). These results were interpreted as evidence for speech coding occurring after lexical access. Kleiman argued such coding was used in the comprehension process possibly as a memory buffer.

There are however, a number of problems; Kleiman complicated the issue in that there is no guarantee that shadowing disrupts pre-lexical phonology therefore, the absence of any disruption by shadowing does not prove that a speech code was not used. Kleiman's conclusions have been criticized by Baddeley (1981) on the grounds that the concurrent task of shadowing required considerable cognitive processing and therefore the observed disruption of performance may reflect an overload of memory rather than shadowing disturbing speech coding. Evidence for this argument comes from Baddeley (1979). He found no difference in the verification time of sentences accompanied by articulatory suppression (by repeating the digits 1 to 6) and a control condition without a secondary activity. However, when a memory load (remembering a sequence of 6 digits) was added to the verification task the subjects produced a substantially slower performance. This was interpreted as evidence for cognitive load influencing reading but not articulatory suppression.

While there is some evidence that disrupting speech coding by secondary tasks such as suppression and shadowing impair speech code fluent reading, attempts to use these techniques to disrupt the reading of individual words provided no real evidence until possibly an experiment reported by Baron (1977). He presented lists of numbers either alphabetically i.e. "one", "two", "three" or "four" ideographically or by using Roman numerals "I", "II", "III" and "IV". The subjects had to read through the lists and check off each number which was larger than the number that preceeded it as in the following sequence "two", "four" but not "two", "one". On half of the trials the subjects were given a secondary task of counting backwards from 10 to 1. Baron found that the irrelevant articulation had a greater interference effect, as measured by the time to perform the task, on the numbers written alphabetically than those presented ideographically.

These results were consistent with the hypothesis of the dual-route model. The meaning of alphabetically written numbers can be accessed either by the nonlexical route or by the direct route. The Roman numerals however, which carry no phonological information, could only be understood by using the direct route therefore, only the alphabetically presented numbers would be expected to be impaired by the suppression task. The effects of suppression had however, been confounded with the effects of physical size. Besner (1979) argued that the Roman numerals increased in physical size as they became numerically larger (only the numbers I, II, III and IV were used). They could therefore be compared on the basis of physical size rather than numerical size. Hulme and Ryder Richardson (1981) repeated this experiment. They overcame the problem of physical size by comparing Arabic numerals (1,2,3,4,5,6,7,8,9) with numbers written alphabetically. Furthermore, by using a greater range of numbers they acknowledged the problem of spelling regularity. In Baron's study three of the four numbers were spelt irregularly (six out of the nine numbers used by Hulme and Ryder Richardson were spelt regularly). Theoretically a speech code can not be used to gain lexical access for such numbers so the strong effects of suppression found by Baron are puzzling.

Hulme and Ryder Richardson found that Arabic and alphabetic numbers did not differ in their susceptability to be disrupted by irrelevant articulation . Although no differences were found, the experiment adds further support to the argument that irrelevant articulation has not been shown to disrupt pre-lexical phonology.

Further evidence consistent with the idea that irrelevant articulation does not disrupt pre-lexical phonology has come from Baddely and Lewis (1981). They had subjects judge whether a nonword was homophonic with a real word (e.g., TRID, YORN), whether pairs of nonwords rhymed (e. g., FRELAME, PHRELAIM) and whether a word and a nonword rhymed (e.g., DOZEN, DUSSEN), with and without concurrent articulation. They found that these judgements were slower and less accurate with suppression but not significantly so. Similar results have been obtained by Besner, Davies and Daniels (1981) who found that irrelevant articulation slowed the performance of rhyme judgements with words while increasing their error rates, for rhyme judgements with nonwords irrelevant articulation only increased error rates. In contrast Wilding and White (1985) who examined the separate effects of acoustic, articulatory and general interfering effects on rhyme judgements in a series of experiments, found that overt and silent concurrent articulation of the syllable "BLAH" and nonverbal articulation produced by chewing nuts and raisins interfered with the speed and accuracy of rhyme judgements in words and less strongly nonwords. This contradiction so far can not be explained. There is however, a problem associated with experiments that have used the irrelevant articulation paradigm. Generally experiments have not equated the tasks for processing capacity. Waters, Komoda and Arbuckle (1985) looked at just this problem in a series of experiments. When the general processing capacity of a concurrent task was partialled out they found that shadowing did not interfere with reading. A final problem with experiments using a suppression paradigm is that the task is different from normal reading therefore it is difficult to assess wheher subjects are using a different strategy in order to carry out the task.

1.3.4(a) Summary and Conclusions.

To date there is no evidence that articulatory suppression specifically disrupts any putative pre-lexical speech code. There is however, evidence that suppression disrupts the effects of the post-lexical code used in comprehension (Levy, 1977, 1978; Baddeley, 1979; Slowiazek and Clifton, 1980) and memory (Baddeley, Thomson and Buchanon, 1975; Richardson and Baddeley, 1975 Salame and Baddeley, 1982). These effects, however, may be largely attributable to non-specific factors related to task difficulty (Waters et al., 1985).

1.3.6 Neuropsychology.

Neuropsychological studies of patients with reading impairments (Shallice and Warrington, 1980; Patterson, 1981), have been an important approach to identifying the cognitive subsystems involved in oral reading. Although the pattern of impairments is unique in each patient, it is generally assumed that as a result of brain damage these individuals exploit those cognitive systems that remain intact, rather than create new systems, and therefore by studying such patients it is hoped some insight into these remaining processes will be produced.

One group of patients who are particularly relevant to the present discussion are refered to as surface dyslexics. Surface dyslexics are thought to have a damaged direct route. Such patients appear to pronounce letter strings using the nonlexical phonological route. The essential characteristic of these patients is their sensitivity to the effects of regularity. They are more successful at reading regular words (Schwartz, Saffran and Marin, 1980; Shallice and Warrington, 1980), than irregular words. The difficulty in reading irregular words has led to two main suggestions as to how such words are misread. One proposal is that grapheme-phoneme correspondence rules are used (Coltheart, 1978; Marshall and Newcombe, 1973), or alternatively a pronunciation is generated by analogy with the phonology of other words or subword segments (Marcel, 1980; Henderson, 1982). Their incorrect responses include neologisms and regularizations for example, PLACEBO might be pronounced as PLACE-BO (Patterson, 1981) and BROAD might be pronounced as BRODE. The mispronunciation of regular and exception words resulting in errors which are sometimes nonwords and in other cases words has also been described as the "partial failures of grapheme-phoneme conversion" (Marshall and Newcombe, 1973). The patient might pronounce recent as "rekunt", where the decision on the pronunciation of the letter c was inappropriate and disease as might be read as "decease" (Marshall and Newcombe, 1973). These individuals can still read some words using the direct route as not all exception words are misread. Irregular homophones are frequently correctly read but misinterpreted e.g., MOWN might be defined as "to cry" and FOUR as "for you, for me, for any one", (Newcombe and Marshall, 1980). The patient's definition of a word follows the pronunciation that they assembled rather than the word's visual appearance. Therefore, the nonlexical route must have been used at some stage for lexical access otherwise the pronunciation of such words could not have been assembled. These types of errors are compatible with and support Coltheart's (1978) assumption that they are due to the successful application of GPC's.

Marcel (1980) and Patterson (1982), have argued that the oral reading errors of surface dyslexics can not be characterized completely by the process of nonlexical reading as their impairments tend to be selective and sensitive to frequency and word class. In addition many of their errors can not be accomodated by the misapplication of GPC's, e.g., patients both add and delete syllables in their pronunciation of letter strings, and words of higher frequency are pronounced correctly more often than lower frequency words. Although they do show regularization errors they are not a prominant feature of their reading ability and can be explained by the application of inappropriate analogies (Marcel, 1980; Henderson, 1982) rather than failed GPC's. A critical finding for the dual-route theory has come from evidence that lexical knowledge for units smaller than a word were shown to influence the naming errors of the surface dyslexic HTR described by Shallice et al (1983). HTR produced complex errors where atypical pronunciations were generated for only part of the word. These pronunciations could not be generated by the nonlexical GPC procedure, therefore, it seems that lexical knowledge at the subword level is available, and therefore contrasts with predictions of the dual-route theory. A comeback can be made in favour of dual-route models for the very nature of brain damage predicts that the decrements will depend on those stages of lexical processing that have been damaged therefore, the symptoms of such patients would not be expected to be cut and dry.

1.3.6 (a) Summary and Conclusions.

In conclusion, the characteristics of Surface Dyslexia are consistent with the idea that such patients read largely by relying on the nonlexical route. Although this account is consistent with the predictions of the dual-route model, these findings do not clinch it. Furthermore it is not clear what the pattern of impairments tell us about normal skilled readers. Not only are there inconsistencies in the expected types of errors made by surface dyslexics in the nonlexical assignment of grapheme-phoneme account but, their impairment can also be accomodated within a theory based on analogies.

1.4 General Summary.

The dual-route theory of word processing in skilled readers holds that access to a printed words' meaning and pronunciation can be gained from two independent routes; the lexical route of word processing operates by the direct mapping of the stimulus's representation on to the stored lexical representation and the nonlexical route of word processing, where the mapping of stimulus and lexical representation is mediated by a speech code involving grapheme-to-phoneme conversion rules. Evidence for nonlexical processing was reviewed in this chapter from three major sources, nonwords, words and an aquired reading disorder.

The processing of nonwords was found to be inconsistent with the idea that grapheme-to-phoneme correspondence rules are used. In the pronunciation task lexical knowledge was on occasion brought into use; nonwords with inconsistent spelling patterns were occasionally assigned an irregular pronunciation and the pronunciation latencies for such nonwords were also longer in comparison to nonwords with consistent spelling patterns. Nonword processing could also be biased towards either a regular or irregular pronunciation depending on the preceding context. The results from pseudohomophones were also equivocal as they may reflect the effects of visual similarity between pseudohomophones and real words rather than phonological similarity.

The effects of spelling-to-sound regularity have also been found not to be uniform. The original argument was based on a dichotomy that ignored the pronunciations of a words neighbours. Recent results have indicated a lexical influence in the processing of words. Regular words with neighbours bearing inconsistent pronunciations have longer pronunciation latencies than regular words with consistent neighbours suggesting that the effects of spelling regularity may be subsidiary to the effects of phonological consistency .

The strongest neuropsychological evidence has come from the syndrome of surface dyslexia. Patients with this syndrome are thought to have an impaired lexical route relative to the nonlexical route. The results of brain damage do not provide a clear contrast between the processing routes because the extent of damage sustained to either or both processes can not be easily partialled out. The original argument proposing a double disociation between the lexical and nonlexical processing routes has recieved little support. There is also contrary evidence from the naming errors of surface dyslexics; atypical pronunciations are occasionally produced suggesting that some lexical knowledge is available to these individuals and consequently is inconsistent with the argument that they achieve lexical access soley through the application of grapheme-to-phoneme correspondence rules.

Overall the evidence for speech recoding occuring prior to lexical access is rather weak. The pseudohomophone effect is just such a case where there is no unequivocal evidence for or against the speech recoding argument. The nature of the pseudohomophone effect needs further examination to resolve the possible interpretation of visual and phonological effects. In considering this question the experiments reported here will investigate the pseudohomophone effect in terms of its visual and phonological make up and attempt to resolve the inconsistencies which exist in the studies of this effect.

CHAPTER 2

THE EFFECT OF PHYSICAL CHARACTERISTICS AND CONTEXT ON THE PSEUDOHOMOPHONE EFFECT.

2.1 EXPERIMENT 1. The Effect of Visual Similarity on the Pseudohomophone Effect: A Replication of Martin (1982).

2.1.1 Introduction

The present study is concerned with Martin's (1982) claim that the pseudohomophone effect demonstrated by Coltheart, Davelaar, Jonasson and Besner, (1977) as well as by others (Rubenstein, Lewis and Rubenstein, 1971; Frederickson and Kroll, 1976; Patterson and Marcel, 1977) is the result of greater visual similarity between the pseudohomophones and other words rather than speech coding. Martin (1982) studied the nonwords used by Coltheart, Davelaar, Jonasson and Besner (1977), who devised the N-count which measures the number of different English words which can be produced by changing just one letter in the nonword. She found that the pseudohomophones and control nonwords differed significantly in their visual similarity to words in general as assessed by this measure.

Martin developed a new set of stimuli to overcome this confounding. She found that reaction times to reject pseudohomophones were not significantly different from the visual control nonwords when these stimuli were matched for N-count. However, the nonwords with lower N-counts did show significantly faster reaction times compared to the pseudohomophones. Martin's (1982) results challenged previous demonstrations of the pseudohomophone effect as evidence that speech coding occurs in the lexical decision task. In particular her work exposed a potential confounding between the effects of pseudohomophony and orthographic neighbourhood size (N-count) of the letter string.

The possible effects of orthographic neighbourhood size are however, less certain following a recent paper by Besner and Davelaar (1983). They demonstrated a significant pseudohomophone effect when the N-count of pseudohomophones and visual controls were matched. However, there is a problem with Besner and Davelaar's experiment. Although, they failed to demonstrate any effects of N-count the visual similarity between the pseudohomophones and visual controls were confounded. The visual controls were formed by changing one letter of the pseudohomophone (BLOO>PLOO) to produce a pronounceable nonhomophonic nonword. Although the visual controls are similar to other real words e.g., PLOT, this was not part of their experimental design. The visual control PLOO is still not as close in visual similarity as the pseudohomophone BLOO is to the target word for the pseudohomophone (BLEW/ BLUE). Also, as already reported in Chapter 1 (section 1.3.1), Besner and Davelaar included a number of pseudohomophones amongst the visual control stimuli in their experiment. This makes the finding of a pseudohomophone effect rather puzzling. In view of the theoretical importance of Martin's findings, it was decided to replicate her experiment.

2.1.2 Method

(a) Subjects.

Nineteen undergraduates, 10 women and 9 men, of mixed age from the University of York were paid for participating in the experiment.

(b) Stimuli and Design.

The nonwords were taken from Martin (1982), and consisted of 25 pseudohomophones (these were homophonic with one English spelling), 25 visual controls, 25 approximate visual controls and 25 distant control nonwords (these can be found in Appendix I). The pseudohomophones and visual controls were created by making comparable changes in two words of similar surface frequency (Kucera and Francis, 1967), a change in one word resulted in a homophonic nonword (WoRD> WERD) and a similar change in the other word resulted in a pronounceable nonhomophonic nonword (CoST> CEST), these were matched for number of letters, syllables and N-count. The approximate visual controls were a direct comparison with the control nonwords of Coltheart, Davelaar, Jonasson and Besner (1977) and were formed by changing one letter of the pseudohomophones (WERD> SERD) these nonwords had significantly lower N-counts than the pseudohomophones. The distant visual control nonwords (KYSE) had an infrequent combination of letters and also significantly lower N-counts compared to the pseudohomophones. The nonwords were presented together with 100 words in a lexical decision task, in a different random order to each subject. The stimuli were presented by means of a cathode ray tube (CRT) display with a P4 phosphor. The CRT was interfaced with a mini computer which was used to control the experiments (see Monk, 1982). Our stimuli were different in one respect from those of Martin, in that they were presented in upper-case. The height of an upper-case letter was 4.9 mm. The width of the letters was 2.5 mm and the spacing between the letters was 0.3 mm. The viewing distance was controlled by a chin rest set at a distance of 60 cm from the screen. The stimuli appeared individually in the center of the screen, and occupied a visual angle of 0.466 degrees vertically and a maximum visual angle of 1.834 degrees horizontally.

(c) Procedure.

During the experiment the subject was seated at a table facing the CRT. Each subject was given a sheet of instructions in which the lexical decision task was explained. The subject's task was to decide whether or not the presented letter string was an English word. A number of written examples such as, HORSE and SLINT were shown to the subject in order to familiarize them with the procedure and to check that the task had been understood. Subjects initiated a block of trials by pressing a start button, following the instruction "PRESS START TO CONTINUE" appearing on the screen in front of them. The letter string remained on the screen until the subject made a response by pressing one of two response keys correponding to "word" and "nonword" with the forefinger of the left and right hand respectively. The inter-trial interval was 600 msec. Subjects were requested to respond as quickly and accurately as possible. In the event of the subject choosing the wrong response key a tone was sounded as feedback. The trials were presented in blocks of twenty, following which they recieved feedback about their performance in terms of speed (whether the present completed block of trials was faster or slower than the last but one block of trials) and accuracy. The subjects could rest between blocks of trials should they feel the need. Subjects saw 35 practice trials followed by 100 words and 100 nonwords in random order.

2.1.3 Results.

The reaction time data were treated in the following manner. Only correct reaction times were analysed and any responses that took 2 seconds or longer were discarded. This procedure only resulted in the discarding of 0.210 per cent of responses to approximate visual control nonwords.

The anti-logged mean reaction times to the nonwords are shown in Table 1 below. Pseudohomophones had longer reaction times than their visually matched controls, and the visual controls had longer reaction times than the approximate visual controls and the distant visual controls.

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these two sets of scores after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table 2). The analysis showed a highly significant main effect of nonword type in the by-subjects analysis (F=22.406; df=3,54; P, <0.001), and in the materials analysis (F=15.023; df=3,72; P, <0.001).

TABLE 1.

Anti-Logged Mean Reaction Times and Error Rates for Nonwords in Experiment 1.

	TYPE OF NONWORD			
	PH	VC	AVC	DVC
R. Time (msec)	674	651	625	588
Error Rate (%)	8.6	5.8	4.4	2.3

PH = Pseudohomophone
VC = Visual Control
AVC = Approximate Visual Control
DVC = Distant Visual Control
R. Time = Reaction Time

Comparisons between the 4 types of nonwords were made using Tukey's HSD test. This showed that there was no significant difference between the pseudohomophones and the visual controls despite the difference of 23 msec between them. Twelve of the 19 subjects, and 14 out of the 25 nonwords pairs, had longer reaction times for the pseudohomophones than for the visual controls. There was a significant difference (p <0.05) between the pseudohomophones and approximate visual controls. Fifteen of the 19 subjects, and 18 out of the 25 nonword pairs, had longer reaction times for the pseudohomophones. The

TABLE 2.

Analysis of Variance on the Reaction Times for Nonwords in Experiment 1.

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	18	2093.750			
Nonwords	3	364.563	121.521	22.406	$p<0.01$
Error	54	292.875	5.424		
Within	57	657.438			
TSQ/N= 5969669.3000		N= 76	SST= 2751.1875		
(By-Materials)					
Materials	24	605.813			
Nonwords	3	482.250	160.750	15.023	$p<0.01$
Error	72	770.438	10.701		
Within	75	1252.688			
TSQ/N= 7863922.6000		N= 100	SST= 1858.500		

Nonwords= Pseudohomophone
Visual Controls
Approximate Visual Controls
Distant Visual Control

TABLE 3

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Error Data of Experiment 1.

Source	df	SS	MS	F	p
Subjects	18	23.040			
Nonwords	3	4.781	1.594	3.206	$p<0.05$
Error	54	26.841	0.497		
Within	57	31.622			

TSQ/N= 70.2930 N= 76 SST= 54.6620

difference between pseudohomophones and the distant visual control nonwords was also significant ($p < 0.05$). Eighteen out of the 19 subjects and 24 of the 25 nonword pairs had longer reaction times to the pseudohomophones.

A summary of the error pattern is shown in Table 1. In general the pattern of errors follows that of the reaction time data, except that the difference between the pseudohomophones and other nonwords on this measure is rather larger. An analysis of variance carried out on the arcsine transformed error data (shown in Table 3) showed that there was a significant difference between the nonword types ($F=3.206$; $df=3,54$; P, <0.05). A Tukey's HSD test showed that the pseudohomophones had significantly ($p < 0.05$) higher error rates than the other three kinds of nonwords. These results therefore indicate that subjects found it particularly difficult to reject the pseudohomophones; they were prone to confuse them for words.

2.1.4 Discussion.

The present results provide partial confirmation for those of Martin (1982). Pseudohomophones were not rejected more slowly than other nonwords that were matched for visual similarity, although there was a trend towards such an effect. This trend was in the opposite direction to that found by Martin. The control nonwords showed a similar pattern to that of Martin with nonwords increasingly dissimilar in visual similarity to other words as measured by their N-count, displaying faster reaction times. However, the pseudohomophones did show significantly more errors than other nonwords. This suggests that speech coding was occurring.

There was a difference between this experiment and the original experiment conducted by Martin (1982) in that the stimuli were presented in upper-case whereas Martin's stimuli were presented in lower-case. This might account for the trend in the reaction time and error data in this present experiment towards a pseudohomophone effect. The second experiment was designed to test the importance of case of presentation directly.

2.2 EXPERIMENT 2. The Effects of Case of Presentation on the Pseudohomophone Effect.

2.2.1 Introduction

The aim of the present experiment is to investigate whether the absence of a pseudohomophone effect in Martin's (1982) original study might be attributable to the use of lower-case presentation. Tinker (1965) demonstrated that words presented in lower-case were easier to read than words written in upper-case script as measured by subjects' reading speed. It is possible that the absence of a pseudohomophone effect reflects the use of a highly efficient visual word recognition process for skilled readers with lower-case presentation. We might predict that a pseudohomophone effect would be absent with lower-case materials which can be read quickly on the basis of purely visual analysis, but reveal itself when the stimuli are presented in upper-case.

2.2.2 Method

(a) Subjects.

A total of thirty six (16 women and 20 men) undergraduates from the University of York were paid to serve as subjects.

(b) Stimuli and Design.

The nonwords were again taken from Martin (1982) and consisted of 25 pseudohomophones and 25 visual controls. There were 50 words that were matched in frequency and number of letters to the root word from which the nonwords were derived (a complete list of the stimuli can be found in Appendix I). A between- subjects design was used, half the subjects saw the stimuli in lower-case and half in upper-case. The stimuli were presented in a lexical decision task using the same apparatus as in Experiment 1. The height of an upper-case letter was 4.9 mm, and for a lower-case letter 4.3 mm. The width of the letters was 2.5 mm and the spacing between the letters was 0.3 mm. The viewing distance was controlled by a chin rest set at a distance of about 60 cm from the screen. The stimuli appeared individually in the center of the screen, an upper-case letter occupied a visual angle of 0.466 degrees vertically and letter strings occupied a maximum of 1.834 degrees horizontally. The lower-case descender letter occupied a visual angle of 0.409 degrees vertically and letter strings occupied a maximum of 1.834 degrees horizontally.

(c) Procedure.

The procedure was identical to that of the first experiment. Subjects saw 32 practice trials (in the appropriate case depending on the group to which subjects had been randomly assigned) followed by 50 words and 50 nonwords.

2.2.3 Results.

The reaction time data were treated in the the same manner as Experiment 1. Only correct reaction times were analysed and any responses that took two seconds or longer were discarded. This procedure resulted in the discarding of 0.222 per cent of the visual control nonwords, and 0.111 per cent of the pseudohomophones. The anti-logged mean reaction times for the nonwords are shown in Table 4.

In the lower-case condition the pseudohomophones had faster reaction times than the matched visual controls. In the upper-case condition, pseudohomophones were slower in reaction time in comparison to the visual controls. The overall reaction times to upper-case materials were slower than to lower-case.

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate split-plot analyses of variance, with letter case as a between-subjects variable (upper-case or lower-case) and type of letter string a within-subjects variable (pseudohomophone or visual control) were performed on these two sets of scores

TABLE 4

Anti-Logged Mean Reaction Times and Error Rates for Experiment 2.

	TYPE OF NONWORD	
	PH	VC
Lower-Case		
R. Time (msec)	628	635
Error Rate (%)	6.2	5.3
Upper-Case		
R. Time (msec)	673	648
Error Rate (%)	4.9	3.8

PH = Pseudohomophones
VC = Visual Controls
R. Time = Reaction Time

after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table 5). The main effect of case was not significant across subjects (F=1.695 ; df=1,34; P>0.1) but it was significant across materials (F=6.673; df= 1,48; P,<0.05), indicating that although letter strings in upper-case had slower reaction times they were not reliably different from lower-case letter strings.

In this experiment a pseudohomophone effect was not found, across subjects (F=0.289; df=1,34 ;P>0.05) or across materials (F=0.208; df= 1,48; P>0.05). The interaction between case and nonword type was, however, significant across subjects ($F=4.965$;$df=1,34$;$P<0.05$) but not across materials, ($F=2.817$; $df= 1,48$; $P>0.05$). This interaction was explored with a Tukey's HSD test. This showed that pseudohomophones presented in either upper or lower-case, did not differ significantly in reaction time to matched visual control nonwords. However, the difference between the upper and lower-case pseudohomophones was significant ($p<0.05$), pseudohomophones presented in upper-case had reliably longer reaction times than pseudohomophones presented in lower-case. There was no such difference between the visual control stimuli.

Pseudohomophones produced slightly higher error rates than the visual controls. An analysis of variance (shown in Table 6) was carried out on the arcsine transformed error data, but there were no significant differences in the error rates ($F=0.584$; $df=1,34$; $P>0.05$)

The materials were then examined in more detail. Martin has argued that a letter string's N-count is important in determining how quickly it can be rejected in a lexical decision task. Therefore it was expected that items with higher N-counts would have slower reaction times than those with lower N-counts. The stimuli were divided into four groups (1) lower-case pseudohomophones, (2) lower-case visual controls, (3) upper-case pseudohomophones, and (4) upper-case visual controls. In each group, the mean reaction time for each letter string was correlated with its N- count, frequency per million according to Kucera and Francis (1967) frequency tables (in the case of the nonwords it was the frequency of the root word from which

TABLE 5

Logged Analysis of Variance for the Effect of Case on Pseudohomophones and Visual Control Nonwords in Experiment 2.

Source	df	SS	MS	F	p
(By-Subjects) Between					
Subjects	35	1837.500			
Case (C)	1	87.250	87.250	1.695	NS
Error	34	1750.250	51.478		
Within					
Nonword (N)	1	1.625	1.625	0.289	NS
N/C	1	27.875	27.875	4.965	$p<0.05$
Error	34	190.875	5.614		
Within	36	220.375			

TSQ/N= 5683027 N= 72 SST= 2057.8750

Source	df	SS	MS	F	p
(By-materials) Between					
Materials	49	1029.813			
Case (C)	1	125.688	125.688	6.673	$p<0.05$
Errors	48	904.125	18.836		
Within					
Nonwords (N)	1	2.188	2.188	0.208	NS
N/C	1	29.625	29.625	2.817	NS
Error	48	504.750	10.516		
Within	50	536.563			

TSQ/N= 7908822.40000 N= 100 SST= 15663750

Nonwords = Pseudohomophones Visual Controls
Approximate Visual Controls
Distant Visual Control

Case = Upper-Case and Lower-Case

TABLE 6

Analysis of Variance Summary Table For Errors made to Pseudohomophones and Visual Control Nonwords in Experiment 2

Source	df	SS	MS	F	p
Between Subjects	35	28.001			
Case (C)	1	1.094	1.094	1.382	NS
Error	34	26.0907	0.791		
Within Nonwords (N)	1	0.369	0.369	0.584	NS
N/C	1	0.089	0.089	0.140	NS
Error	34	21.530			
Within	36	21.998			

TSQ/N= 91.9983 N= 72 SST= 49.9882

Nonwords = Pseudohomophones
Visual Controls
Approximate Visual Controls
Distant Visual Controls

Case = Upper-Case and Lower-Case.

it was derived) and word length. If N-count is critical it should correlate with reaction time when given sufficient spread in the data.

The correlations are shown in Table 7. It was found that the logged reaction time and N-count were not reliably correlated for either the pseudohomophones (lower-case r= 0.1735, NS; upper-case r= 0.1548, NS) or visual controls (lower-case r= -0.2396, NS; upper-case r= -0.2518, NS). The frequency of the root word also did not correlate reliably with the logged reaction time. Significant correlations were found for lower-case visual controls (r= 0.5534, P<0.05), upper-case pseudohomophones (r= 0.4221, P<0.05) and upper-case visual controls (r= 0.6233, P<0.05)

TABLE 7

Logged Reaction Times for Upper and Lower-case Pseudohomophones and Visual Control Nonwords, Correlated with N-Count, Frequency of Root Word and Length of Letter String in Experiment 2.

	N	R W Freq	S L
Lower-Case			
Pseudohomophones	0.1735	0.2205	0.3528
Visual Controls	-0.2396	0.0685	0.5534 *
Upper-Case			
Pseudohomophones	0.1548	0.2243	0.4221 *
Visual Controls	-0.2518	0.1818	0.6233 *

N = N-Count
R W Freq = Root Word Frequency
SL = String Length
* = sig at 0.05 level

between logged reaction times and letter string length. Shorter letter strings were associated with faster reaction times. These results contrast with Martin's argument for the importance of N-count as an explanation of the pseudohomophone effect found in Coltheart et al's (1977) experiment .

2.2.4 Discussion.

These results generally confirm those of Martin (1982); when the visual similarity of the pseudohomophones and nonwords are appropriately matched then pseudohomophones do not take longer to be rejected than other nonwords. This effect is true in upper and lower-case though there is a slight trend towards a pseudohomophone effect in upper-case.

An interesting aspect of this experiment was the effect of case. The main effect was not significant but the interaction with nonword type was, but only in the by-subject analysis. Pseudohomophones in upper-case did tend to take longer to reject than their visual controls. However, the trend disappeared in lower-case, where pseudohomophones had faster reaction times than their matched controls. Although this effect was not significant it does lend some support to the notion that the use of lower-case presentation might have played some part in Martin's failure to find a pseudohomophone effect

Martin's explanation for Coltheart et al's (1977) demonstration of the pseudohomophone effect relies heavily on the relationship between a letter string's N- count and reaction time. However, the analyses for the pseudohomophones and visual control nonwords failed to show a significant relationship between a nonword's N-count and reaction time. This casts doubt on the relevance of the N-count as an explanation for the occurrence of the pseudohomophone effect in previous studies.

2.3 EXPERIMENT 3. The Variable Reliance on a Speech Code and the Pseudohomophone Effect

2.3.1 Introduction

There could be reasons other than visual similarity for Martin's failure to find a pseudohomophone effect. McQuade (1981) has claimed that phonological recoding in lexical access is "variable and contextually defined". When she controlled the visual similarity of pseudohomophones and their control nonwords by matching them on summed positional frequencies, she obtained a pseudohomophone effect only when the pseudohomophones constituted a small percentage of the nonwords (13%) but not when they made up the majority of the nonwords. She argued that subjects were able to rely on visual coding when phonological recoding would have led to too many errors, as when nearly all the nonwords were pseudohomophones. Although McQuade demonstrated a pseudohomophone effect when the visual similarity of pseudohomophones and visual controls were matched on summed positional frequencies, it is still possible that the pseudohomophones were closer in visual similarity to a particular word than were the visual control nonwords. As the stimuli were not published this possibility can not be dismissed. Therefore, the observed pseudohomophone effect may have been due to a greater visual similarity of pseudohomophones to real words compared to the nonhomophonic nonwords.

Following McQuade's demonstration that the pseudohomophone effect may be a variable one depending on the distribution and type of nonwords that are used as filler items, in the present experiment a high proportion of nonhomophonic nonwords were used as filler items so as to encourage subjects to use a phonological stategy. The pseudohomophones formed 15.4% of the nonword set, as did the visual control nonwords.

In the present experiment, it was decided to check on the generality of the negative results obtained in Experiments 1 and 2, across different English language materials. This is of particular importance if we are to be able to dismiss earlier studies where demonstrations of the pseudohomophone effect were confounded with visual similarity. It is therefore necessary to repeat the findings of Experiments 1 and 2 using a new set of stimuli following Martin's criteria for matching pseudohomophones to visual control nonwords. In addition, neither the beginning or the end of a word were changed as Haber and Haber (1981) have shown these to be particularly important in the identification of words. Finally, following Taft (1982) only one graphemic change was made when changing words into nonwords; that is either one letter was added , substituted or deleted in the medial position of a word to produce the pseudohomophones and visual control nonwords for the present experiment.

In order to achieve this two root words of approximately equal surface frequency with the same number of syllables and letters and which shared a common internal letter in the same letter position were chosen. A letter was either added substituted or deleted at comparable letter positions within in each root word so as to produce a pseudohomophone (all the pseudohomophones were homophonic with only one English word) and a pronounceable nonword. For example the letter strings WORD and COST both share the letter O in the second position and are of equal frequency. When this letter is substituted with the letter E two new letter strings (WERD and CEST) are formed, one of which is a pseudohomophone and the other a visually controlled nonword.

The other nonword fillers were created by producing another set of pseudohomophones from a wide ranging sample of words in Kucera and Francis. These pseudohomophones then had a letter changed arbitrarily to produce a nonhomophonic nonword equivalent to Martin's approximate visual controls. The words were also chosen from Kucera and Francis (1967) to approximately match the frequency and length of the pseudohomophone target word. A pilot study was carried out on the pseudohomophones and visual controls as a final check. The nonwords were printed on sheets of paper and given to six subjects who were run individually. They had to read all the stimuli out loud, any that were read incorrectly or resulted in confusion were discarded. Five of the nonwords were replaced as a result of this.

The nonwords had the following N-counts; Pseudohomophones = 3.85; Visual controls = 3.25. The difference was not significant ($t (24) = -0.7036$; $P>0.05$). (Details of the stimuli used can be found in Appendix I).

2.3.2 Method

(a) Subjects.

Twenty University of York students (11 females and 9 males) were paid to participate in this experiment.

(b) Stimuli and Design.

The nonwords consisted of 20 pseudohomophones, 20 visual controls and 110 filler nonwords. There were 150 words. Following the results of Experiment 2 the stimuli were presented in upper-case in order to magnify the probability of a pseudohomophone effect emerging.

(c) Procedure.

The procedure was identical to that in Experiment 1, subjects saw 35 practice trials followed by 150 nonwords and 150 words in random order.

2.3.3 Results.

The reaction time data were treated in the same way as in Experiment 1. Only correct reaction times were analysed and any responses that took two seconds or longer were discarded. This procedure resulted in the dicarding of 0.5 per cent of responses to pseudohomophones. The anti-logged mean reaction times to pseudohomophones and visual controls can be seen in Table 8. Here the subjects produced faster reaction times to the pseudohomophones than the visual controls.

TABLE 8

Anti-Logged Mean Reaction Times and Error Rates for Experiment 3.

TYPE OF NONWORD	PH	VC
R. Time (msec)	636	650
Error Rate (%)	6.8	5.3

PH = Pseudohomophones
VC = Visual Controls
R. Time = Reaction Time

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate one-way analyses of variance were performed on these two sets of scores after applying a log transformation; one by treating subjects as a random factor, and the other treating materials as a random factor (See Table 9). The analysis showed that reaction times to pseudohomophones were not significantly different from those for the visual controls by-subjects, (F=1.254; df=1,19; P>1.0) and across words (F= 1.156; df= 1,19; P>0.05).

The error rates were low, an analysis of variance (shown in Table 10) carried out on the arcsine transformed error data showed that the difference between conditions was not significant (F=0.702; df=1,19; P>0.05).

TABLE 9

Analysis of Variance on the Reaction Times for Nonwords in Experiment 3.

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	19	929.688			
Nonwords	1	7.688	7.688	1.254	NS
Error	19	116.469	6.130		
Within	20	124.156			

TSQ/N= 3155913.8000 N= 40 SST= 1053.8438

Source	df	SS	MS	F	p
(By-Materials)					
Materials	19	566.500			
Nonwords	1	9.875	9.875	1.156	NS
Error	19	162.250	8.539		
Within	20	172.125			

TSQ/N= 3164908.2000 N= 40 SST= 738.6250

Nonwords= Pseudohomophone
Visual Controls

TABLE 10

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Error Data of Experiment 3.

Source	df	SS	MS	*F*	*p*
Subjects	19	17.167			
Nonwords	1	0.332	0.332	0.702	NS
Error	19	8.994	0.473		
Within	20	9.326			

TSQ/N= 53.6500 N= 76 SST= 54.6620

Nonwords = Pseudohomophones and Visual Controls.

As in the previous experiments, correlations between N-count, frequency and length were computed. If an items N-count is an important factor in determining reaction time we should expect significant correlations between these variables for both the pseudohomophones and visual control nonwords. The correlations are shown in Table 11.

TABLE 11

Logged Reaction Times for Upper-Case Pseudohomophones and Visual Control Nonwords, Correlated with N-Count, Frequency of Root Word and Length of Letter String and Frequency Weighted N-Count in Experiment 3.

	N	R W F	S L	F W N
Pseudohomophones	-0.3835	-0.3616	0.4705*	0.3441
Visual Controls	-0.1543	-0.2715	0.5526*	-0.1324

N = N-Count
R W F = Root Word Frequency
S L = String Length
F W N = Frequency Weighted N-Count

* = significant at the 0.05 level

The correlations between the logged reaction times and N-counts for the pseudohomophones is (r=-0.3835, NS) and for the visual controls is (r=-0.1543, NS); neither of these values approached significance. The correlation between the nonword logged reaction time and frequency of the root words were also not significant. The correlation between the logged reaction time and letter string length for the pseudohomophones is significant (r= 0.4705, $P<0.05$) as it is for the visual controls (r= 0.5526, $P<0.05$). Both of these correlations are significant; the shorter letter strings were associated with faster reaction times.

The failure to find any significant correlations between reaction time and a letter string's N-count led us to construct a new measure of N-count that was sensitive to the frequency of all those words which were visually similar to it. The frequency of each word that was included in the N-count of a letter string was summed to give an overall frequency for those words. That is the N-count for each letter string was frequency weighted, as it was considered that reaction time to a letter string may be related to the frequency of the words that make up the letter strings N-count. Those letter strings with orthographic neighbours (N-count) having high frequencies, should differ from those with only low-frequency neighbours in their reaction times. It was hypothesized that letter strings with large frequency weighted N-counts might have slower reaction times than those with lower frequency weighted N-counts, because of differences in the amount of lexical activation produced by these two types of letter string.

The correlation between the frequency weighted N-count and logged reaction time for the pseudohomophones is ($r=0.3441$, NS) and for the visual controls is ($r=-0.1324$, NS), neither of these values approached significance.

2.3.4 Discussion

The results from this experiment are consistent with those of Martin (1982), and Taft (1982). It was shown using a new set of stimuli that when pseudohomophones are carefully matched with other nonwords for their visual properties they do not show slower reaction times. In contrast with McQuade (1981) who probably did not sufficiently control her nonwords for visual similarity, the pseudohomophones were rejected more quickly than the matched control nonwords when they constituted a small proportion of the nonword set. This supports the idea that previous demonstrations of the effect were a result of greater visual similarity to real words amongst pseudohomophones than other nonwords.

However, the low correlations between a letter string's N-count and reaction time failed to support Martin's suggestion that N-count is an important determinant of reaction time. This remains something of a paradox. On the one hand when N-count is equated between pseudohomophones and other nonwords there is no difference, or little difference in reaction time. On the other, quite large differences in N-count exist between the nonwords used in these experiments, but these differences do not correlate with differences in reaction time. This leads to the idea that N-count itself may not be a good predictor of reaction time, but that it may well be correlated with some other variables that are. One possibility was examined in the present experiment, which involved taking account of word frequency. When a new N-value was devised, which allowed the frequencies of the visually similar neighbours to be included, this too failed to correlate significantly with a letter string's reaction time.

2.4 Summary and Conclusions.

These three experiments, have produced only very weak support for the pseudohomophone effect: none of the experiments has produced a reliable effect. The results are consistent with those found by Martin (1982), but, they are at odds with the majority of the literature (Rubenstein, Lewis and Rubenstein, 1971; Coltheart, Davelaar, Jonasson and Besner, 1977; Patterson and Marcel, 1977; Cohen and Freeman, 1978; Barry, 1981; McQuade, 1981) where the effects of pseudohomophones have been found to be both reliable and robust. How can these inconsistencies be explained? Traditionally, it had been argued that the pseudohomophone effect could only arise as a result of speech coding in lexical access. However, an alternative explanation can be put forward when the nonwords are subjected to a detailed analysis. Martin proposed that those studies demonstrating a pseudohomophone effect had failed to adequately control the visual similarity of pseudohomophone and control nonwords to real words. Although these nonwords had been matched to some degree, pseudohomophones still bore a greater resemblance to real words, partly as a result of sharing many letters with the target word with which they are homophonic.

An objective measure of the visual similarity of a letter string (N-count) developed by Coltheart, Davelaar, Jonasson and Besner (1977) seemed to provide an explanation for the pseudohomophone effect in terms of differences in visual similarity (Martin, 1982). Besner and Davelaar (1983) however, challenged this interpretation by claiming that a pseudohomophone effect can still be found when the visual similarity of the nonwords are matched on N-count.

The present results support the findings of Martin. When pseudohomophones and control nonwords are matched for visual similarity a pseudohomophone effect will not be found. The evidence for the pseudohomophone effect being critically dependent on N-count was not supported by Experiments 2 and 3, N-count failed to correlate with reaction time. If the number of orthographic neighbours does determine a letter string's reaction time one would predict that the time to respond to a nonword would be slower when its N-count is high rather than low. Results consistent with this idea were found by Coltheart et al., (1977). They found that 2 groups of nonwords one with high N-counts (with a mean of 11.27 words) were rejected more slowly than nonwords with low N-counts (with a mean of 2.25 words). The difference in the rejection times between the high and low-N nonwords was explained as a function of the similarity between the nonword being encoded, and the lexical entry. High-N nonwords are similar to more lexical entries and therefore, will take longer to be rejected than nonwords with low N-counts which are similar to fewer lexical entries. However, despite the reasonable expectation, no reliable correlations between the N-count of a letter string and its corresponding reaction time were found in the present experiment.

The absence of an effect of N-count on lexical decision times in the present experiment in comparison to that found by Coltheart, Davelaar, Jonasson and Besner (1977) may be due to a range effect. The high N value for nonwords in the experiment of Coltheart et al., (1977) ranged from 6 to 27 words, the low N-nonword values ranged from 0 to 4 four words. Therefore, the very high values found in the nonword stimulus set used by Coltheart et al., may have taken longer to reject as a result of being similar to many more lexical entries than the low N-nonwords. In Experiment 2 the N values for the pseudohomophones and visual controls ranged from 0 to 14 and 1 to 10 in Experiment 3. Therefore, the narrower range of values may not have allowed the effect N-count to emerge. The absence of an effect between a letter string's N-count and reaction time led us to consider the possibility that N might be correlated with some other predictor of reaction time such as a frequency. A weighted N-count was therefore developed. The importance of N was further questioned when the relationship of N and the frequencies of those words composing the orthographic neighbours was considered. It was expected that the summed frequencies of the N-count neighbours would correlate with the lexical decision times; high frequency neighbours with higher resting levels of activity would have a greater interfering influence with the response time than those neighbours with medium or low frequencies, and so would take longer to be recognized as a nonword. However, the correlation between the frequency weighted N-counts and reaction time was very low and not significant.

Another factor of interest raised by these experiments was the effect of case. In the first experiment using upper-case presentation, the pseudohomophones derived from Martin's (1982) paper were more difficult to reject than the matched visual controls and this trend was in the opposite direction to that found by Martin. Experiment 2 explored this trend and showed that case produced selective effects on reaction times although they were not reliable. This suggests that upper-case presentation may have slowed the process of lexical access but not significantly, in these experiments, thereby allowing the optional speech coding route to have more effect on the response.

In Experiment 3 another aspect that was considered was the nonword context; McQuade (1981) offered an explanation for the inconsistent demonstrations of the pseudohomophone effect in terms of strategy effects employed by subjects. She argued that subjects might be reluctant to rely on the optional phonological code when pseudohomophones constitute a large proportion of the nonwords as this would lead to many errors. This suggestion remains some what in doubt as the extent to which the nonwords were matched in their similarity to real words could not be evaluated. This explanation of the pseudohomophone effect was not supported by Experiment 3. Here pseudohomophones formed only 15.4 % of the nonword set so it might reasonably be expected that subjects could confidently rely on a speech code rather than visual access. A possible explanation of the difference between the present results and those of McQuade (1981), might be due to the pseudohomophones and matched control nonwords not being matched on N-count, (as the stimuli were not published this explanation remains untested) when such differences exist between nonwords longer reaction times have been found (Martin ,1982; Coltheart et al., 1977).

In conclusion, the present experiments show that the pseudohomophone effect provides very little support for the role of speech coding in the lexical decision task.

CHAPTER 3

VISUAL SIMILARITY IN NONWORD DECISIONS.

3.1 EXPERIMENT 4. The Effect of Double Pseudohomophones on the Pseudohomophone Effect.

3.1.1 Introduction.

Experiments 2 and 3 presented in the previous chapter examined some possible explanations for the inconsistencies amongst studies of the pseudohomophone effect. Experiment 2 established that the slower reaction times produced to pseudohomophones, are not reliably affected by case. Experiment 3 examined the influence of a low proportion of pseudohomphones in the nonword set and showed that even in the context of a small number of pseudohomophones an effect will not necessarily be found.

Two papers (Coltheart, Davelaar, Jonasson and Besner 1977; Besner and Davelaar, 1983) have suggested that the pseudohomophone effect is influenced by another factor, whether the pseudohomophones sound like homophones (BLUE/ BLEW; PAWS/ PAUSE/ PORES/ POURS). The pseudohomophones of Coltheart et al., (1977) were homophonic with two or more English words e.g. FLORE is homophonic with FLOOR and FLAW. Coltheart et al., (1977), proposed that the pseudohomophone effect might be small and by using double pseudohomophones the "no" response would be slowed down, as double pseudohomophones undergo two or more unsuccessful spelling checks; this would lead to a magnification of the pseudohomophone effect. Following this logic Besner and Davelaar (1983) set out to test if this would explain

Martin's failure to obtain a pseudohomophone effect with materials matched for N-count. They carried out an experiment using Coltheart et al's set of stimuli matched to a set of nonwords of the same N-count. They found a pseudohomophone effect with these materials. They therefore argued, contrary to Martin and Taft, that this effect was not attributable to uncontrolled visual similarity to other nonwords.

There are however, a number of problems with Besner and Davelaar's experiment. On analyzing the stimulus set it was found that amongst the matched control nonwords was one real word (SILD, a kind of fish) and up to eight pseudohomophones depending on one's pronounciation of the stimuli [(KORM, (corm); HEGE, (hedge); CORZE, (cause); FIE, (fee); BAID, (bade); BORT, (bought); and SLOO (slew); STOUK, (stook)]. There is an inconsistency in the control nonwords in that STOUK is spelt as STOAK (which is homophonic with STOKE) in the paper by Dennis, Besner and Davelaar (1985), nevertheless both these nonwords are pseudohomophones. With 23% of the control nonwords being either real words or pseudohomophones it is somewhat surprising that they found such a strong pseudohomophone effect with this "contamination".

In addition to this problem, the visual control nonwords in Besner and Davelaar's experiment are open to criticism. Martin's pseudohomophones and visual controls differed by only one letter from the words that they were derived from, whereas the approximate visual controls differed by two letters from the "parent" word. Besner and Davelaar's stimuli on the other hand had not been systematically formed by deleting, substituting or adding a letter to a word to produce a pseudohomophone and control nonword. The matched contol words in their experiment were formed by changing one letter of the pseudohomophone which it self differed frequently by two or more letters from the homophonic real word. For example BLOO, differs by two letters from the words BLUE and BLEW, the control nonword PLOO differs by three letters from these. Besner and Davelaar's control nonwords are equivalent to Martin's approximate visual controls, and are visually more different than the pseudohomophones are from real words (even when they have similar N-counts) and may have therefore, less common combinations of letters occuring in a string. This might lead to them being be rejected as nonsense more quickly on the basis of their visual characteristics. Their results could then be explained purely in terms of visual factors and not as a result of a phonological code being used to access the lexicon.

To check on these possibilities Experiment 4 was designed to replicate Besner and Davelaar's findings using a new set of stimuli. The double pseudohomophones and control nonwords were systematically formed following the criteria advanced by Martin (1982); by substituting or adding a letter in the medial position of two words of similar frequency (cf Experiment 3). This ensures that the control nonwords are as visually similar to a real word as the pseudohomophones. The proportion of pseudohomophones to other nonwords was kept low so as to encourage the subjects to use a phonological code during lexical decisions. The pseudohomophones formed 13.33% of the nonword stimuli as did the matched visual control nonwords.

3.1.2 Method

(a) Subjects.

Sixteen University of York students (8 women and 8 men) were paid for participating in this experiment.

(b) Stimuli and Design.

A within-subjects design was used. The nonwords consisted of 20 double pseudohomophones and 20 visual controls. These were formed in the same manner as the stimuli in Experiment 2. There were 110 nonword fillers and 150 words. The pseudohomophones had an N-count of 3.7 words and the visual controls an N-count of 4.55 words (This difference was not significant (t (19)= 0.7597, NS). The stimuli were presented in upper-case (Details of the pseudohomophones and the nonword fillers and words can be found in Appendix II).

(c) Procedure.

The procedure was identical to that in Experiments 1, 2 and 3. Subjects saw 35 practice trials followed by 150 nonwords and 150 words in random order.

3.1.3 Results.

Only correct reaction times were analysed and any reaction times of two seconds or longer were discarded. This procedure resulted in the discarding of 0.625 per cent of responses to pseudohomophones. The anti-logged mean reaction times to pseudohomophones and visual controls can be seen in Table 12. No trace of a pseudohomophone effect was in evidence; in fact the pseudohomophones were rejected more quickly than the control nonwords.

TABLE 12

Anti-logged Mean Reaction Times and Error Rates for Experiment 4.

	TYPE OF NONWORD	
	PH	VC
R. Time (msec)	666	688
Error Rate (%)	5.9	3.1

PH = Pseudohomophones
VC = Visual Controls
R. Time = Reaction Time

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these two sets of scores after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table 13). The by-subjects analysis showed that the pseudohomophones were rejected significantly faster than the visual controls ($F= 4.964$; $df=1,15$; $P<0.05$). However this difference was not significant in the materials analysis ($F= 2.832$; $df= 1,19$; $P> 0.05$).

An analysis of variance performed on the arcsine transformed error rates showed that these did not differ

TABLE 13.

Analysis of Variance on the Reaction Times for Nonwords in Experiment 4.

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	15	2226.719			
Nonwords	1	17.250	17.250	4.964	$p<0.05$
Error	15	52.125	3.475		
Within	16	69.375			
TSQ/N=	256542.3000	N= 32	SST= 2296.0938		
(By-Materials)					
Materials	19	229.094			
Nonwords	1	38.594	38.594	2.832	NS
Error	19	258.906	13.627		
Within	20	297.500			
TSQ/N=	3212011.5000	N= 40	SST= 526.5938		

Nonwords= Pseudohomophone
Visual Controls

TABLE 14

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Error Data of Experiment 4.

Source	DF	SS	MS	F	p
Subjects	15	12.896			
Nonwords	1	0.669	0.669	1.060	NS
Error	15	9.466	0.631		
Within	16	10.135			

TSQ/N= 25.6640 N= 32 SST= 23.0305

significantly (F=1.060; df=1,15; P,>.05, See Table 14)

A further analysis was carried out in which the N-counts for the pseudohomophones and visual control nonwords were correlated with reaction time. This was found to be not significant for pseudohomophones (r = -0.0509, NS), or visual controls (r = 0.0102, NS). The correlations between the frequency weighted N-count and reaction time (r= -0.2564, NS) for double pseudohomophones and (r= -0.1015, NS) for the control nonwords were not significant.

TABLE 15.

Logged Reaction Times for Pseudohomophones and Visual Control Nonwords, Correlated with N-Count, and Frequency Weighted N-Count in Experiment 4.

	N	F W N
Pseudohomophones	-0.0509	-0.2564
Visual Controls	0.0102	-0.1015

N = N-Count
FWN = Frequency Weighted N-Count

3.1.4 Discussion.

Once again in this experiment a pseudohomophone effect was not found, providing no support for the argument that the pseudohomophone effect will be greater when they sound like two or more English words. These results are inconsistent with those of Besner and Davelaar (1983). While the pseudohomophone effect might be small and easily obscured the stronger manipulation of using pseudohomophones sounding like English homophones did not lead to a magnification in the observed effect. The argument that the reaction times to double pseudohomophones would be slowed by the unsucessful spelling checks was not supported here. In fact, the double pseudohomophones were rejected faster than the control nonwords in this experiment. Therefore the findings of Besner and Davelaar can be explained on the grounds of the poor construction of their stimuli.

The relationship between a nonword's reaction time and N-count was once again explored. However, the correlations between an item's N-count, frequency weighted N-count and reaction time were disappointingly small. This pattern is consistent with the results of Experiments 2 and 3. It would seems that N-count per se is not a good predictor of reaction time.

These results are consistent with the idea that previous demonstrations of the pseudohomophone effect were a result of there being greater visual similarity to real words amongst the pseudohomophones than other nonwords. The results are consistent with Martin's findings. Again the results confirm with new stimuli that if the pseudohomophones are adequately matched with other nonwords they do not show slower reaction times.

3.2 EXPERIMENT 5. The Pseudohomophone Effect and the Criteria Used in the Production of Nonwords

3.2.1 Introduction

In view of the negative results produced in the previous experiments (1,2,3,4), the present study considered another possible factor that might have contributed to the discrepant findings surrounding the pseudohomophone effect. One difference between studies is the way in which the nonwords were constructed. Martin (1982) and Taft (1982), produced their pseudohomophones and control nonwords in a systematic way by changing usually one letter (either by deletion, addition or substitution) in a target word, for example the pseudohomophone MEEN was derived from MEAN by substituting the letter A with an E.

The pseudohomophones of Besner and Davelaar (1983) on the other hand frequently differ in two or more letter positions from the target word with which it shares its pronunciation, and the paired controls were created by changing a single letter in the pseudohomophone. Therefore, the pseudohomophones and visual control nonwords differ in the number of letter positions they share with the target word.

It seemed worthwhile considering whether the different criteria adopted to form the nonword set might contribute to the different reported outcomes. It seems conceivable that a pseudohomophone effect will only be found for nonwords which differ in a number of letter positions from a real English word. Such letter strings might be expected to produce little activation of lexical recognition units on the basis of their visual properties but produce activation because of their phonological characteristics. If many of the letter strings in an experiment visually show little resemblance to words subjects might adopt a longer response deadline which would encourage the use of an alternative stategy for lexical access involving a phonological code.

To test this in the following experiment a new set of stimuli (pseudohomophones and visual controls) were produced by carrying out analogous orthographic changes involving two or more letters. Two host words with similar numbers of letters and syllables and where possible frequency were found. The two host words were required to share letters in the same spatial position if those letters were to be deleted or substituted by other letters. Two or more letter changes were made to form one pseudohomophone and one nonhomophonic nonword. For example CAME and COME both share the letters C and E. By substituting a K for the letter C and deleting the terminal E and then adding an I at the third letter position in each of the words a pseudohomophone KAIM and control nonword KOIM are formed. (The nonword set can be found in Appendix II). The pseudohomophones were homophonic with either one or two English words.

We would therefore predict that if the increased number of letter changes, which distinguishes Besner and Davelaar's stimuli from those of Martin's, is an important factor, then pseudohomophones formed by two or more letter changes should show longer reaction times than matched control nonwords. If however, only the visual similarity of the nonwords determines reaction time then no difference would be expected between the pseudohomophones and visual control nonwords.

3.2.2 Method

(a) Subjects.

Nineteen adults (9 women and 10 men) nine of whom were undergraduates at the University of York and ten others attending an open day at the University served as subjects.

(b) Stimuli and Design

The nonwords consisted of 25 pseudohomophones and 25 matched control words (Details of these stimuli can be found in Appendix II). The 110 nonword fillers were nonhomophonic, for example SLINT. There were also 160 real words. The stimuli were presented in upper-case with each subject receiving a different random order.

(c) Procedure.

The procedure was identical to that in previous experiments. After reading a set of written instructions, the subjects saw 32 practice trials followed by 160 words and 160 nonwords.

3.2.3 Results

The treatment of results was identical to that in previous experiments. Only correct reaction times were analysed any reaction times that took 2 seconds or longer were discarded. This procedure resulted in the discarding of 0.631 per cent of responses to pseudohomophones and

1.066 per cent of responses to visual control nonwords. The anti-logged mean reaction time and error rates for Experiment 5 can be seen in Table 16. Pseudohomophones were responded to more quickly than matched control words.

TABLE 16

Anti-logged mean reaction times and error rates for Experiment 5.

	TYPE OF NONWORD	
	PH	VC
R. Time (msec)	660	674
Error Rate (%)	3.6	4.0

PH = Pseudohomophones
VC = Visual Controls
R. Time = Reaction Time

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these two sets of scores after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table 17). The difference in reaction time between pseudohomophones and visual controls was not significant across subjects (F=0.692; df=1,18; P,>0.05) or across materials (F=0.108; df=1,24; P,>0.05).

The pattern of errors scores is summarized in Table 16. An analysis of variance was carried out on the arcsine transformed error scores (See Table 18). There was no difference between the error rates for pseudohomophones

TABLE 17.

Analysis of Variance on the Reaction Times for Nonwords in Experiment 5.

Source	df	SS	MS	F	p
(By-subjects)					
Subjects	18	2942.281			
Nonwords	1	7.219	7.219	0.692	NS
Error	18	187.781	10.432		
Within	19	195.000			

TSQ/N= 3032242.9000 N= 38 SST= 3137.2813

Source	df	SS	MS	F	p
(By-Materials)					
Materials	24	395.938			
Nonwords	1	1.844	1.844	0.108	NS
Error	24	408.938	17.039		
Within	25	408.938			

TSQ/N= 3988347.9000 N= 50 SST= 806.7188

Nonwords= Pseudohomophone
Visual Controls

TABLE 18

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Nonword Error Data of Experiment 5.

Source	df	SS	MS	F	p
Subjects	18	14.781			
Nonwords	1	0.330	0.330	0.588	NS
Error	18	10.101	0.561		
Within	19	10.430			

TSQ/N= 42.4126 N= 38 SST= 25.2109

Nonwords = Pseudohomophones
Visual Controls

and control nonwords, (F=0.588; df=1,18; P,>0.05).

3.2.4 Discussion

The results of Experiment 5 showed that there was no evidence of a pseudohomophone effect when the nonwords are constructed by making two or more letter changes in the host word. The pseudohomophones are essentially identical in form to those of Besner and Davelaar (1983), yet here the pseudohomophones were rejected more rapidly than matched control nonwords.

The different outcomes between these and Besner and Davelaar's results can be explained in terms which do not rely on phonological encoding. Their pseudohomophones were created in many cases by changing two or more letters of a real word, but the visual controls were not similarly produced; the latter were formed by changing one letter of the pseudohomophone so these two nonwords do not share the same relationship to real words. The paired visual control nonwords share fewer letters with the target word than the pseudohomophones do. This difference is important as Martin (1982) has demonstrated (in Experiment 1) and which we confirmed in Experiment 1; nonwords that are less word like are rejected more quickly than those that are more word like. Therefore a parsimonious explanation for the results found by Besner and Davelaar (1983), is in terms of a failure to adequately control the visual similarity between nonwords and real words; there is no need to appeal to the item's phonological properties.

3.3 EXPERIMENT 6. The Effect of Context on the Pseudohomophone Effect.

3.3.1 Introduction

It has been proposed by Dennis, Besner and Davelaar (1985) that the pseudohomophone effect is context sensitive; they suggested that some feature of the words used in the lexical decision task may have contributed to the discrepant findings in the literature. Evidence for context effects consistent with this line of thought has come from McQuade (1981) who showed that the proportion of pseudohomophones in an experiment contribute to the probability of finding a pseudohomophone effect. Davelaar, Coltheart, Besner and Jonasson (1978) reported that the lower frequency member of a homophonic pair of words was responded to more slowly in the absence of pseudohomophones, but this difference disappeared in their presence. Andrews (1982) has also reported that pseudohomophones influenced the response time to words; in the context of pseudohomophones words yielded faster and more accurate reaction times. More specifically Dennis et al., (1985) proposed that the presence of homophones amongst the word stimulus set may be important for producing a reliable pseudohomophone effect. If this finding proves to be reliable then an explanation is available for previous failures to find the effect.

Dennis et al., (1985) carried out a series of four experiments in which the pseudohomophones and control nonwords of Martin (1982) and Besner and Davelaar (1983) were presented in different word contexts. In Experiments 1 and 2 the nonwords were presented in the context of either high or low-frequency nonhomophonic words and in Experiments 3 and 4 the nonwords were intermixed with words, half of which were homophones.

Dennis et al (1985) in their fourth experiment compared the pseudohomophones and visual control nonwords used by Besner and Davelaar (1983) in two groups of subjects. For one group the nonwords were presented with 39 lower frequency members of a homophone pair and their matched control words taken from Coltheart et al., (1977). For the other group the nonwords were presented with 39 higher frequency members of a homophone pair and control words again taken from Coltheart et al., (1977). A significant pseudohomophone effect was found in both groups with the frequency of the homophone words having little effect. In contrast, when the same nonword stimuli were used (Experiment 1) in the context of nonhomophonic words a pseudohomophone effect was not found.

Similarly in their third experiment they found a significant pseudohomophone effect using Martin's (1982) pseudohomophones and visual controls when they were presented with a mixture of 25 nonhomophonic and 25 lower frequency members of a homophone word pair. The pseudohomophone effect was not elicited with the same stimuli when the homophones were absent as in their second experiment. In fact, pseudohomophones were rejected more quickly than control nonwords in the context of low-frequency words.

The interplay between the word context, and the pseudohomophone effect, was explained by Dennis et al., with reference to the subject's task. They argue that pseudohomophones have the property of sounding like a real word (or several words) without the corresponding spelling and that this characteristic can be used in identifying a letter string as a nonword when homophones are absent or occur only occasionally amongst the stimulus word set. However, this evidence for making negative responses is lost in the presence of homophones when alternative spellings are used in English words which are spelt differently. Hence the reaction times to pseudohomophones in the presence of homophonic words are lengthened.

This demonstration of a pseudohomophone effect is not without problems: The pseudohomophone and visual control nonwords used by Besner and Davelaar (1983) differed from the target word in relation to the number of letters that they shared whereas the stimuli of Martin (1982) differed from the target word by the same number of letters. Therefore, the inconsistent results between the four experiments may reflect visual similarity between nonwords and words rather than phonological similarity. Although Dennis et al., (1985) did find a pseudohomophone effect using Martin's stimuli in the context of homophones the effect was significant only across subjects and not across materials.

A further problem with the context sensitive pseudohomophone effect put forward by Dennis et al., (1985) comes from the work of Taft (1982). He failed to find a pseudohomophone effect with pseudohomophones and visual control nonwords strictly controlled for visual similarity when homophones were included among the background words.

The aim of the present experiment was to test the proposal of Dennis et al., (1985) that the presence of homophones should influence the pseudohomophone effect. This experiment can be readily executed as a new set of stimuli had already been constructed (cf Experiment 3) which were identical in their form to those of Martin (1982). If the presence of homophones is important for the occurence of the pseudohomophone effect it seems reasonable to expect to find a pseudohomophone effect with these stimuli when in the presence of homophones.

3.3.2 Method

The general details of the method used were identical to those in earlier experiments.

(a) Subjects.

A total of nineteen subjects took part in this experiment (9 women and 10 men). Nine of these were undergraduates at the University of York. The remaining ten were adults attending an Open Day at the University.

(b) Stimuli and Design.

The nonwords consisted of 20 pseudohomophones (homophonic with one English word) and 20 matched nonhomophonic controls The filler nonwords were the same as those used in Experiment 3. The words were taken from Coltheart et al., (1977) and consisted of 20 homophones (the lower frequency member of a pair) and 20 matched controls. The stimuli were presented in a different random order to each subject, in upper-case (details of all the stimuli can be found in Appendix II).

(c) Procedure.

The procedure was identical to that in previous experiments. Each subject saw 32 practice trials followed by 40 words and 40 nonwords in a different random order .

3.3.3 Results

The results were treated in the same manner as those of the preceding experiments. Only correct reaction times were analysed. Any reaction times of two seconds or longer and reaction times to incorrect responses were discarded. This procedure resulted in the discarding of 1.315 per cent of responses to pseudohomophones and 1.052 per cent of responses to visual control nonwords. The mean reaction times for correct responses can be seen in the Table 19 below.

If we look at the nonwords first it can be seen that pseudohomophones were responded to more quickly than visually matched control nonwords. Amongst the words, the homophones had faster reaction times than the control words of similar frequency.

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these two sets of scores after applying a log transformation; one treating subjects as a random

TABLE 19

Anti-Logged Mean Reaction Times and Error Rates for the Words and Nonwords in Experiment 6

	TYPE OF STIMULI			
	PH	VC	HW	NCW
R. Time (msec)	732	749	676	687
Error Rate (%)	9.2	5.3	15.5	10.52

PH = Pseudohomophone
VC = Visual Control
HW = Homophonic Word
NCW = Nonhomophonic Control Word
R. Time = Reaction Time

factor, the other treating materials as a random factor (See Tables 20 and 21). The logged reaction times for the nonwords were entered into a one-way between subjects analysis of variance. The tendency for faster responses to our pseudohomophones than visual controls was not significant by subjects (F=2.751; df= 1,18; P,> 0.1) or across materials (F=0.019; df= 1,19; P,> 0.05).

An equivalent analysis of homophones and control words showed that there was no difference in reaction time across subjects (F=0.377; df= 1,18; P,>0.05) or by-materials (F=0.026; df= 1,19; P,> 0.05).

The higher error rates were associated with the faster reaction times for both the words and nonwords. The difference in error rates was not significant between the pseudohomophones and visual controls in an analysis of

TABLE 20

Analysis of Variance on the Reaction Times for Nonwords in Experiment 6.

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	18	1676.344			
Nonwords	1	10.750	10.750	2.751	NS
Error	18	70.344	3.908		
Within	19	81.094			
TSQ/N= 3131393.8000		N= 38	SST= 1757.4375		
(By-Materials)					
Materials	19	500.250			
Nonwords	1	0.313	0.313	0.019	NS
Error	19	315.438	16.602		
Within	20	315.750			
TSQ/N= 3308394.0000		N= 40	SST= 816.0000		

Nonwords= Pseudohomophone
Visual Controls

TABLE 21

Analysis of Variance on the Reaction Times for Words in Experiment 6.

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	18	1585.469			
Words	1	4.844	4.844	0.377	NS
Error	18	231.281	12.849		
Within	19	236.125			
TSQ/N=	3052145.1000	N= 38	SST= 1821.5938		
(By-Materials)					
Materials	19	398.125			
Words	1	0.813	0.813	0.026	NS
Error	19	598.000	31.000		
Within	20	589.813			
TSQ/N=	3228417.8000	N= 40	SST= 987.9375		

Words= Homophones
Nonhomophonic Controls

TABLE 22

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Nonword Error Data of Experiment 6.

Source	DF	SS	MS	F	p
Subjects	18	10.990			
Nonwords	1	1.112	1.112	1.855	NS
Error	18	10.789	0.599		
Within	19	11.901			

TSQ/N= 62.3613 N= 38 SST= 22.8902

Nonwords = Pseudohomophones
Visual Controls

TABLE 23

Analysis of Variance Summary Table Carried out on the Arcsine Transformed Word Error Data of Experiment 6.

Source	df	SS	MS	F	p
Subjects	18	3.015			
Words	1	0.327	0.327	2.013	NS
Error	18	2.927	0.163		
Within	19	3.254			

TSQ/N= 104.1168 N= 38 SST= 6.2695

Words = Homophones
Nonhomophonic controls

variance on the arcsine transformed error scores (F=1.855 ; df= 1,18; P,>0.1, See Table 22). Similarly the difference in error rates between homophones and control words was not significant (F=2.013; df= 1,18; P,>0.1, See Table 23).

3.3.4 Discussion

The results of Experiment 6 show that there is no pseudohomophone effect when pseudohomophones and matched visual controls are presented in the context of homophones. There was also no sign of a homophone effect, when the lower frequency member of a homophonic pair was compared with control words of similar frequency. These results fail to support those of Dennis, Besner and Davelaar (1985) and would suggest that the pseudohomophone effect that they found to be significant only in a by-subjects analysis was indeed not reliable.

An explanation can be offered as to why Dennis et al., found a significant pseudohomophone effect across subjects and stimuli in their fourth experiment. In that experiment they used the nonwords produced by Besner and Davelaar (1983). As was earlier argued (section 1.3.1)if these stimuli are closely examined it can be shown that the visual controls which were formed by changing one letter of the pseudohomophone do not bare as close a relationship to real words as the pseudohomophones. Therefore the visual controls are less visually similar to other real words and so are rejected more readily. These results therefore provide no support for the proposal that the presence of homophones amongst the word set is important for the finding of a pseudohomophone effect.

3.4 Summary and Conclusions

These experients (4,5,6) together with those presented in Chapter 2 failed to produce a pseudohomophone effect. This pattern of results was interpreted in terms of visual processing; previous observations of the pseudohomophone effect could not be attributed to the effects of phonology.

The argument forwarded by Coltheart et al., (1977), and Besner and Davelaar (1983), that the pseudohomophone effect is a modest one that can be magnified by manipulating the number of words that they are homophonic with, was not supported. The results of Experiment 4 are inconsistent with those of Besner and Davelaar (1983). In fact, the pseudohomophones were rejected slightly faster than the other nonwords in this experiment.

In Experiment 5 the relationship between the nonwords and the words from which they were produced in terms of the number of shared letters was considered. It was not known whether the possible effects of interference from the visual similarity of these nonwords would lead subjects to adopt different strategies. However, the results of Experiment 5 showed that the different criteria adopted by Martin (1982); Coltheart et al., (1977) and Besner and Davelaar (1983) had no effect on the rejection times of the pseudohomophones.

Dennis, Besner and Davelaar (1985) argued that the pseudohomophone effect is more easily found in the presence of homophones. They reasoned that in the absence of homophones the phonological characteristic of pseudohomophones is a reliable property that can be used to identify them as nonwords. However, when homophones are present such an attribute can no longer be used reliably to identify nonwords, as the homophones share the same characteristic. The task of discriminating the nonwords from words therefore becomes more difficult, and the assumption is that the process of identification as a consequence becomes slower.

The results of Experiment 6 are inconsistent with their claim and with their findings. The finding of slower reaction times to Martin's pseudohomophones by Dennis et al., (1985) remains unexplained but, as the effect was significant only across subjects the outcome cannot be generalized. Support for this view comes from Experiment 6, where the letter strings were generated in the same way as those of Martin, but failed to produce a similar pattern of results.

Despite the apparant consistency of the effects of a homophone context in the experiments (3 and 4) of Dennis et al., the view that the pseudohomophone effect is phonologically based is not well founded. The longer reaction times obtained for the set of pseudohomophones compared to the visual controls produced by Besner and Davelaar were confounded with their visual similarity to real words. The pseudohomophones of Besner et al., as a consequence of their production, were still more similar to the target word than the visual control nonwords were. When this similarity is controlled, as in Experiment 6, longer reaction times to pseudohomophones will not be produced in the presence of homophones.

CHAPTER 4

POSSIBLE INDIVIDUAL DIFFERENCES IN SPEECH RECODING.

4.1 EXPERIMENT 7. The Effects of Individual Differences on the Pseudohomophone Effect.

4.1.1 Introduction

Following the failure to find a significant pseudohomophone effect in Experiments 1 to 6 in the present experiment it was decided to examine the possible existence of individual differences in the use of a speech code as an explanation for the absence of a pseudohomophone effect in these experiments.

The work of Boder (1973) suggests that there are individual differences in the ability to use spelling-to-sound rules. She studied the spelling and reading patterns of children diagnosed as having specific developmental dyslexia. Boder claims, that "A consistent relationship between how a dyslexic child reads and how he spells" was found. From the examination of their reading and spelling errors, three main subtypes of dyslexic children were differentiated according to their knowledge of spelling-to-sound rules. Dysphonetic dyslexic children showed a deficit in phonological decoding although they could read words in their sight vocabulary. The reading errors of this group tended to be visual; alternative visually similar words were substituted e.g., they would read money as "monkey" and step as "stop". Their spelling tended to be bizzare as they could not analyse the word into its component sounds e.g., rough was spelt as "refet" and scrambled was spelt "sleber". The dyseidetic dyslexic child showed a deficit in whole word reading with words being sounded out phonetically, it was "as if he is seeing each word for the first time". Their reading errors were typically phonetic e.g., business may be read as "bussyness" or talk as "talc". Their spelling errors were largely phonetic e.g., laugh was spelt as "laf", and bird as "burd". The third group, mixed dysphonetic-dyseidetic dyslexia, reflected a combination of reading and spelling patterns of the other two subtypes. Boder's (1983) work suggests that "in the dyslexic child the normal reading process is dissociated" with those dyslexics with a knowledge of spelling-to-sound rules in reading producing spelling errors that reflected these rules and in those dyslexics who did not know these rules producing spellings which reflected their absence. A similar division of poor readers has been made by Mitterer (1982).

A parallel pattern of individual differences in the application of phonic and whole word skills has been demonstrated by Baron and Strawson (1976) in the normal adult reader. Baron and Strawson, introduced the idea that individuals vary along a continuum in the way that they pronounce printed words. Two polar subgroups of normal readers were distinguished on their relative reliance on spelling-to-sound correspondence rules (that is the mapping or correspondences between symbols and phonemes) in reading words out loud. The "Phoenician" group relied to a greater extent on spelling-to-sound rules, and the "Chinese" group relied to a greater degree on whole word visual identification.

Baron and Strawson identified these groups on the basis of a number of tests that measured the use and knowledge of spelling-to-sound rules. The "use" of rules was tested by subjects reading regular and exception words aloud; the application of rules being indicated by the faster reading of regular than exception words. The knowledge of spelling-to-sound rules was tested by subjects' ability to read a list of nonsense words some of which were homophonic with real English words, such as FLOE (that is it sounds like " FLOW"). The subjects' task was to decide whether the letter string sounded like a real word when pronounced according to rules of English. Phoenicians were those who scored very few or no errors on this test, indicating a knowledge of spelling-to-sound correspondence rules, whereas the Chinese readers had a high error rate indicating a lack of knowledge about spelling-to-sound correspondence rules. A spelling test was also given to test the subject's knowledge of word specific associations; this was in two parts. The subjects had to spell 25 "difficult " words dictated to them without making any corrections, this gave a baseline measure of spelling ability. In the second part the subject had to identify the correct spelling of the words given in the first part from two alternatives e.g., Inoculate and Innoculate. They were scored according to the number of errors that they made in the first part, less the number of errors in the forced choice test. This "difference score" gave a measure of spelling improvement as a result of being able to see the correct spelling. The rationale for this was that individuals who rely to a greater extent on word specific associations would use this as a spelling check; therefore, their ability to identify a word from an alternative would be better than their ability to spell the word without additional clues. Phoenicians were those who had a small difference between the two spelling tests and the Chinese were those with a high difference score between the first and second spelling test. The scores on the nonsense word and spelling tests were then combined. Baron and Strawson selected subjects at the two ends of the individual differences continuum according to their relative reliance on spelling-to-sound correspondence rules in the tests described above.

These individuals who differed on their relative ability to use spelling-to-sound correspondence rules, were then tested on their ability to pronounce regular and exception words. The use of rules would be predicted to cause the slower reading of exception words than of regular words (That is the regularity effect). They found that subjects (Phoenician) who used rules as shown by the nonsense word test but few specific associations as indicated by the spelling test, read lower-case exception words aloud slower than regular words. Those subjects (Chinese) who demonstrated the reverse pattern of results on the nonsense reading and spelling test did not show such a difference in their reading of regular and exception words. Studies of the Phoenician- Chinese continuum have been extended to reading (Baron, 1979) and spelling ability (Treiman, 1984) in children.

Following on from this work, we might predict that if the pseudohomophone effect is a phonological effect, that Phoenician and Chinese style readers would respond differently to pseudohomophones in a lexical decision task. If Phoenicians rely more on spelling-to-sound rules and Chinese readers on a word specific (lexical) mechanism rather than rules, we would expect that Phoenicians would show a pseudohomophone effect whereas Chinese style readers would not. In this case the null results of previous experiments may reflect the joint effects of different sub-groups of readers. Some (Phoenecicians) who are sensitive to spelling-to-sound rules and others (Chinese) who are not. It was decided to test this prediction.

A different method was used to select subjects on the Phoenician-Chinese dimension from that used by Baron and Strawson (1976). As our subjects were to be specifically tested on their responses to pseudohomophones it would be circular to use such materials in the selection process. It was decided that the subjects' knowlege of spelling-to-sound correspondences could be tested through their ability to identify words that do not follow such rules. Phoenicians who know and use the spelling-to-sound rules should be good at distinguishing regular from irregular words that do not follow such rules. On the other hand, Chinese style readers who rely to a lesser degree on spelling-to-sound information, should perform poorly in such a task.

This study investigated the performance of subjects, classified as either Phoenician or Chinese readers, in a lexical decision task including pseudohomophones. Following the reasoning outlined above we would expect that Phoenicians would show a pseudohomophone effect whereas Chinese readers would not. In addition this study also looked at the performance of Chinese and Phoenician style readers responses to spelling regularity in the lexical decision task as another measure of speech coding.

4.1.2 Subject Selection

4.1.3 Method

(a) Subjects.

148 students from the University of York served as subjects. There were 71 women and 77 men. Only subjects whose native language was English were accepted, two subjects were discarded as a result of this criterion.

(b) Stimuli and Design.

The materials used were derived from Parkin (1984) and were typed in lower-case in four columns of 30 words. The words were printed in random order and were of three types. (A) 30 Exception words that had unique or unusual spelling-to-sound correspondences, for example MONK and PINT. (B) 30 Mildly irregular words that had regular pronounciations according to higher order rules, or had common alternative pronounciations, for example BULL and PALM. (C) 60 Words that were regular in their spelling-to-sound correspondence. These were matched to the exception and mildly irregular words, for example VENT and HIKE. Two of the regular words from Parkin's stimulus set were replaced (by hobby and root) as one was not regular (roll) and the other had been repeated (hitch). The materials can be found in Appendix III.

(c) Procedure.

The experiment was presented to subjects as a study concerned with the spelling and pronunciation of English words. The subjects were asked to read through the list of words and underline those which they thought were irregular in their pronunciation. They were given "Cat" as an example of a regular word, where the correct pronunciation of the word could be derived from the sequence of letters in the word. In contrast "yacht" was given as an example of an irregular word where it would be hard to arrive at the correct pronunciation from its spelling. The subjects were not told how many of the words were irregular.

4.1.4 Results.

One hundred and nine subjects returned the spelling regularity test. The number of exception, mildly irregular, and regular words underlined by each subject was calculated. Eleven subjects who underlined ten or fewer exception and mildly irregular words out of the potential group of sixty were discarded for not underlining enough words.

In order to determine which subjects were good or poor at using spelling-to-sound rules the proportion of exception, mildly irregular and regular words underlined were converted to d' and beta values according to signal detection theory (Green and Swets, 1966), a technique for assessing a subject's ability to discriminate the occurrence of some event (d') which is independent of response biases (beta). In order to obtain measures of the d' and beta, the proportion of irregular words correctly and the proportion of times that a regular word was incorrectly identified as an iregular word (False Alarm Rate) was calculated. These Hit Rates and False Alarm Rates were transformed to d' and beta with the following formula (Hochhaus 1972).

When both hit rate and false alarm rate are >.5

$d' = ABS\ (HR) - ABS\ (FAR)$

When hit rate is >.5 and false alarm rate is <.5

$d' = ABS\ (HR) + ABS\ (1-FAR)$

When both hit rate and false alarm rate are <.5

$d' = -ABS\ (1-HR) + ABS\ (1-FAR)$

Beta was calculated with the following formula

$beta = ORD\ (HR) / ORD\ (FAR)$

Where the ABS and ORD are the abscissa and ordinate values of the standardized normal distribution (given in a table by Hochhaus (1972)).

The reliability of the spelling regularity test as a selection test was assessed by using a split half measure. The test was divided in half by taking alternate items to form two equal groups of data which were then correlated. The split half correlations across 109 subjects were as follows : Exception words, r (107)= 0.8071, p=<0.01;Mildly Irregular words, r (107)= 0.8659, p=<0.01; Regular words, r (107)= 0.8386, p=<0.01. The full correlation between the exception and mildly irregular words was r (107)= 0.9012, p=<0.01. The split half scores showed that the subjects ability to detect irregular words was constant over both halves of the test. Therefore, it seems that the spelling-regularity test was a reasonable method of selecting subjects on their ability to use knowledge of spelling-to-sound correspondence rules.

The range of d' scores varied from 3.2290 to -0.1600. A high d' score indicates that the subject has a good knowledge of spelling-to-sound rules whereas a low d' value represents a poor knowledge of spelling -sound rules. From the 98 potential subjects 20 Phoenician (who had a high d' and so identified a large proportion of irregular words and mistook only a few regular words for irregular words) and 20 Chinese readers (who had a low d' and underlined approximately equal numbers of irregular word and regular words) were invited to take part in a further experiment. As a result 12 Phoenician and 12 Chinese style readers took part in 2 experiments, one examining the effects of pseudohomophones, the other the effects of spelling regularity on reaction time.

4.2 The Performance of "Chinese" and "Phoenician" Style Readers in Two Lexical Decision Experiments.

4.2.1 Method

(a) Stimuli and Design.

The aim of this experiment was to compare subjects classified as either Phoenician or Chinese style readers in two lexical decision tasks. One being a test for the pseudohomophone effect and the other a test for the effects of spelling regularity.

The stimuli for the pseudohomophone effect were the same as those used in Experiment 3. Two root words of approximately equal surface frequency with the same number of syllables and letters and which shared a common internal letter in the same letter position were chosen. A letter was either added, substituted or deleted at comparable letter positions within each root word so as to produce a pseudohomophone (all the pseudohomophones were homophonic with only one English word) and a pronounceable nonword. For example the letter strings WORD and COST both share the letter O in the second position and are of equal frequency. When this letter is substituted with the letter E two new letter strings (WERD and CEST) are formed, one of which is a pseudohomophone and the other a visually controlled nonword.

The other nonword fillers were created by producing another set of pseudohomophones from a wide ranging sample of words in Kucera and Francis. These pseudohomophones then had a letter changed arbitrarily to produce a nonhomophonic nonword equivalent to Martin's approximate visual controls. The words were also chosen from Kucera and Francis (1967) to approximately match the frequency and length of the pseudohomophone target word. The nonwords consisted of 20 pseudohomophones, 20 visually controlled nonwords and 110 filler nonwords. There were also 150 words (Details of these materials can be found in Appendix III).

The materials used in the test for spelling regularity were the same as those used in the spelling -pronunciation test (these were derived from Parkin, 1984). There were 30 exception words, 30 mildly irregular words and 60 regular words. In addition 120 nonwords were formed by changing one letter of each of the words (Details of these materials can be found in Appendix III).

The stimuli for both tests were presented in uppercase on a terminal controlled by a computer. The order of presentation of the two experiments was alternated within each group of subjects.

(b) Subjects.

Twenty four subjects, 12 Phoenician and 12 Chinese style readers (14 women and 10 men) selected by the procedure described above, were paid for participating in the experiment.

(c) Procedure.

The procedure was identical to that in previous experiments. In the pseudohomophone experiment, subjects saw 35 practice trials followed by 150 nonwords and 150 words in a different random order.

For the spelling regularity experiment, subjects saw 40 practice trials followed by 30 exception words, 30 mildly irregular words, 60 regular words and 120 nonwords in a different random order. There was a short break between the two experiments.

4.2.2 Results.

(a) Pseudohomophone Experiment

Only correct responses were analysed and reaction times taking two seconds or longer were discarded. This procedure resulted in the discarding of 0.833 per cent of responses to pseudohomphones, and 1.875 per cent of responses to visual control nonwords. The anti-logged mean reaction times to pseudohomophones and visual control nonwords are shown in Table (24).

As can be seen from the table the Phoenician group had overall longer reaction times than the Chinese readers. Pseudohomophones were rejected more quickly than visually controlled nonwords by Chinese readers and there was only a two millisecond difference in the Phoenician subjects.

TABLE 24.

Anti-logged Mean Reaction Times and Error Rates for Pseudohomophones and Visual Control Nonwords in Experiment 7(a).

	TYPE OF NONWORD	
	PH	VC
CHINESE		
R. Time (msec)	699	714
Error Rate (%)	5.0	7.5
PHOENICIAN		
R. Time (msec)	755	753
Error Rate (%)	3.33	5.42

PH = Pseudohomophones
VC = Visual Controls
R. Time = Reaction Time

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these two sets of scores after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table 25). The main effect of reader type (Chinese or Phoenician) was not significant across subjects (F=1.004; df= 1,22; P,>0.05) or across materials (F=3.594; df= 1,38; P,>0.05). The main effect of nonword type (Pseudohomophone, Visual Control) was not significant across subjects (F=0.174; df=1,22; P>.05) or across materials (F=0.335; df= 1,38; P,>0.05). The interaction between type of reader and nonword was not significant across subjects (F=0.386; df=1,22; P,>0.05) or across materials (F=1.961; df= 1,38; P,>0.05, see Table 24).

The error rates were relatively low, although the Chinese group had overall more errors than the Phoenician group, but this difference was not significant (F=3.300; df=1,22; P,>0.05).

(b) Spelling Regularity.

Only correct responses were analysed and reaction times taking two seconds or longer were discarded. This procedure resulted in the discarding of 0.138 per cent of responses to regular words, and 1.25 per cent of responses to irregular words. The anti-logged mean reaction times can be seen in the Table 27. For the Chinese readers it can be seen that exception words were responded to more slowly than their matched regular words. The mildly irregular words however, showed faster reaction times than their matched regular words

TABLE 25.

Analysis of Variance on the Logged Reaction Times for Nonwords in Experiment 7(a).

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	23	2149.375			
R Style (RS)	1	93.813	93.813	1.004	NS
Error	22	2055.563	93.435		
Nonwords (N)	1	1.406	1.406	0.174	NS
(RS) / (N)	1	3.125	3.125	0.386	NS
Error	22	178.281	8.104		
Within	24	182.813			

TSQ/N= 3937418.5000 N= 48 SST= 2332.1875

Source	df	SS	MS	F	p
(By-Materials)					
Materials	39	1370.000			
R Style (RS)	1	118.375	118.375	3.594	NS
Error	38	1251.625	32.938		
Nonwords (N)	1	5.375	5.375	0.335	NS
(RS) / (N)	1	31.500	31.500	1.961	NS
Error	38	610.313	16.061		
Within	40	647.188			

TSQ/N= 6569465.1000 N= 80 SST= 2017.1875

(RS) = Reader Style = Chinese
= Phoenician

(N) = Nonwords = Pseudohomophone
= Visual Controls

TABLE 26

Analysis of Variance Summary Table for the Arcsine Transformed Error Data of Experiment 7(a).

Source	df	SS	MS	F	p
Subjects	23	16.683			
R Style (RS)	1	2.176	2.176	3.300	NS
Error	22	14.507	0.659		
Nonwords (N)	1	1.310	1.310	2.105	NS
(RS) / (N)	1	1.896	1.896	3.048	NS
Error	22	13.688	0.622		
Within	24	16.894			

TSQ/N= 46.2433 N= 48 SST= 33.5770

(RS) = Reader Style = Chinese
= Phoenician

(N) = Nonwords = Pseudohomophones
= Visual Controls

TABLE 27

Anti-Logged Mean Reaction Times and Error Rates for Regular and Exception Words in Experiment 7(b).

	TYPE OF WORD			
	E	R-e	MI	R-mi
CHINESE				
R. Time (msec)	717	706	711	734
Error Rate (%)	3.05	6.11	5.55	8.33
PHOENICIAN				
R. Time (msec)	699	691	699	707
Error Rate (%)	4.44	3.33	3.33	8.33

R. Time = Reaction Time
E = Exception Words
R-e = Regular Words Matched to Exceptions
MI = Mildly Irregular Words
R-mi = Regular Words Matched to Mildly Irregular Words

The Phoenician style readers showed an equivalent pattern of results. Exception words had longer reaction times than their matched regular words; the mildly irregular words showed the opposite result and were responded to more quickly than their matched regular words.

Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these sets of scores after applying a log transformation; one treating subjects as a random factor, the other treating materials as a random factor (See Table

28).

The main effect of reader style was not significant across subjects (F=0.237; df=1,22; P,>.05) or across materials (F=1.475; df=1,58; P,>0.05). The main effect of word type was also not significant across subjects (F=0.670;df=3,66; P>.05) or across materials (F=1.786; df= 3,174; P,>0.05). The interaction was not significant across subjects (F= 0.077; df= 3,66; P,>0.05) or across materials (F= 0.380; df= 3,174; P,>0.05).

The difference in error rates between Phoenician and Chinese readers was found not to be significant in an analysis of variance on the arcsine transformed error scores (F= 0.710; df= 1,22; P, >0.1). There was no interaction in the error rates between word type and reader style either (F= 1.011; df= 3,66; P,>0.1) . There was a significant difference in the nonword set (F=4.094; df= 3,66; P, <0.01). A Tukey's HSD test showed that Phoenician readers made more errors to the control words matched to mildly irregular words than to the mildly irregular words.

The results reported so far indicate that exception words do not take longer to respond to than regular words in a lexical decision task. However these results do not rule out the possibility that a significant regularity effect might be found when the words are of low-frequency. The slower processing shown to low-frequency words may allow any effects of phonology to emerge before the subject's response deadline is exceeded.

TABLE 28.
Analysis of Variance on the Logged Reaction Times for Regular and Exception Words in Experiment 7(b).

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	23	2586.938			
R Style (RS)	1	27.625	27.625	0.237	NS
Error	22	2559.313	116.332		
Words (W)	3	23.813	7.938	0.670	NS
(RS) / (W)	3	2.750	0.917	0.077	NS
Error	66	781.438	11.840		
Within	72	808.000			

TSQ/N= 7801820.8000 N= 96 SST= 3394.9375

Source	df	SS	MS	F	p
(By-Materials)					
Materials	59	1743.750			
R Style (RS)	1	43.250	43.250	1.475	NS
Error	58	1700.500	29.319		
Words (W)	3	117.500	39.167	1.786	NS
(RS) / (W)	3	25.000	8.333	0.380	NS
Error	174	3815.000	21.925		
Within	180	3957.500			

TSQ/N= 19535060.0000 N= 240 SST= 5701.2500

(RS) = Reader Style = Chinese or Phoenician

(W) = Words = Exception Words
= Regular Words Matched to the Exception Words
= Mildly Irregular Words
= Regular Words Matched to the Mildly Irregular Words

TABLE 29

Analysis of Variance Summary Table for the Arcsine Transformed Error Rates for Exception and Regular Words in Experiment 7(b).

Source	df	SS	MS	F	p
Subjects	23	15.725			
R Style (RS)	1	0.492	0.492	0.710	NS
Error	22	15.234	0.692		
Nonwords (N)	3	5.428	1.809	4.094	0.01
(RS) / (N)	3	1.340	0.447	1.011	NS
Error	66	29.165	0.442		
Within	72	35.934			

TSQ/N= 168.8957 N= 96 SST= 51.6589

(RS) = Reader Style = Chinese
= Phoenician

(N) = Nonwords = Pseudohomophones
= Visual Controls

TABLE 29(a)

Analysis of Variance Summary Table for the Logged Reaction Times for High and Low-Frequency Regular and Exception Words in Experiment 7(b).

Source	df	SS	MS	F	p
Subjects	14	13729.359			
W. Type	1	1813.523	1823.523	0.965	NS
Error	14	26316.766	1879.769		
Frequency (F)	1	141315.710	141315.710	85.166	0.01
Error	14	23230.102	1659.293		
(WT) / (F)	1	24.203	24.203	0.019	NS
Error	14	18253.148	1303.796		
Within	45	10953.450			

TSQ/N= 836853.5800 N= 60 SST= 224682.8100

(W. Type)= Word Type = Regular and Irregular words

(F)= Frequency = High or Low-Frequency

To test this possibility, the exception and matched regular words were reclassified in terms of low and high-frequency for the Chinese and Phoenician readers. The mean frequencies (from Kucera and Francis 1967) were as follows: High-frequency Regular = 53.9; High-frequency Exception = 91.0; Low-frequency Regular = 5.8; Low-frequency Exception = 8.1. The difference within groups for high and low-frequency words was not significant (F = 0.965; df =1,14; P> 0.05). See Table 29(a).

TABLE 30.

Anti-Logged Mean Reaction Times and Error Rates for High and Low-Frequency Exception and Regular Words in Experiment 7(b).

	TYPE OF WORD			
	EXCEPTION		REGULAR	
FREQUENCY	HIGH	LOW	HIGH	LOW
CHINESE	695	746	679	756
PHOENICIAN	677	732	677	726

The mean reaction time to high and low-frequency regular and exception words can be seen in Table 30. Two sets of scores were computed for each condition, one by collapsing across subjects and the other by collapsing across materials. Separate analyses of variance were performed on these sets of scores after applying a log transformation; one treating subjects as a random factor

TABLE 31.

Analysis of Variance for the Effect of Frequency on Exception and Regular Words

Experiment 7(b).

Source	df	SS	MS	F	p
(By-Subjects)					
Subjects	23	3153.750			
R Style (RS)	1	20.500	26.250	0.144	NS
Error	22	3133.250	142.420		
Words (W)	1	8.500	8.500	0.697	NS
(W) / (RS)	1	0.000	0.000	0.000	NS
Error	22	268.313	12.196		
Frequency (F)	1	283.375	283.375	33.062	p<0.01
(F) /(RS)	1	6.125	6.125	0.715	NS
Error	22	188.563	8.571		
(W) / (F)	1	0.188	0.188	0.039	NS
(W) /(F)/ (RS)	1	0.438	0.438	0.090	NS
Error	22	106.375	4.835		
Within	72	861.875			

TSQ/N= 7784797.4000 N= 96 SST= 4015.6250

(RS) = Reader Style = Phoenician or Chinese

(W) = Words = Exception or Regular

(F) = Frequency = High or Low

TABLE 32.

Materials Analysis of Variance for the Effect of Frequency on Exception and Regular Words Experiment 7(b).

Source	df	SS	MS	F	p
(By-Materials)					
Materials	29	401.125			
R Style (RS)	1	26.250	26.250	1.961	NS
Error	28	374.875	13.388		
Words (W)	1	1.125	1.125	0.041	NS
(W) / (RS)	1	0.250	0.250	0.009	NS
Error	28	777.125	27.754		
Frequency (F)	1	383.500	383.500	35.698	$p<0.01$
(F) /(RS)	1	3.625	3.625	0.339	NS
Error	28	299.125	10.683		
(W) / (F)	1	2.875	2.875	0.133	NS
(W) /(F)/ (RS)	1	6.625	6.625	0.307	NS
Error	28	603.625	21.558		
Within	90	2077.875			

TSQ/N= 9762427.6000 N= 120 SST= 2479.0000

(RS) = Reader Style = Phoenician or Chinese

(W) = Words = Exception or Regular

(F) = Frequency = High or Low

the other treating materials as a random factoer. The results of these analyses are presented in Tables 31 and 32. The only significant effect in these analyses was that of frequency [(F=33.062; df=1,22; $P<0.01$) across subjects and (F=35.888; df=1,28; $P<0.01$) across materials]. This indicates that high-frequency words were responded to more quickly than low-frequency words. The trend noted in the literature for low-frequency exception words to have longer reaction times than low-frequency regular words was not significant in this study across subjects (F=0.03; df=1,22; $P>0.05$) or across materials (F= 0.133; df=1,28; $P>0.05$). The interaction of subjects classified as Chinese or Phoenician readers and the effect of frequency on word type was also not significant across subjects (F=0.090; df=1,22; $P>0.05$) or across materials (F= 0.307; df=1,28; $P>0.05$).

4.2.3 Discussion

(a) Pseudohomophones

Overall the experimental results were disapointing. Individuals who differ in the extent to which they are aware of spelling-to-sound correspondences do not differ in their performance in the lexical decision task to nonwords that differ in their reaction times to pseudohomophones, or to regular and exception words in a lexical decision task. It would seem that the Chinese-Phoenician continuum, which has been supported by studies of oral reading and spelling, does not extend to the lexical decision task. The Phoenician and Chinese readers did not differ reliably in their reaction times and error rates to pseudohomophones and visually controlled nonwords. These results are inconsistent with the idea that the pseudohomophone effect is an effect of phonology. If it is an effect of phonology, it should be enhanced in the Phoenician readers since they rely more heavily on spelling-to-sound rules than Chinese readers; this difference was however not found.

(b) Spelling Regularity.

Studies of spelling-to-sound regularity (sections 1.3.2) have produced inconsistent results. An early study conducted by Baron and Strawson (1976) showed that exception words, that is words with irregular spelling-to-sound correspondence such as PINT, took longer to read aloud than regular words such as TINT. These results were subsequently replicated by Glushko (1979), Stanovitch and Bauer (1978); Gough and Cosky (1977) and Coltheart, Besner, Jonasson and Davelaar (1979). The regularity effect has however, not always been found in the lexical decision task, Coltheart, Besner, Jonasson and Davelaar (1979), Andrews (1982), and Seidenberg, Waters, Barnes and Tanenhaus (1984) all failed to find a regularity effect in the lexical decision task. However, using the lexical decision task regularity effects have been found by Stanovitch and Bauer (1978 experiment 2), and Parkin (1982).

Seidenberg, Waters, Barnes and Tanenhaus (1984) set out to explore possible differences between the effects of regularity in the lexical decision task and pronunciation tasks. They presented 12 exception and 12 regular words amongst other words and nonwords in a pronunciation and lexical decision task to different groups of subjects. They reported a significant regularity effect in the pronunciation task, but in the lexical decision task, the regularity effect was significant only across subjects. These results are problematic in two respects. Firstly, the material sample size was very small and it is doubtful whether the regularity effect found in the lexical decision task is reliable, as it achieved significance through 3 lower frequency items. The second point is that the exception words and regular words were not matched for initial phonemes, so it is possible that the exception words were more difficult to pronounce, or slower to stop the timer, this would exaggerate any differences between the words without spelling-to-sound regularity necessarily being the important variable.

In another study Seidenberg et al., (1984) investigated whether word frequency may have contributed to the inconsistent results. In one experiment, lexical decision times were compared for high and low-frequency regular and exception words and in the other to high and low-frequency regular and very irregular or strange words were compared. Strange words e.g., SUADE and ACHE, were characterized by not only having irregular spelling-to-sound correspondences but, in addition, unusual orthographies (spelling patterns). They found no reliable differences between the high-frequency regular, exception and strange words across subjects. Unlike the pronunciation task there was no difference in the lexical decision latencies responses to low-frequency regular and exception words. There was however, a low-frequency strange effect, strange words had significantly longer reaction times than regular and exception words. Seidenberg et al., concluded that the effects of spelling-to-sound correspondence are not found in the lexical decision task, but that the effects of irregular orthography are found. They proposed that earlier demonstrations of the regularity effect in the lexical decision task, were a result of including a large proportion of irregular words with unusual spelling patterns

The results of Seidenberg et al (1984); Waters and Seidenberg (1984), Waters and Seidenberg (1985) and Waters, Seidenberg and Bruck (1984) show that for skilled readers the effects of spelling-to-sound regularity are limited to low-frequency strange words in the lexical decision task. This raised the question whether the absence of a regularity effect in our results reflects the performance to high-frequency words masking the response to the low-frequency words. For these reasons the exception and regular words were reanalysed with respect to frequency. The mildly irregular words were not analysed because Parkin has demonstrated that words that are irregular at a minor level do not elicit an effect of regularity. A low-frequency regularity effect was not found; these results are consistent with the work of Waters and Seidenberg (1984). An explanation for the inconsistant regularity effect in the lexical decision task has been put forward by Waters and Seidenberg (1984) in terms of the combination of stimuli presented to the subject. They found that for low-frequency words a regularity effect could be elicited under certain circumstances; notably when the stimuli included a mixture of regular, irregular and strange words, a regularity effect was found, but was absent when strange words were not included amongst the stimuli. They proposed that the composition of the stimli influenced the criteria by which subjects come to a decision and that the presence of strange words slows down the decision process, thereby allowing the effects of regularity to become evident.

In the present experiment orthographically irregular words, (strange) words were not included; Waters and Seidenberg demonstrated that the regularity effect in lower frequency words is contingent on the presence of strange words amongst the stimuli. This would seem to provide a reasonable explanation for the pattern of results obtained. Essentially the present results extend those of Seidenberg and Waters in showing that regularity per se does not influence lexical decision times even in subjects selected for having a good knowledge of spelling-to-sound rules. This strengthens the case for rejecting the idea that a pre-lexical phonological code is important in the lexical decision task. There certainly seems to be no good evidence from the present experiment, or other work, that spelling regularity per se is an important factor in determining lexical decision times.

CHAPTER 5.

THE EFFECTS OF HOMOPHONY ON LEXICAL DECISION LATENCY.

5.1 EXPERIMENT 8. Lexical Decision Responses for Homophones.

5.1.1 Introduction

In the experiments reported in Chapters 2, 3 and 4 there was no evidence for an influence of phonology on subjects' lexical decision responses to pseudohomophones and words which differed in their spelling-to-sound regularity. These results cast serious doubt on the importance of speech recoding in the lexical decision task by skilled readers.

The other major effect, which with normal subjects has been used as evidence for speech recoding in the lexical decision task, is the effect of homophones. If lexical access is based on a phonological representation then words with the same phonological description e.g., SALE and SAIL should be easily confused. This was the starting point for the work carried out by Rubenstein, Lewis and Rubenstein (1971). In their third experiment they presented two types of words either homophones e.g., SAIL/SALE and BLUE/BLEW, or nonhomophones e.g., LAMP and TREE, together with nonwords in a lexical decision task. They found that homophones took longer to be accepted as real words than did the nonhomophonic control words. In a post hoc analysis they found that the slower reaction times to homophones were confined to the lower frequency member of a homophonic pair. They proposed that lexical access proceeds on the basis of a frequency ordered serial search after the letter string has been translated into a phonological code. The search procedure stops when the phonologically recoded letter string matches a lexical entry with the same phonological representation. A spelling check is then carried out between the stimulus representation and the lexical entry. This is necessary for the reliable identification of homophones and also so that errors are not made in the case of pseudohomophones like BRANE, which sound the same as a real word. If the two entries are matched both in their phonological representation and spelling the search process comes to an end. But, if the spelling check fails, the search is resumed from the point at which it stopped until a match is found or all entries in the lexicon have been checked. The break in the search process to permit a spelling check results in a time cost. The mismatch at the spelling check stage for homophones will only impair the response time of the lower frequency member of a homophonic pair. If the higher frequency member of a homophonic pair is presented e.g., WHICH (with a frequency count of 3562 from Kucera and Francis (1967) the frequency ordered search will stop at that entry and will be confirmed by the spelling check. The fact that another lexical entry (WITCH) has the same phonological representation will not affect the response time to WHICH. However, if the word WITCH (with a frequency count of 5 from Kucera and Francis 1967) is presented the search through the lexicon will first stop at the entry WHICH but this will be rejected on the basis of the spelling check. The search procedure is then restarted at some point later thereby slowing the lexical decision time of the entry

WITCH when it is located.

Although this type of finding was interpreted as evidence for phonological recoding prior to lexical access, these results have subsequently been questioned on statistical grounds by Clark (1973). Clark argued that as the data were not analysed with both subjects and materials treated as random factors that the findings may not be reliable. When he applied the appropriate statistical procedures the homophone effect failed to reach significance.

Coltheart, Davelaar, Jonasson and Besner (1977) also found fault with the homophonic stimuli of Rubenstein et al;they noted that the homophonic words and control words were not matched for word frequency, part of speech or number of letters. They subsequently carried out an experiment designed to overcome these problems, and failed to find a homophone effect.

In a further experiment Davelaar, Coltheart, Besner and Jonasson (1978) claimed that this effect was dependent on the kind of nonword stimuli used in the experiment. They carried out two parallel experiments, one using the low-frequency member of a pair of homophones and the other using the high-frequency member. The experimental design was such that there were three sections without there being a discrete change between sections. In the first third, subjects were presented homophones (either high or low-frequency depending on the group) and control words in the context of nonhomophonic nonwords such as SLINT. This was followed by 20 trials consisting of 10 nonhomophonic nonwords and then 10 pseudohomophones e.g., GRONE. The final section was again composed of homophones and control words in the context of pseudohomophones.

Davelaar et al., (1978) found longer reaction times for low-frequency homophones in comparison to control words when the nonword distractors were orthographically legal and pronounceable e.g., SLINT. The effect disappeared however, in the presence of pseudohomophone distractors such as BRANE. High-frequency homophones were not differentially affected by the type of nonword distractor present. These results were interpreted as evidence for an optional strategy which subjects could bring into play when it was advantageous to do so. Davelaar et al., proposed that subjects have simultaneous graphemic and speech-coding procedures. The differential effects arise following the outcome of the first few trials. Lexical decisions in the presence of "slint" type nonwords are accurately identified using a speech-coding strategy, but in the presence of "grone" type nonwords, a speech code would produce many errors and so the subject abandons this strategy in favour of a graphemic code. The homophone effect was found only on the low-frequency member of a pair and not the high-frequency member. The authors explained this as a result of a spelling check following the proposal of Rubenstein, et al., (1971).

Henderson (1982) has however, pointed to a weakness in the strategy based procedure argument put forward by Davelaar et al., (1978). Henderson (1982) argued that if the low-frequency homophone effect is a consequence of a spelling check procedure then the same procedure could be used to disambiguate pseudohomophones from real words.

Therefore, it is somewhat puzzling that the speech-coding strategy is abandoned in the presence of pseudohomophones. There is further reason to doubt the reliability of this homophone effect. The effect was very small and reliable only on a one-tailed t-test. It therefore does not provide strong support for the phonological recoding hypothesis of lexical access.

None of the studies reviewed here, or in Chapter 1 (section 1.3.4), provide clear evidence for speech-coding prior to the lexical access of homophones in the lexical decision task. In view of the proposal put forward by Davelaar et al., (1978) that phonological recoding is an optional strategy dependent on the nonword context, and in the absence of any unequivocal evidence, this idea will be explored in the present chapter. In the present experiment homophonic words are presented within a background of nonhomophonic nonwords such as SLINT. If the encoding strategy is determined within the first few trials of the experiment, it seems reasonable to think that the subject could use a speech encoding strategy with perfect accuracy if they chose to do so. It was hoped that in line with the findings of Davelaar et al., (1978), in the present experiment low-frequency homophones would be responded to less quickly than matched low-frequency nonhomophonic words.

5.1.2 Method

(a) Subjects

Twenty eight undergraduates (14 women and 14 men) from the University of York were paid for participating in the experiment.

(b) Stimuli and Design

The words were the same as those used by Davelaar, Coltheart, Besner and Jonasson (1978) and consisted of 59 low-frequency members of a homophonic pair, 59 matched control words; and 59 high-frequency members of a homophonic pair with 59 matched control words. The low-frequency homophones had an average frequency count of 10 per million using Kucera and Francis (1967) and the high-frequency homophones had an average frequency of 192 per million. The control words were matched for frequency and part of speech to their homophonic mates. There were also 120 nonhomophonic nonwords which were formed by deleting or substituting a letter in the medial position of words of varying frequency (Details of the stimuli can be found in Appendix IV)

The stimuli were presented in upper-case on a terminal in a lexical decision task in the same way as Experiment 1 (cf section 2.1.2).

(c) Procedure.

The procedure was identical to that in Experiment 1, the subjects saw 32 practice trials followed by 236 words and 120 nonwords in a different random order.

5.1.3 Results

The reaction time data were treated in the following manner. Only correct reaction times were analysed and any responses that took 2 seconds or longer were discarded. This procedure resulted in the discarding of 0.000006 per cent of responses to high-frequency homophones, 0.665 per cent of responses to low-frequency homophones, 0.363 per cent of responses to high-frequency control words, and 0.003 per cent of responses to low-frequency control words. The anti-logged mean reaction times to the homophones and control words of high and low-frequency are shown in Table 33.

TABLE 33.

Anti-logged reaction times and error rates for High and Low-Frequency Homophone and Control Words in Experiment 8

	TYPE OF WORD	
	HOMOPHONE	CONTROL
FREQUENCY		
HIGH-FREQUENCY	578	574
ERROR RATE (%)	(1.15)	(1.45)
LOW-FREQUENCY	645	633
ERROR RATE (%)	(4.63)	(4.84)

The homophones had marginally longer reaction times compared to the control words and there is strong evidence for a frequency effect in both the control and homophonic words. High-frequency homophones were responded to 67 msec faster than the low-frequency homophones and the high frequency control words were responded to 59 msec faster than low-frequency control words.

The logged reaction time scores were collapsed across subjects and were entered into a two-way within-subjects analysis of variance. The results of this analysis are presented in Table 34. The main effect of word type was not significant (F= 2.566, df= 1,27; P> 0.05). The main effect of frequency was highly significant (F= 191.566; df= 1,27; P< 0.001) with high-frequency words having faster reaction times than low-frequency words. The interaction of word type and frequency did not approach significance (F= 0.750; df= 1,27; P> 0.05).

As the decision time to high-frequency homophones and control words, was not crucial to the speech-coding issue, only the low-frequency homophones were analysed across materials. The scores for the critical group comparison between the low-frequency member of a homophone pair and low-frequency control word were collapsed across materials. The results of the analysis are shown in Table 34. This difference was not significant across materials (F= 1.044; df= 1,58; P> 0.05).

The error rates were relatively low, and are presented in Table 34. Low-frequency words were associated with higher error rates compared to the high-frequency words. An analysis of variance carried out on the arcsine transformed error rates showed there were no significant differences between homophonic and control words

TABLE 34.

Analysis of Variance for the Effect of Homophony on Lexical Decision Times in Experiment 8.

Source	DF	SS	MS	F	p
(By Subjects)					
Subjects	27	3375.625			
Words (W)	1	8.125	8.125	2.566	NS
Error	27	85.500	3.167		
Freq (F)	1	580.875	580.875	191.556	p<0.001
Error	27	81.875	3.032		
(W)/(F)	1	1.625	1.625	0.750	NS
Error	27	58.500	2.167		
Within	84	816.500			

TSQ/N= 8677467.00000 N= 112 SST= 4192.1250

Source	DF	SS	MS	F	p
(By Materials)					
Materials	58	6940.375			
Words (W)	1	123.750	123.750	1.044	NS
Error	58	6875.750	118.547		
Within	59	6999.500			

TSQ/N= 9252228.3000 N= 118 SST= 13939.8750

Words = Homophones and Control Words

Frequency = Low or High-Frequency

TABLE 35.

Analysis of Variance for the Arcsine Transformed Error Data of Experiment 8.

Source	DF	SS	MS	F	p
(By Subjects)					
Subjects	27	7.080			
Words (W)	1	1.010	1.010	2.616	NS
Error	27	10.427	0.386		
Freq (F)	1	8.921	8.921	25.189	$p<0.001$
Error	27	9.562	0.354		
(W)/(F)	1	1.126	1.126	3.198	NS
Error	27	9.508	0.352		
Within	84	40.554			

TSQ/N= 227.1028 N= 112 SST= 47.6339

Words = Homophones and Control Words.

Frequency = Low or High-Frequency

(F= 2.616; df= 1,27; P> 0.1). There was however a significant frequency effect (F= 25.189; df= 1,27; P< 0.001), responses to low-frequency words were more error prone than those to high-frequency words. The higher error rates were associated with the slowest reaction times and therefore a speed-accuracy trade off can be rejected as a possible explanation of the data .

5.1.4 Discussion

The major finding of this experiment was that lexical decision responses to homophones and matched control words were not significantly different from each other. The effects of homophony also did not interact with frequency. These results contrast with those of Davelaar, Coltheart, Besner and Jonasson (1978) who claimed that the effects of speech recoding are evident for the less frequent member of a homophonic pair when they are presented within the context of nonhomophonic nonwords like SLINT, but, not when they are presented within the context of pseudohomophones like BRANE. Could the procedural differences between the present experiment and that of Davelaar et al., (1978) be responsible for the absense of a homophone effect? The results of Davelaar et al., (1978) were couched in terms of an "optional encoding stategy"; it was argued that subjects could rely on either direct lexical access or a phonologically mediated access procedure. The preference for a particular mode of access was established within the first few experimental trials, depending on the number of errors that were made. Since the homophone effect found by Davelaar et al., (1978) was only found in the context of nonhomophonic nonwords (e.g., SLINT) and as the present experiment used only nonhomophonic nonword distractors, the subjects could have used a phonological strategy with complete accuracy. The difference in the nonword background between the present experiment and that of Davelaar et al., (1978) cannot account for the conflicting results, in fact the homophone effect should have been enhanced in the present experiment as there were no pseudohomophones present to make the subjects produce false positive errors. There is therefore no reason to suppose procedural differences are responsible for the different results obtained in the present experiment compared to those of Davelaar et al. The reasons for the differences between the present results and those of Davelaar et al., are not clear. It is important to note however, that the effect demonstrated in the paper by Davelaar et al., was only marginally significant. There was a weak trend in in the present experiment for the lower frequency homophones to be accepted more slowly than their control words but this was far from significant. It seems a safe conclusion therefore that that this effect is not a reliable one. It would seem that the effects of homophonic words do not provide any convincing evidence for the role of speech recoding in the lexical decision task

5.2 Summary and Conclusions

The results presented here, provided no support for the homophone effect. The results are consistent with those found by Coltheart et al., (1977) and Clark's (1973) reanalysis of the Rubenstein et al data, and contrast with those found by Davelaar et al., (1978). The conditions of the present experiment, should, according to the optional encoding theory of Davelaar et al, have maximised the size of the homophone effect. It seems safe to conclude therefore that such an effect is not a reliable one. We must conclude, that there is no good evidence from the use of homophonic words, that skilled readers routinely use a phonological code in the lexical decision task.

CHAPTER 6.

GENERAL DISCUSSION

6.1 Dicussion and Summary

A current issue in word recognition is the extent to which pre-lexical phonology mediates lexical access. A popular view is that lexical access can be achieved through two main routes; either on the basis of phonological or visual information. This widely adopted view is captured in the dual-route model put forward by Coltheart (1978) and has recently been elaborated by Patterson and Morton (1985). The basic model postulates that in skilled readers there are two functionally independent routes for processing words. The lexical or direct route proceeds by mapping the word's visual features onto a corresponding representation stored within the lexicon. In the second, nonlexical route, lexical access proceeds by translating the word's visual representation into a speech code which is subsequently used to access lexical information. Coltheart (1978) has argued that the only viable parsing process is one using grapheme-phoneme correspondence rules (GPC's). These rules allow single letters or groups of letters to be mapped onto corresponding phonemes.

In this thesis three pieces of evidence supporting the dual-route model of word recognition were investigated : pseudohomophones, homophones and spelling regularity.

6.2 Pseudohomophones

The pseudohomophone effect observed in the lexical decision task refers to the finding that nonwords which sound like a real word take longer to be rejected as nonsense (e.g., BRANE which sounds like brain) than nonwords which do not sound like a real word (e.g., PRANE, Rubenstein, Lewis and Rubenstein, 1971). This result has typically been interpreted as evidence that the lexical entries of words were accessed by a speech code generated nonlexically for the nonwords. It has recently been suggested by Martin (1982) and Taft (1982) that this effect was not a phonological one. They argued that there was a greater visual similarity between pseudohomophones and words than between visual control nonwords and words in studies which showed slower reaction times to pseudohomophones. When the visual similarity of nonwords to words was carefully controlled, both Martin and Taft separately, failed to find any difference between the rejection times of pseudohomophones and visual control nonwords. The visual similarity of the nonwords were controlled in two different ways, Taft used a measure of orthographic segment similarity. Words which shared a group of letters which could be pronounced in more than one way e.g., OST in ghost and frost were subjected to a single letter change to produce two nonwords one of which was a pseudohomophone (e.g., GHOAST) and the other a nonhomophonic nonword (e.g., FROAST). Martin used an alternative method based on the N-count measure devised by Coltheart, Davelaar, Jonasson and Besner (1977). The N-count reflects the number of words which can be created from a letter string when one letter is changed while holding the other letter positions constant.

Martin produced evidence to suggest that when nonwords were equated on the N-count measure no differences between pseudohomophones and control nonwords would be found. However, there has been conflicting evidence on this point, Besner and Davelaar (1983) found a pseudohomophone effect when the visual similarity of the nonwords were controlled along this measure. This finding is problematic for the visual similarity argument

From the evidence reviewed in Chapter 1 (section 1.3.1) it can be seen that experiments examining the pseudohomophone effect are often contradictory. There is a suggestion that the pseudohomophone effect might reflect visual similarity rather than pre-lexical phonology in the lexical decision task. The results of Experiments 1 and 2 essentially confirmed the findings of Martin (1982) and Taft (1982). Pseudohomophones when appropriately controlled so that they share a similar visual relationship to each other and other words are not responded to differently. There was, however, a trend for pseudohomophones to have longer reaction times than their matched visual control nonwords. As the stimuli were presented in lower-case the results suggested that the pseudohomophone effect may have been masked by the greater ease (Tinker, 1965; Seidenberg 1985) of processing lower-case in comparison to upper-case characters.

This question was examined directly in Experiment 2. It was found that pseudohomophones presented in upper-case produced longer reaction times than visual control nonwords in upper-case, in contrast pseudohomophones presented in lower-case were responded to more quickly than their matched control nonwords. Although neither of these trends were significant they do weakly support the view that a pseudohomophone effect would be more difficult to find when the stimuli are presented in lower-case.

A further possible explanation for the failure to demonstrate the effects of speech recoding was examined by Besner and Davelaar (1983). They proposed that Martin's (1982) failure to find a pseudohomophone effect was due to the phonological nature of her stimuli. In her experiment the pseudohomophones were homophonic with a single English word (e.g., MUNEY which sounds like money) whereas those studies which demonstrated the strongest pseudohomophone effect used double pseudohomophones which were homophonic with an English homophone (e.g., BLOO which sounds the words blue and blew). They hypothesized that double pseudohomophones would take longer to be rejected following the failure of two or more spelling checks to find a matching lexical entry. This idea was tested in Experiment 4. A new set of stimuli was generated following the criteria advanced by Martin (1982) to produce double pseudohomophones and control words which were matched in the number of letter changes made to the target word and in their visual similarity to real words as measured by N-count. In this experiment the pseudohomophones were not rejected more slowly than the matched nonwords. The discrepancy between these results and those shown by Besner and Davelaar can be explained. Unlike the stimuli of Martin the pseudohomophones and visual control nonwords used by

Besner and Davelaar were not matched in the number of letters by which they differed from a particular word. Their visual control nonwords were produced by changing a single letter of each pseudohomophone, therefore, the visual control nonwords differed by one more letter from the word from which they were derived. This makes the visual control nonwords of Besner and Davelaar less visually similar to their root words than the pseudohomophones despite the nonwords having similar N-counts.

Given the absence of any effects of pre-lexical phonology the issue of context effects was addressed as a possible explanation for the negative findings of Experiments 1, 2 and 4. According to the dual-route theory the nonlexical processing route is subject to strategic control depending on the relative costs and benefits of the context. McQuade (1981) found a pseudohomophone effect under certain circumstances; she found a pseudohomophone effect only when a low proportion of pseudohomophones were included in the experiment. With a small number of pseudohomophones the nonlexical route could be used relatively accurately therefore allowing the effects of pre-lexical phonology to emerge. However, with an increased proportion of pseudohomophones the costs in terms of mistakes would be too high. A similar point of view was put forward by Dennis, Besner and Davelaar (1985). They argued that the pseudohomophone effect was dependent on the presence of homophones in the experiment. The possibly critical effect of context effects was therefore investigated. Neither the low proportion of pseudohomophones in Experiment 3 or the homophone context in Experiment 6 influenced the reaction times to pseudohomophones and visual control words. The contrasting effects of Experiment 3 with those of McQuade suggest that the original finding may have reflected the greater visual similarity of nonwords to words rather than the phonological similarity. The results of Experiment 6 also did not confirm the findings of Dennis et al. This difference was not altogether surprising; the pseudohomophone effect observed by Dennis et al., using Martin's (1982) stimuli was only significant in the by-subjects analysis. Furthermore a similar picture also emerges from an experiment carried out by Taft (1982) using a different set of stimuli, he also failed to find a pseudohomophone effect when homophones made up 25% of the nonword context.

Overall the negative findings in chapters 2 and 3 can not be explained away as a consequence of "hostile" contexts; when the costs of using a speech code were minimized as in Experiments 3, 5 and 6 the pseudohomophone effect was still not found to be reliable.

From the experiments presented in Chapters 2 and 3 it appears that earlier demonstrations of the pseudohomophone effect can be reinterpreted as visual, rather than phonological, effects. However, another possibility was discussed in Chapter 4. It has been argued by Coltheart (1978) that words can be read through either the lexical or nonlexical route. Although both processes may be used to identify words there is evidence to suggest that among both normal, and dyslexic, readers that there are individual differences in the relative reliance on spelling-to-sound rules (Baron, 1979; Baron and Strawson, 1976 and Treiman and Hirsh-Pasek, 1985).

Baron and Strawson (1976) differentiated subjects who were relatively better at one process than the other on the basis of spelling and pronunciation tasks. These tasks discriminated two sub-groups of readers from individuals who showed an unbiased use of both processes. At one end they identified readers who relied more heavily on spelling-to-sound rules (known as Phoenician readers) and at the other end readers (known as Chinese readers) who relied more on word specific associations. With this study in mind the individual differences approach was applied in Experiment 7. The selection of procedure was based on the subjects' ability to identify words which do not follow the spelling-to-sound rules of English that is, irregular words such as "have" from regular words such as "best" whose pronunciation is predictable on the basis of such rules. Phoenicians who have a good knowledge of spellling-to-sound rules should be good at distinguishing regular from irregular words that do not follow such rules. On the other hand Chinese style readers who rely to a lesser extent on spelling-to-sound information should perform poorly in such a test. The performance of Phoenician and Chinese style readers was found to be statistically indistinguishable in a lexical decision task involving pseudohomophones. The results again support those of Martin (1982) and Taft (1982) while using an alternative approach to the problem. The nonword results and error analyses were inconsistent with the proposal that the pseudohomophone effect is an effect of phonology; if it had been an effect of pre-lexical phonology the pseudohomophone effect should have been enhanced in the Phoenician readers since they rely more heavily on spelling-to-sound rules than Chinese style readers.

In sum the present results support the hypothesis that earlier demonstrations of the pseudohomophone effect may have reflected the greater shared visual similarity between pseudohomophones and words than that of nonhomophonic control nonwords and words. When the orthographic differences are strictly controlled the phonological differences between nonwords produce no difference in the reaction time to pseudohomophones and visual control nonwords. However, Martin's (1982) proposal that N-count is an important determinant of reaction time remains something of a paradox. On the one hand when N-count is equated between pseudohomophones and other nonwords, other variables being equal, there is little or no difference in reaction time. On the other hand, quite large differences in N-count exist between the nonwords used in these experiments, but these differences do not correlate with differences in reaction time. This led to the idea that N-count itself may not be a good predictor of reaction time, but that it may well be correlated with some other variable(s) that are. It was expected that the summed frequencies of the N-count neighbours would correlate with the lexical decision times; high-frequency neighbours with higher resting levels of activity would have a greater interfering influence with the response time than those neighbours with medium or low-frequencies, and so would take longer to be recognised as a nonword. However, the correlations between the frequency weighted N-counts and reaction time in Experiments 3 and 4 were very low and not significant. The absence of a significant relationship between N-count and reaction time even when the effects of frequency are considered suggests that the measure is not sensitive to small differences in visual similarity.

6.3 Homophones

A second major test for the nonlexical processing route was investigated in Experiment 8. Davelaar, Coltheart, Besner and Jonasson (1978) and Rubenstein, Lewis and Rubenstein (1971) proposed that the low-frequency homophone effect provides evidence for the nonlexical processing of words. Both studies found that the lower frequency member (e.g., WITCH) of a homophonic (e.g., WHICH) pair of words took longer to be accepted in a lexical decision task as real words in comparison to nonhomophonic words of similar frequency. Davelaar et al., further argued that the nonlexical processing route was under strategic control in that the effect was only observed in specific contexts which favoured pre-lexical phonology. Although the results of Davelaar et al., were consistent with the dual-route theory the reliability of the result is questionable considering that it was significant only on a one-tailed t-test. This criticism was the starting point for Experiment 8. The stimuli were based on those used by Davelaar et al., but unlike their study only nonhomophonic nonwords were used in order to facilitate the adoption of a nonlexical strategy by the subjects. In contrast to the findings of Davelaar et al., and Rubenstein et al., (1971) a homophone effect was not found. That is decisions to the lower frequency member of a homophonic pair of words (e.g., WITCH) were not slower than decisions to frequency-matched nonhomophonic words. These results cast doubt on the idea that nonlexical processing is under strategic control. According to dual-route theory it has been argued that homophony effects are rarely found on the processing of words because the lexical entries of words are addressed prior to the completion of the nonlexical phonological code. However; following the reasoning put forward by Davelaar et al., (1978) the low-frequency homophones and nonhomophonic context presented the subjects with ideal conditions for adopting a phonological strategy. An alternative interpretation for the negative findings may be that the low-frequency homophones were not sufficiently rare to slow down the processing of words. However, as the stimuli were the same as those used by Davelaar et al., their results were expected to generalize to a different population of subjects. Overall these results extend the findings of Experiments 3, 4, 5 and 6 which used nonwords; when the experimental conditions are such that subjects can adopt a nonlexical phonological strategy the effects of phonology will not necessarily be found.

6.4 Spelling Regularity

A third area of study examined adults' use of spelling-to-sound correspondence rules (Venezky, 1970) in the lexical decision task. If the nonlexical route is used there should be processing differences between words with regular spelling-to-sound correspondences and words that do not follow the spelling-to-sound correspondences rules. The effects of spelling regularity were investigated in Experiment 7 using subjects who had been previously identified as Phoenician (readers who rely more on spelling-to-sound rules) or Chinese (readers who rely more on word specific associations) style readers. Although the Chinese-Phoenician continuum has been demonstrated in studies of spelling regularity using oral reading and spelling tests (Baron and Strawson, 1976; Baron, 1979; Baron and Treiman 1981; Treiman, 1984) the performance of the two groups of readers in Experiment 7 did not differ on a test involving pseudohomophones or irregular and regular words.

These findings concerning spelling regularity in the lexical decision task are however, consistent with later lexical decision studies which have not specifically looked for individual differences (Coltheart, Besner, Jonasson and Davelaar,1979; Andrews, 1982; Seidenberg, Barnes and Tanenhaus, 1984). A further analysis was carried out on the spelling regularity data in order to check that a low-frequency regularity effect had not been masked by higher frequency words. Seidenberg et al (1984) provided evidence that the regularity effect is found for only lower frequency words. That is words with irregular spelling-to-sound correspondences only take longer to be responded to than matched regular words when the words are of lower frequency. This analysis also failed to show any effects of regularity.

Recent research (Seidenberg, Barnes and Tanenhaus, 1984;Waters, Seidenberg and Barnes, 1984; Waters and Seidenberg 1985) has provided an explanation for the inconsistent results obtained in studies of spelling regularity in terms of the combination of stimuli presented to the subject. In particular they demonstrated that a low-frequency regularity effect, that is, longer reaction times to low-frequency irregular words compared to low-frequency regular words, will only be elicited in the lexical decision task if strange words (that is, words with both unusual spelling patterns and irregular pronunciations) are included in the stimulus set. They argued that such stimuli influence the criteria by which subjects come to a decision that a letter string is a word; the presence of strange words slows down the decision process thereby allowing the effects of regularity to become evident.

6.5 Is Lexical Access Phonologically Mediated?

This series of experiments raised the question of whether pre-lexical phonological coding is an important component in the reading of single words. Given the evidence presented here, there does not appear to be any good evidence in favour of this view. Given this view an attempt will be made to relate these experimental findings to current models of word recognition.

How are nonwords processed? In Experiments 1-7 subjects were required to discriminate pseudohomophones (e.g., BRANE) from nonhomophonic nonwords (e.g., BRAME) matched for visual similarity to each other and other real words in a lexical deciion tasks. Slower reaction times to respond "no" to pseudohomophones compared to matched control nonwords were not demonstrated. These findings contradict one major piece of evidence for dual-route models of word recognition. According to that theory pseudohomophones produce slower "no" responses than nonhomophonic nonwords because the phonological code generated by these nonwords activate the lexical addresses of words with a matching phonological entry.

Such effects of homophony have been demonstrated more often in the processing of nonwords compared to words. The explanation being that subjects adopt a longer response deadline when processing nonwords than when processing words which gain lexical access prior to the deadline being exceeded. Furthermore, the dual-route theory assumes that the lexical process is amenable to the control of the subject depending on the relative costs and benefits of using a phonological code. The experiments presented in Chapters 2, 3 and 4 did not support this view. When the experimental conditions were arranged to favour nonlexical processing evidence for speech coding was still not obtained.

It is not clear as Humphreys and Evett (1985) point out whether it is the generation or actual use of the speech code that is under the control of the subject. If the use of a speech code is amenable to strategic control as has been proposed by Davelaar, Coltheart, Besner and Jonasson (1978) and McQuade (1981) then it is not obvious why the subjects in the present series of experiments did not make use of this opportunity. In any event, the present results, together with those of Martin (1982) and Taft (1982) demonstrate that the effects of nonlexical processing will not necessarily be found in lexical decision responses to nonwords. A possible criticism is that the subjects may have been responding under severe time pressure. There was no evidence to suggest that the subjects in the present experiments were responding so rapidly that phonological access which if it proceeds at a slower rate, did not have a chance to influence the subjects response. Overall the mean reaction time to pseudohomophones and visual control nonwords (Experiment 1 = 662 msec; Experiment 2 lower-case stimuli = 631 msec, upper-case stimuli = 660 msec; Experiment 3 = 643 msec; Experiment 4 = 677 msec; Experiment 5 = 667 msec; Experiment 6 = 740 msec; Experiment 7 "Chinese" readers = 706 msec, "Phoenician" readers = 754 msec) were generally comparable and even longer than those obtained by Coltheart et al., (1977, mean reaction time to pseudohomophones and visual control nonwords = 619 msec) and Besner and Davelaar (1983, mean reaction time = 654 msec).

How might previous demonstrations of the pseudohomophone effect be interpreted? It was argued in Chapters 2, 3 and 4 that the effect may reflect the visual similarity rather than the phonological similarity between the nonwords and words. Martin (1982) originally attempted to control the visual similarity of nonwords by using Coltheart et al's (1977) measure of N-count. The experimental results were consistent with this explanation in that when pseudohomophones and control nonwords were matched for visual similarity, pseudohomophones did not take longer to be responded to. However, a paradox exists in that N-count was not a good predictor of lexical decision time in the experiments reported in this thesis.

Rumelhart and McClelland (1971) proposed in their interactive activation model that the processing of a given letter string is critically dependent upon the "neighbourhood" of lexical units that are activated. The model predicts no difference in lexical response times to pseudohomophones and control nonwords which are matched for visual similarity even though the pseudohomophones sound like a real word(s) while the control nonwords do not. A significant difference might be expected between pseudohomophones and nonwords not controlled for visual similarity since the pseudohomophones having a greater visual similarity to real words will produce more activity at the word level than a letter string which is less similar to real words.

In the case of dual-route theory, a significant difference might be expected between the pseudohomophones and nonwords matched for visual similarity if speech coding affects the subjects' "No" response times.

The results were inconsistent with the dual-route theory, but they are consistent with the interactive activation position. While the results suggest that previous studies may have confounded the visual and phonological components of the effect an explanation based on N-count is incomplete. While it has been shown that N-count is related to lexical decision times for nonwords (Coltheart et al., 1977; Martin 1982) in Experiment 1; the approximate visual control and distant visual control nonwords which had lower N-counts than the pseudohomophones were rejected significantly more quickly than the pseudohomophones. N-count did not correlate with reaction time as would be expected by the interactive activation model. If the pseudohomophone effect is critically dependent on N-count as Martin (1982) proposed, the absence of any direct evidence for such an influence is somewhat puzzling.

It could be argued that the original measure was somewhat crude as it did not take into account word frequency. A new measure, the frequency weighted N-count of a letter string incorporated the summed frequencies of all its N-count neighbours. This also failed to correlate with lexical decision time for nonwords. This remains something of a paradox for when N-count is controlled a pseudohomphone effect is not found but, N-count itself does not correlate reliaby with reaction time.

A further problem is that the processing of nonwords is subject to lexical influence. Nonwords like HEAF derived from inconsitent words (e.g., LEAF which is regular and DEAF which is irregular) are occasionally given irregular pronunciations (Glushko, 1979; Kay, 1982). The probabability of an irregular pronunciation can be increased by the prior presentation of an appropriate irregular word (Kay and Marcel 1981). In addition inconsistent nonwords also take longer to pronounce than consistent nonwords (Glushko 1979); that is they show a consistency effect. These findings are problematic for a simple dual-route theory which proposes that nonwords are processed nonlexically.

In the processing of words the dual-route theory makes the prediction that the processing of homophones (e.g., WHICH and WHICH) will differ from nonhomophonic words. In the lexical decision task it has been found that the lower frequency member of a homophonic pair takes longer to be accepted as a real word than other nonhomophonic words matched for frequency (Rubenstein et al., 1971). According to the dual-route model, homophone effects occur when the lexical address of the higher frequency member (e.g., WHICH) of a pair becomes activated by the nonlexical phonological code assembled from the lower frequency member (e.g., WITCH) of the homophonic pair. The lower frequency homophone is delayed until the higher frequency homophone has completed and failed a spelling check, the incurred delay results in slower response times to lower frequency homophones compared to nonhomophonic words which do not have to wait for an unsuccessful spelling check. A possible explanation for why homophone effects are elusive might be that subjects respond before the nonlexical code has been assembled. The homophone effect, is thought to be more easily found when subjects adopt a longer response deadline as this allows the nonlexical phonological code to be completed (Davelaar et al., 1978). The results of Experiment 8 were not consistent with this argument. The absence of any difference in response time between the low-frequency homophones and the frequency-matched control words when presented in a context (the background context only included nonhomophonic nonwords) that would facilitate nonlexical processing suggests that the original finding of Davelaar et al., was not reliable. This argument is further supported by the work of Clark (1971) and Coltheart et al., (1977). It therefore seems reasonable to reject the dual-route proposal that phonological access occurs in parallel with visual access but at a slower rate.

A further prediction that the dual-route theory makes is that if pre-lexical phonological recoding does occur then there should be effects of the regularity of spelling patterns on lexical decision times. Generally the results looking for such effects have been inconsistent. A number of factors such as frequency (Seidenberg et al 1984), orthographic complexity of the stimulii (Seidenberg et al 1984) and the nature of the other items in the list (Waters and Seidenberg 1985; Andrews 1982) seem to have contributed to the lack of significant results.

Spelling regularity effects can result from either the application of spelling-to-sound correspondence rules (Wijk 1966; Venezky 1970) or from the effects of neighbouring words with inconsistent pronunciations. Glushko (1979) showed that regular inconsistent words (e.g., Leaf) took longer to pronounce than regular consistent words (e.g., Lean). These findings are at variance with the dual-route theory for two reasons. First of all the theory would not predict a difference in the latencies of consistent and inconsistent regular words, and secondly consistency effects imply the use of lexical knowledge. The consistency might provide an explanation for the elusiveness of the regularity effect (Bauer and Stanovitch 1980). Those studies which included a high proportion of regular inconsistent words would not be expected to show a regularity effect. Therefore, it has been suggested (Humphreys and Evett, 1985) that the regularity effect may be an effect of consistency rather than spelling-to-sound correspondence rules

From the review of the present experiments there is no evidence to support the position of prelexical phonology. On this basis the dual-route model of word recognition will be tentatively rejected. One alternative account of word processing that dispenses with the idea of separate lexical and nonlexical processes is the interactive activation model (McClelland and Rumelhart, 1981). The framework of this model is composed of a visual analysis level of representation which is made up of a feature level and a letter level of representation. When a letter string is first shown, detectors at the feature level become activated or inhibited depending on whether they are present in the stimulus. Before activation at the feature level is complete the next level, the letter level, becomes activated which in turn activates detectors at the word level setting up a pattern of stimulation in a neighbourhood of visually similar words. Therefore the word SPOT will give rise to momentary activation in other words such as SHOT STOP and BLOT. The inhibition that exists between words at the word level and the resulting feedback down to the letter level from the word level results in a single word over and above the others being identified.

Word recognition results in the identification of a word's meaning and pronunciation, this latter level still needs to be elaborated. A phonological level of representation could be incorporated whereby activity from the whole word level could activate phonological units of some kind. The output of these units as in anology theory

(Glushko, 1979; Marcel, 1980) could then be synthesized into a pronunciation.

The model can in principle account for the processing differences of regular and irregular words and their interaction with frequency. The units at the word level of representation have different levels of resting activation. High-frequency or common words have higher resting levels of activation than less common words; activity in high-frequency regular and irregular words will build up more quickly leading to faster identification times and pronunciation latencies than low-frequency words. The rapid build up of activation in high-frequency words is such that inconsistent words in their orthographic neighbourhood tend not to influence the pronunciation of the word. Low-frequency words with lower resting levels of activation take more time to be identified; at the word level regular words tend to activate a consistent pattern of phonology which leads to a pronunciation with the same pattern. Irregular words on the other hand, will activate a mixture of phonological patterns some of which will be consistent with the target word and some of which will be inconsitent. This variety of representation at the phonological level slows down the assembly of a pronunciation, so irregular words and regular inconsistent words will take longer to be pronounced.

6.6 Task Demands

The lexical decision task has been widely used to study lexical access. The task requires the subject to provide one of two responses in reply to the visual presentation of words and nonwords. A "yes" response is required for those letter strings which are known words in the subjects' vocabulary and a "no" response is required for those stimuli that do not occur in the subjects' vocabulary. It has been argued by Coltheart, Davelaar, Jonasson and Besner (1979) that discriminations between words and legal nonwords such as SLINT and SLANT can only be established by checking that SLINT is not present in the lexicon. Nonwords like AZPKR, which do not follow the rules of English spelling, can be judged as nonsense without lexical access taking place. Negative responses to unpronounceable nonwords are faster than to pronounceable nonwords, as are negative responses to illegally spelt nonwords compared to decision times for nonwords which are consistent with English orthography. The rejection of nonwords often requires less time than the decision to accept words. Following the development of the lexical decision task the dependent measure of reaction time was believed to provide a reflection as to how the mental lexicon is organized.

A number of criticisms have however, been made of this experimental paradigm. It has been argued by Henderson (1982) that the very nature of the task is unnatural. Requiring the subject to decide whether a letter string is a legal word or not may elicit stategies not normally used in the reading of text. Evidence for the strangness of the task is seen in the reaction time to words. In general lexical decision times are longer than pronunciation latencies to the same stimuli with high-frequency words showing about a 100 msec disparity between the two tasks and low-frequency words producing an even greater difference (Frederikson and Kroll 1976). Henderson (1982) pointed out that the large difference in the response times between the two tasks even if the pronunciation task does not usually require lexical access suggests that the lexical decision task "may force a deeper visual analysis of real word neighbours". Coltheart et al (1979) have echoed Henderson's objections that the lexical access procedure may differ from normal reading. They argued that in normal reading the partial analysis of a letter string is sufficient to identify a word. The word BRIBE can be identified from the knowledge that it starts with "BR" and ends in "BE" for no other five letter word in English has this particular initial and terminal combination of letters. However, in the lexical decision task a more thorough analysis of the letter string is necessary for the subject to confidently reject it as a nonword. In normal reading only real words occur whereas in the lexical decision task the nowords add an element of uncertainty to the task.

The typically extended response times found in the lexical decision task may reflect more than just the lexical access process alone. Indeed, Stanovitch and West (1983) found results that were consistent with the idea that additional post-lexical processes are involved in the lexical decision task. They found that both the lexical decision task and the pronunciation task showed strong facilitation effects (that is faster response times) when the prior sentence context was semantically related to the target word. In addition, the lexical decision task produced large inhibition effects (longer response times) when the prior sentence context was not semantically related to the target word; this effect was not found in the pronunciation task. If the lexical decision task and the naming task reflected the same lexical access processes differences between the two tasks would not be expected. As the two tasks resulted in different amounts of inhibition to the same stimuli, they concluded that the larger inhibition effects found in the lexical decision task reflected further post-lexical decision processes over and above the processes involved in lexical access process.

The effects of phonology are observed more frequently in the pronunciation task than in the lexical decision task. Seidenberg, Waters, Barnes and Tanenhaus (1984) have demonstrated that high-frequency words are not affected by uncommon orthography or irregular pronunciation in both the pronunciation task and the lexical decision task. However, low-frequency irregular words and low-frequency strange words (that is irregular words with unusual orthographies) take longer to be responded to in the pronunciation task but only low-frequency strange words take longer to be responded to in the lexical decision task. This difference raises the question as to whether phonological information plays a role in the lexical decision task.

The proposal that the lexical decision task may reflect semantic processing is not new. Jaastrzemski (1981) found that lexical decision performance could be predicted from the number of dictionary meanings associated with a word. James (1975) in an earlier study found that low-frequency concrete words were responded to more quickly than low-frequency abstract words. Similarly, Whaley (1978) showed that lexical decision performance to words could predicted when frequency and word length were controlled, by such semantic variables as meaningfulness, concreteness, imagery and age of aquisition.

Balota and Chumbley (1984) also share the view that the lexical decision task may be heavily influenced by processes other than lexical access. Word frequency is assumed to play an important role in lexical access, for instance, an item's frequency is thought to affect recognition time by influencing the item's threshold level. This being the case, the impact of frequency effects should not be task dependent. Balota and Chumley examined the role of frequency amongst other variables on three tasks that involved lexical access. These were the lexical decision task, the pronunciation latency task and category verification. In the latter task, the subject after seeing a category name (e.g. BIRD) had to verify whether the following example (e.g., ROBIN) belonged to that particular category. They found that word frequency had very little effect on the categorization task but a significantly greater effect on the pronunciation task and lexical decision task of which the lexical decision task produced the most accentuated effect. From this they concluded that word frequency in the lexical decision task affected a post-lexical decision stage as it had an influence beyond that which could be attributable to lexical access.

Overall the lexical decision task as a measure of lexical access has generated many objections that cannot easily be rebutted. It seems clear that in addition to lexical access the task involves additional post-lexical processes which are reflected in the accentuated response times.

If the lexical decision task is not a good measure of lexical access what alternative procedure is available to investigate the variables influencing lexical access? An alternative to the lexical decision task is the pronunciation latency task where the subject is required to orally read a given letter string. It has been argued by Henderson (1982) that this task is more natural than asking the subject to discriminate real words from nonwords. However, it is not without its own problems. Theoretically it has been proposed that oral reading does not necessarily require lexical access (Coltheart, 1978) but can proceed nonlexically by the application of phonological rules such as the grapheme-phoneme correspondence rules. If the nonlexical route was always faster the number of words that would be correctly read would be limited to regular words. Irregular words are not correctly decoded by such rules therefore one would expect high error rates for such words. If the lexical route is more rapid it could reasonably be argued that lexical access has taken place.

Although the pronunciation latency task seems to be less subject to post-lexical processes (Chumbley and Balota, 1984) it is not without its own limitations. As it is the initial onset of the subject's articulation that stops the clock then differences between experiments may reflect differences in the production requirements of the initial consonant or vowel. Secondly, an apparent difference in response latency even when the former observation has been controlled, may reflect a difference in articulatory coding difficulty and not necessarily a difference in lexical access as such. Not withstanding these problems it would appear that the pronunciation latency task which bears a greater resemblance to normal reading may be a better indicator of lexical access.

Phonological recoding has been implicated in the reading of sentences and phrases. Doctor and Coltheart (1980) found that children aged 6-10 years found it more difficult to reject nonsense sentences which included a homophone or pseudohomophone lure which made the sentence sound correct. Similar results have been found by Baron (1973) with adults reading short phrases, although the effects were reduced in comparison to less skilled younger readers, an effect was observed in their error rates. Treiman, Freyd and Baron (1983) found that subjects took longer to complete sentences which had embedded words with similar spellings but different pronunciations (e.g., He made a nasty hasty remark) compared to sentences in which the critical pair of words had similar spellings and pronunciations (e.g., Bring string with you).

Although these experiments seem to support the argument that speech-coding has taken place at some stage, it is not clear whether it occurred at a pre-lexical or post-lexical stage of processing. Most of these tasks which have shown such influences require the interactive comprehension of a number of words. Therefore, the effects of speech coding could have occurred at some post-lexical stage rather than at a pre-lexical stage of processing.

With this evidence in mind, prudence is required in drawing conclusions about lexical access until a fuller understanding of the processes involved in differing tasks has been gained. Although the implications for future research are not encouraging it may be that the pronunciation task is probably a better tool with which to study lexical access.

6.7 Summary and Conclusions

Although the current research seems to suggest that phonological information plays a minor role in word recognition for skilled readers, there is evidence to support the view that less skilled readers may make use of such information. Such information does seem to play a role in the aquisition of reading skills (Perfetti and Hogaboam 1975; Waters, Seidenberg and Bruck 1984).

Evidence to support the existence of pre-lexical phonological coding was assessed from three sources; pseudohomophones, homophones and spelling regularity. The experimental results clearly did not support the view that phonological mediation is normally used in the processes involved in the reading of single words. In the light of these findings the acceptability of the lexical decision task was also questioned. It was concluded that the task reflects additional post-lexical processes and therefore the relevance of findings from the lexical decision task to the processes involved in lexical access during normal reading are questionable.

APPENDIX I

STIMULUS MATERIALS FOR EXPERIMENTS 1, 2 AND 3.

Mean Reaction Time (msec) to Each of the Nonwords Presented in Experiment 1.

Pseudohomophones			Visual Controls		
	RT	E		RT	E
WERD	641	0	CEST	594	1
SUNE	670	0	BUKE	724	1
GROE	657	0	DREE*	618	1
GERL	599	1	FEVE	623	0
WERK	629	3	LENG	584	1
MEEN	650	3	PLEN	663	0
TURM	678	2	NUCK	568	1
DERT	604	0	VECE	610	2
WITE	796	1	TINK	750	5
WHIFE	756	2	SHEEM	723	1
RUFE	589	0	FUTE	728	3
WHALL	619	2	THALK	688	0
DED	603	1	NER	531	0
GARD	751	4	GAND	690	1
CONSEPT	958	4	RESORDS	747	1
SHURE	668	4	THELL	586	1
REECH	662	2	PLENT	670	2
SERTAIN	756	2	SOUNTRY	736	1
BRETH	619	3	TUGHT	644	1
HERT	733	1	PESH	630	1
SIRCLE	667	1	SLOSER	678	2
MERDER	623	1	JENIOR	717	1
MUNNY	777	2	TUDDY	629	1
LERN	653	2	TRIN	666	1
SNOE	686	1	GREE	668	1

RT = Reaction Time   E = Error Rate

* DREE is infact a word meaning to endure.

Mean Reaction Time (msec) and Error Rates to Each of the Nonwords Presented in Experiment 1.

Approximate V. C.			Distant V. C.		
	RT	E		RT	E
SERD	593	0	KYSE	672	0
WUNE	603	0	GHER	566	1
GRYE	608	1	PHOU	582	1
DERL	551	0	REMM	581	0
FERK	570	1	TWUP	593	0
NEEN	656	1	BYPH	572	2
LURM	579	1	NAFF	615	1
DERF	593	1	UNCK	609	0
WUTE	591	0	PUHM	596	0
SHIFE	683	3	MULST	605	0
LUFE	646	2	VULS	544	1
THALL	612	1	SCKOP	562	0
VED	640	0	IRM	677	1
GARK	599	1	KENJ	570	1
MONSEPT	693	2	ICKTION	630	1
SHURB	633	1	ZHAMP	557	0
SEECH	714	0	AUNGS	637	0
MERTAIN	726	0	IRDKASP	587	0
PRETH	632	0	KNUTH	529	0
ZERT	540	0	HAAN	657	0
HIRCLE	629	0	OQUARS	582	0
PERDER	643	0	IHRMOT	579	0
MURNY	662	1	WRULO	587	0
LORN	667	4	GUZP	642	0
SKOE	640	0	OOMS	598	2

Approximate V. C. = Approximate Visual Controls
Distant V. C. = Distant Visual Controls
RT = Reaction Time   E = Error Rate

Words Presented in Experiment 1.

WORDS			
WEEK	BOOK	ELSE	MALE
HALF	EDGE	LIVE	PLOT
SEEN	FAST	HOPE	FOOL
TELL	TONE	EAST	FRIDAY
HELD	GRAY	GRAND	GARDEN
MEAN	COAT	PLAIN	TRAVEL
TYPE	PACE	SWUNG	BUDGET
NEAR	PATH	COUNT	KILLED
ROAD	SALE	CLASSED	FAILED
HARD	LARGE	PRODUCT	MEMORY
KILL	LEAST	BATTLE	BOTTLE
SHOP	LIGHT	APPEARS	MUMMY
WIND	OFTEN	FREE	METAL
COOL	WEST	REAL	GULPS
LAND	TURN	MISS	FIFTY
ABLE	LOVE	PAST	NAMED
COST	TRUE	SCENE	BROAD
FULL	SNOW	DRIVE	SHAPE
LONG	MINE	SERVE	SPEED
MAKE	DROP	PRICE	TRAIN
GOOD	TEXT	ATTEND	DRINK
LIFE	CENT	MOTION	LOSE
TOWN	FINE	LOOSE	HOLE
RATE	CARE	SLIGHT	BUSY
PLAY	SORT	GATE	TREE

Practice Trials Used in Lower-Case in Experiment 1 and Either Upper or Lower-Case in Experiment 2

PH	VC	WORDS
GLOE	BROE	FLAG
SAIVE	HAIVE	FUND
MUVE	DUVE	COLD
YOOTH	MOOTH	DRINK
TUTCH	PUTCH	TAKE
HOAM	SOAM	WADE
WOSP	GOSP	LEAD
LEEF	DEEF	SPOKE
		GRAB
		DUTY
		HOLD
		CELLS
		WENT
		WAVY
		LEAK
		UNITS

PH = Pseudohomophone
VC = Visual Control

Mean Reaction Times (msec), Error Rates and N-counts to each of the Nonwords Presented in Lower-Case in Experiment 2.

Pseudohomophones				Visual Controls			
	N	RT	E		N	RT	E
werd	5	707	0	cest	14	655	1
sune	7	624	0	buke	4	623	1
groe	3	547	0	dree*	6	608	1
gerl	3	544	0	feve	2	670	0
werk	7	590	0	leng	4	638	0
meen	7	716	2	plen	4	620	1
turm	4	597	2	nuck	12	617	0
dert	7	591	0	vece	1	582	1
wite	13	742	1	tink	13	658	2
whife	3	725	2	sheem	4	566	2
rufe	1	542	1	fute	7	691	2
whall	2	614	1	thalk	2	644	1
ded	11	598	0	ner	10	546	0
gard	8	653	4	gand	8	649	1
consept	2	749	6	resords	1	724	2
shure	2	607	0	thell	1	685	0
reech	3	554	1	plent	2	719	6
sertain	1	696	0	sountry	1	710	0
breth	1	614	2	tught	1	599	0
hert	10	587	1	pesh	5	567	0
sircle	1	611	1	sloser	2	720	1
merder	1	617	0	jenior	2	683	2
munny	4	688	0	tuddy	4	594	0
lern	4	655	4	trin	4	618	1
snoe	5	593	1	gree	5	621	1

N = N-Count RT = Reaction Time E = Error Rate
* DREE infact is a word meaning to endure.

Mean Reaction Times (msec), Error Rates and N-counts to each of the Nonwords Presented in Upper-Case in Experiment 2

Pseudohomophones				Visual Controls			
	N	RT	E		N	RT	E
WERD	5	683	1	CEST	14	621	0
SUNE	7	624	0	BUKE	4	636	1
GROE	3	609	0	DREE*	6	579	0
GERL	3	600	0	FEVE	2	597	0
WERK	7	685	0	LENG	4	669	0
MEEN	7	688	1	PLEN	4	687	1
TURM	4	669	0	NUCK	12	646	0
DERT	7	661	0	VECE	1	572	0
WITE	13	822	1	TINK	13	724	2
WHIFE	3	641	2	SHEEM	4	673	1
RUFE	1	590	0	FUTE	7	636	1
WHALL	2	618	0	THALK	2	660	0
DED	11	652	1	NER	10	554	0
GARD	8	691	1	GAND	8	645	0
CONSEPT	2	853	7	RESORDS	1	735	0
SHURE	2	697	3	THELL	1	660	3
REECH	3	613	0	PLENT	2	735	3
SERTAIN	1	736	0	SOUNTRY	1	708	1
BRETH	1	756	1	TUGHT	1	693	1
HERT	10	671	2	PESH	5	628	0
SIRCLE	1	656	0	SLOSER	2	659	0
MERDER	1	673	0	JENIOR	2	700	3
MUNNY	4	798	0	TUDDY	4	687	0
LERN	4	683	1	TRIN	4	704	0
SNOE	5	625	0	GREE	5	619	0

N = N-Count   RT = Reaction Time   E = Error Rate

* DREE is infact a word meaning to endure.

Words Presented in Experiment 2.

WORDS			
WEEK	NEAR	KILL	LAND
STILL	SOON	EDGE	COAT
EARLY	SEEM	SNOW	CENT
DATA	GRAND	CLASSES	KEEP
SCEAN	SERVICE	HANDLE	GATE
FRIDAY	KILLED	SHALL	NAMED
MINE	FULL	CALL	BEAT
GAVE	WORK	HARD	FILE
BARS	WATER	WIFE	DUST
HEAR	MEAN	GUARD	PARENTS
HELD	TRUTH	CERTAIN	STRIKE
WASH	ACTING	STAYED	LOCAL
YOUTH	WORE		

Mean Reaction Times (msec), Error Rates and N-counts to each of the Nonwords Presented in Upper-Case in Experiment 3.

Pseudohomophones				Visual Controls			
	N	RT	E		N	RT	E
YEIRS	2	578	0	STITE	3	652	3
WERK	8	606	0	LENG	7	633	1
BOWTH	1	607	1	VEWRY	0	592	0
HARF	9	592	0	TERL	4	520	0
MUNEY	1	683	3	LUCAL	3	745	0
WHIFE	5	724	1	CHOST	3	650	0
LEEVE	3	599	1	CLESS	4	692	0
NEER	8	562	1	PLEN	2	635	0
THURD	1	610	1	CHULD	1	605	0
WERKING	1	665	1	FEREIGN	1	742	2
MUNTH	2	599	0	HUTEL	1	635	1
FEAD	7	666	1	POAT	10	684	4
TUCH	4	738	2	PEMS	4	713	3
LERN	4	647	2	BROD	5	587	0
MERDER	1	639	1	JENIOR	2	746	2
VILLIGE	1	856	8	COMMIND	2	712	0
BURDS	4	644	3	MUNOR	3	675	1
BRETH	1	709	1	AFRID	1	762	5
FEERS	4	616	2	GREND	4	633	1
DERT	10	578	0	PENK	6	596	0

N = N-Count
RT = Reaction Time
E = Error Rate

Word Set Presented in Experiment 3.

WORD SET					
AFTER	FIRST	THOSE	COULD	WORLD	STILL
BEING	ABOUT	MAKE	GOOD	CAME	LIFE
EACH	SAME	LAST	COME	UNDER	NEVER
MIGHT	SINCE	THREE	HOUSE	AGAIN	BODY
PAST	FEET	KEEP	HELD	SURE	FREE
SHALL	WORDS	FIELD	DEATH	HANDS	TODAY
ABOVE	HUMAN	VOICE	WOMEN	FRONT	FORCE
COURT	CLOSE	SOUTH	SOUND	BLACK	VALUE
CLEAR	NORTH	TOTAL	STOOD	SOON	ROAD
GONE	BOOK	HARD	TYPE	MEAN	IDEA
BASIS	SPACE	MOVED	LEVEL	SHORT	PARTY
MUSIC	WRITTEN	PURPOSE	RESULTS	PASSED	MEETING
SIMILAR	NATURAL	CAUSE	WRONG	FORMS	TRIAL
PRESS	TRUTH	PLANT	LOWER	GLASS	FIGHT
HAPPY	AWARE	SHAPE	RULES	NAMED	LOSS
ROSE	POST	KING	FILE	NECK	NINE
LADY	TRIP	GRAY	PAIN	BANK	SHIP
TEAM	EDGE	STAYED	CLAIMS	FAILED	REGION
MEMORY	BOTTLE	KILLED	SHELTER	ANCIENT	FASHION
POINTED	ASSUMED	WRITERS	BROTHER	SHOOK	TRUCK
TRULY	UNCLE	ROMAN	SMILE	STONE	AVOID
CHEST	CROWD	DEPTH	GRASS	ALIVE	APART
NOTES	HENCE	GRANT	HUMOR	OPERA	PRIOR
GUARD	HOPED	LIMIT	COUNT	COAT	IRON
PACE	TEND	MILE	POEM	SUIT	COOK

Filler Nonwords Presented in Experiment 3.

NONWORD SET					
YEITS	NERK	DOWTH	HIRF	MUNES	SHIFE
NEEVE	NEEK	THULD	SERKING	MUNTS	PLAEM
TUCE	JORN	FERDER	MILLIGE	GUNDS	FRETH
FEEMS	GERT	SICH	THAID	WOUT	WEP
WHOB	DAS	TAED	CENY	MALK	BURLD
JAIM	PRAIT	GARST	TAIB	CIRSE	LORTER
PITE	BORK	TERSED	SRUNT	NITH	GARL
LANT	HORT	INSTER	SEECHED	BEEL	TARMS
FLON	NAIPER	PLOO	RHIN	TRAIG	BRUBLE
DREND	LUNTH	MONG	WURTED	NOST	FEEP
THIDE	PIESH	FLAD	HAIM	TUPLE	KLUD
CHEEN	NAEN	WANDOE	SREAN	DOOT	CHOISP
STAP	DARS	HAVY	SPEET	FULM	JAIT
BEATH	KLAG	RARS	VAET	TRAIP	SHAIG
WOAST	HAIDY	ROTCH	FAMP	CRAIM	DIFE
FLOB	LURTH	NAIG	MUFE	PIRCLE	RAFE
SNOM	HINSE	PAEP	SANF	STOON	SHILD
THEAT	BROSS	KLITE	PRAVE	LAIF	SLOTE
MAIVED	DEVITE				

Frequency Weighted N-counts for the Pseudohomophones and Visual Control Nonwords used in Experiment 3.

Pseudohomophones		Visual Controls	
	F W N		F W N
YEIRS	1	STITE	808
WERK	1072	LENG	802
BOWTH	7	VEWRY	0
HARF	518	TERL	347
MUNEY	265	LUCAL	288
WHIFE	1050	CHOST	101
LEEVE	205	CLESS	219
NEER	613	PLEN	205
THURD	190	CHULD	213
WERKING	151	FEREIGN	158
MUNTH	131	HUTEL	126
FEAD	921	POAT	319
TUCH	2242	PEMS	4
LERN	21	BROD	9
MERDER	75	JENIOR	109
VILLIGE	72	COMMIND	79
BURDS	4	MUNOR	63
BRETH	3	AFRID	0
FEERS	11	GREND	99
DERT	62	PENK	55

F W N = Frequency Weighted N-Count

Practice Materials Presented in Experiment 3.

PH	VC	NONWORDS	WORDS
LEEF	DEEF	GEEF	GAZE
SAIVE	VAIST	TAIVE	LIMP
YOOTH	TROCK	LOOTH	CANE
STEDY	OBTIN	STIDY	BEACH
DED	NER	DOD	ARMED
		DEET	SHORE
		RAIST	TRAIN
		SROCK	FRESH
		OBAIN	TRULY
		NUR	SMOKE
			HARDY
			PRIDE
			LOW
			PAY
			RED

PH = Pseudohomophone

VC = Visual Control

Nonword = Nonword fillers.

APPENDIX II.

STIMULUS MATERIALS FOR EXPERIMENTS 4, 5 AND 6.

Mean Reaction Times (msec), Error Rates and N-counts to each of the Nonwords Presented in Upper-Case in Experiment 4.

Pseudohomophones				Visual Controls			
	N	RT	E		N	RT	E
HEER	11	651	1	SOEM	3	671	0
NEWE	2	733	1	TWOE	2	601	1
WURLD	1	670	0	NURTH	1	607	0
WOR	7	610	1	DOY	19	645	1
FLORE	3	696	4	SHOAK	4	746	2
WAET	4	585	1	TREP	7	672	0
RAEN	1	624	0	SKEN	5	697	1
WUN	12	677	0	JUB	17	703	0
WOUD	2	726	1	SPUT	9	808	0
PLAEN	0	638	0	ADMET	1	886	0
MAEL	4	646	0	ASEA	2	701	0
LOWN	7	781	2	HEWP	4	648	0
FAITE	1	698	1	CAISH	0	652	2
MAED	2	673	0	VEEN	8	697	1
HURD	4	656	2	ZURO	1	709	0
PRAI	3	608	2	VARI	0	662	0
SAEL	3	632	2	GREM	4	710	0
WAURN	0	697	0	DAUSH	0	682	0
POAR	5	651	0	GLAE	4	773	0
SEAME	2	714	1	SLABE	4	738	0

N = N-Count
RT = Reaction Time
E = Error Rate

Word Set Presented in Experiment 4.

WORD SET					
AFTER	FIRST	THOSE	COULD	WORLD	STILL
BEING	ABOUT	MAKE	GOOD	CAME	LIFE
EACH	SAME	LAST	COME	UNDER	NEVER
MIGHT	SINCE	THREE	HOUSE	AGAIN	BODY
PAST	FEET	KEEP	HELD	SURE	FREE
SHALL	WORDS	FIELD	DEATH	HANDS	TODAY
ABOVE	HUMAN	VOICE	WOMEN	FRONT	FORCE
COURT	CLOSE	SOUTH	SOUND	BLACK	VALUE
CLEAR	NORTH	TOTAL	STOOD	SOON	ROAD
GONE	BOOK	HARD	TYPE	MEAN	IDEA
BASIS	SPACE	MOVED	LEVEL	SHORT	PARTY
MUSIC	WRITTEN	PURPOSE	RESULTS	PASSED	MEETING
SIMILAR	NATURAL	CAUSE	WRONG	FORMS	TRIAL
PRESS	TRUTH	PLANT	LOWER	GLASS	FIGHT
HAPPY	AWARE	SHAPE	RULES	NAMED	LOSS
ROSE	POST	KING	FILE	NECK	NINE
LADY	TRIP	GRAY	PAIN	BANK	SHIP
TEAM	EDGE	STAYED	CLAIMS	FAILED	REGION
MEMORY	BOTTLE	KILLED	SHELTER	ANCIENT	FASHION
POINTED	ASSUMED	WRITERS	BROTHER	SHOOK	TRUCK
TRULY	UNCLE	ROMAN	SMILE	STONE	AVOID
CHEST	CROWD	DEPTH	GRASS	ALIVE	APART
NOTES	HENCE	GRANT	HUMOR	OPERA	PRIOR
GUARD	HOPED	LIMIT	COUNT	COAT	IRON
PACE	TEND	MILE	POEM	SUIT	COOK

Filler Nonwords Presented in Experiment 4.

NONWORD SET					
YEITS	NERK	DOWTH	HIRF	MUNES	SHIFE
NEEVE	NEEK	THULD	SERKING	MUNTS	PLAEM
TUCE	JORN	FERDER	MILLIGE	GUNDS	FRETH
FEEMS	GERT	SICH	THAID	WOUT	WEP
WHOB	DAS	TAED	CENY	MALK	BURLD
JAIM	PRAIT	GARST	TAIB	CIRSE	LORTER
PITE	BORK	TERSED	SRUNT	NITH	GARL
LANT	HORT	INSTER	SEECHED	BEEL	TARMS
FLON	NAIPER	PLOO	RHIN	TRAIG	BRUBLE
DREND	LUNTH	MONG	WURTED	NOST	FEEP
THIDE	PIESH	FLAD	HAIM	TUPLE	KLUD
CHEEN	NAEN	WANDOE	SREAN	DOOT	CHOISP
STAP	DARS	HAVY	SPEET	FULM	JAIT
BEATH	KLAG	RARS	VAET	TRAIP	SHAIG
WOAST	HAIDY	ROTCH	FAMP	CRAIM	DIFE
FLOB	LURTH	NAIG	MUFE	PIRCLE	RAFE
SNOM	HINSE	PAEP	SANF	STOON	SHILD
THEAT	BROSS	KLITE	PRAVE	LAIF	SLOTE
MAIVED	DEVITE				

Frequency Weighted N-count of the Pseudohomophones and Visual Control Nonwords Used in Experiment 4.

Pseudohomophones		Visual Controls	
	F W N		F W N
HEER	91	SOEM	306
NEWE	110	TWOE	2
WURLD	787	NURTH	206
WOR	10030	DOY	1111
FLOAR	169	SHOAK	88
WAET	434	TREP	163
RAEN	70	SKEN	326
WUN	503	JUB	281
WOUD	55	SPUT	141
PLAEN	48	ADMET	37
MAEL	50	ASEA	367
LOWN	977	HEWP	325
FAITE	111	CAISH	0
MAED	31	VEEN	2789
HURD	264	ZURO	24
PRAI	13	VARI	0
SAEL	12	GREM	100
WAURN	0	DAUSH	0
POAR	142	GLAE	49
SEAME	30	SLABE	10

F W N = Frequency Weighted N-Count

Practice Materials Presented in Experiments 4, 5 and 6.

PH	VC	NONWORDS	WORDS
LEEF	DEEF	GEEF	GAZE
SAIVE	VAIST	TAIVE	LIMP
YOOTH	TROCK	LOOTH	CANE
STEDY	OBTIN	STIDY	BEACH
DED	NER	DOD	ARMED
		DEET	SHORE
		RAIST	TRAIN
		SROCK	FRESH
		OBAIN	TRULY
		NUR	SMOKE
			HARDY
			PRIDE
			LOW
			PAY
			RED

PH = Pseudohomophone

VC = Visual Control

Nonword = Nonword fillers.

The Production of Pseudohomophones and Visual Control Nonwords Used in Experiment 5.

Nonword Construction			
ROOT	PH	ROOT	VC
came	KAIM	come	KOIM
later	LAITA	cover	COIVA
break	BRAIK	clean	CLAIN
word	WHERD	told	THELD
rate	RHAIT	take	THAIK
control	KONTROAL	central	KENTRAAL
figure	FIGA	future	FUTA
value	VALEW	issue	ISSEW
wrote	ROAT	white	HIAT
care	KAIR	code	KOID
wall	WORL	harf	HORF
bear	BAIR	rode	ROID
ball	BORL	palm	PORM
read	RHEED	plan	PHLEN
makes	MAIKS	comes	COIMS
floor	FLORE	blood	BLODE
paper	PAIPA	lover	LOIVA
purpose	PERPUSS	suppose	SEPPUSS
court	KORT	count	KONT
grate	GRAIT	drone	DROIN
wore	WOAR	some	SOAM
wade	WAID	hone	HOIN
hole	HOAL	gone	GOAN
bird	BHURD	sing	SHUNG
laugh	LARF	baugh	BARF

PH = Pseudohomophone. VC = Visual Control.

Mean Reaction Times (msec) and Error Rates to each of the Nonwords Presented in Experiment 5.

NONWORD REACTION TIMES					
PH	RT	E	VC	RT	E
KAIM	608	0	KOIM	722	0
LAITA	599	0	COIVA	590	0
BRAIK	704	0	CLAIN	739	3
WHERD	793	1	THELD	682	0
RHAIT	644	0	THAIK	708	0
KONTROAL	648	0	KENTRAAL	726	0
FIGA	583	0	FUTA	618	1
VALUW	686	1	ISSEW	640	1
ROAT	720	1	HIAT	667	0
KAIR	618	1	KOID	588	1
WORL	655	1	HORF	645	0
BAIR	683	1	ROID	654	0
BORL	693	0	PORM	675	0
RHEED	692	1	PHLEN	671	1
MAIKS	631	0	COIMS	778	1
FLORE	811	1	BLODE	705	0
PAIPA	680	0	LOIVA	646	1
PERPUSS	743	1	SEPPUSS	590	0
KORT	643	0	KONT	656	3
GRAIT	603	2	DROIN	628	0
WOAR	681	2	SOAM	692	1
WAID	651	0	HOIN	612	0
HOAL	602	0	GOAN	941	5
BHURD	597	0	SHUNG	643	0
LARF	701	3	BARF	642	2

PH = Pseudohomophone VC = Visual Control.
RT = Reaction Time E = Error Rate

Word Set Presented in Experiment 5.

WORD SET					
AFTER	FIRST	THOSE	COULD	WORLD	STILL
BEING	ABOUT	MAKE	GOOD	CAME	LIFE
EACH	SAME	LAST	COME	UNDER	NEVER
MIGHT	SINCE	THREE	HOUSE	AGAIN	BODY
PAST	FEET	KEEP	HELD	SURE	FREE
SHALL	WORDS	FIELD	DEATH	HANDS	TODAY
ABOVE	HUMAN	VOICE	WOMEN	FRONT	FORCE
COURT	CLOSE	SOUTH	SOUND	BLACK	VALUE
CLEAR	NORTH	TOTAL	STOOD	SOON	ROAD
GONE	BOOK	HARD	TYPE	MEAN	IDEA
BASIS	SPACE	MOVED	LEVEL	SHORT	PARTY
MUSIC	WRITTEN	PURPOSE	RESULTS	PASSED	MEETING
SIMILAR	NATURAL	CAUSE	WRONG	FORMS	TRIAL
PRESS	TRUTH	PLANT	LOWER	GLASS	FIGHT
HAPPY	AWARE	SHAPE	RULES	NAMED	LOSS
ROSE	POST	KING	FILE	NECK	NINE
LADY	TRIP	GRAY	PAIN	BANK	SHIP
TEAM	EDGE	STAYED	CLAIMS	FAILED	REGION
MEMORY	BOTTLE	KILLED	SHELTER	ANCIENT	FASHION
POINTED	ASSUMED	WRITERS	BROTHER	SHOOK	TRUCK
TRULY	UNCLE	ROMAN	SMILE	STONE	AVOID

(continued)

WORD SET					
BEGGAR	ADORE	COVE	STUMP	SNIFF	RINK
REEK	PEARS	MIXER	OPTED	SUIT	COOK
CHEST	CROWD	DEPTH	GRASS	ALIVE	APART
NOTES	HENCE	GRANT	HUMOR	OPERA	PRIOR
GUARD	HOPED	LIMIT	COUNT	COAT	IRON
PACE	TEND	MILE	POEM		

Filler Nonwords Presented in Experiment 5.

NONWORD SET					
YEITS	NERK	DOWTH	HIRF	MUNES	SHIFE
NEEVE	NEEK	THULD	SERKING	MUNTS	PLAEM
TUCE	JORN	FERDER	MILLIGE	GUNDS	FRETH
FEEMS	GERT	SICH	THAID	WOUT	WEP
WHOB	DAS	TAED	CENY	MALK	BURLD
JAIM	PRAIT	GARST	TAIB	CIRSE	LORTER
PITE	BORK	TERSED	SRUNT	NITH	GARL
LANT	HORT	INSTER	SEECHED	BEEL	TARMS
FLON	NAIPER	PLOO	RHIN	TRAIG	BRUBLE
DREND	LUNTH	MONG	WURTED	NOST	FEEP
THIDE	PIESH	FLAD	HAIM	TUPLE	KLUD
CHEEN	NAEN	WANDOE	SREAN	DOOT	CHOISP
STAP	DARS	HAVY	SPEET	FULM	JAIT
BEATH	KLAG	RARS	VAET	TRAIP	SHAIG
WOAST	HAIDY	ROTCH	FAMP	CRAIM	DIFE
FLOB	LURTH	NAIG	MUFE	PIRCLE	RAFE
SNOM	HINSE	PAEP	SANF	STOON	SHILD
THEAT	BROSS	KLITE	PRAVE	LAIF	SLOTE
MAIVED	DEVITE				

Nonwords Presented in Experiment 6.

Pseudohomophones			Visual Controls		
	RT	E		RT	E
YEIRS	695	0	STITE	758	0
WERK	808	1	LENG	842	0
BOWTH	749	1	VEWRY	798	1
HARF	845	0	TERL	574	1
MUNEY	784	0	LUCAL	687	0
WHIFE	793	2	CHOST	851	3
LEEVE	745	5	CLESS	824	3
NEER	715	1	PLEN	621	1
THURD	727	1	CHULD	691	1
WERKING	710	1	FEREIGN	845	1
MUNTH	668	1	HUTEL	664	1
FEAD	862	3	POAT	782	1
TUCH	691	0	PEMS	669	1
LERN	732	1	BROD	805	0
MERDER	766	4	JENIOR	848	1
VILLIGE	888	7	COMMIND	844	1
BURDS	794	1	MUNOR	817	0
BRETH	723	2	AFRID	882	4
FEERS	721	3	GREND	671	0
DERT	635	1	PENK	695	0

RT = Reaction Time

E = Error Rate

Mean Reaction Times (msec) and Error Rates to each of the Words Presented in Experiment 6.

HOMOPHONES			CONTROL WORDS		
	RT	E		RT	E
ALOUD	605	0	ERECT	809	2
ALTAR	680	3	ASSET	686	0
BEECH	626	1	BRUTE	681	1
BOARDER	663	4	BOOSTER	757	4
SELLER	754	4	HELPER	626	0
KERNEL	833	6	KENNEL	778	1
URN	839	14	OWL	616	1
FLOUR	595	0	FRAUD	865	6
GUESSED	659	1	DRAGGED	626	0
HARE	673	1	HARP	754	1
HAUL	717	2	CHAT	743	2
HEAR	675	1	MEET	655	2
HERD	737	6	JOKE	573	0
HIRE	729	0	DRAG	634	3
HOUR	544	0	FOOD	581	0
HYME	720	12	HINT	693	4
LEASED	756	0	LAGGED	749	2
LONE	690	1	SANE	629	1
MAID	786	4	BEEF	692	5
MANOR	622	0	SATIN	867	5

RT = Reaction Time
E = Error Rate

APPENDIX III.

STIMULUS MATERIALS FOR EXPERIMENT 7.

Spelling-Regularity Test Used in the Selection of Subjects in Experiment 7.

tank	sieve	head	hood
link	dose	wasp	wail
swindle	wealth	pour	click
vase	help	bush	marble
pill	steak	ease	root
truck	seep	grace	mist
vent	green	lager	threat
weld	dread	daze	sweat
level	shed	boar	worm
fever	boil	hobby	weed
earn	palm	shoe	marine
lever	wheel	bull	warp
gross	bulb	sign	float
great	swap	health	soot
squat	pipe	wand	demon
monk	sting	seed	watch
bear	brain	rinse	dream
blood	money	side	bowl
breast	brief	touch	glove
swish	flood	block	rook
clerk	squid	hover	love
route	breeze	hike	swallow

(continued)

word	dove	swig	wilt
break	surge	swarm	wipe
soul	throat	hitch	pain
pint	toll	wink	minor
belt	nutty	latin	wither
heal	glide	halve	broad
naked	hammer	dope	swing
wart	delta	foggy	hook

Mean Reaction Times (msec) and Error Rates to each of the Nonwords Presented to Chinese Style Readers in Experiment 7(a).

Pseudohomophones			Visual Controls		
	RT	E		RT	E
YEIRS	754	0	STITE	684	1
WERK	658	0	LENG	828	0
BOWTH	697	1	VEWRY	709	0
HARF	659	0	TERL	579	0
MUNEY	684	0	LUCAL	584	0
WHIFE	726	1	CHOST	760	2
LEEVE	792	0	CLESS	731	2
NEER	596	0	PLEN	686	2
THURD	651	1	CHULD	698	0
WERKING	768	0	FEREIGN	814	0
MUNTH	640	0	HUTEL	678	1
FEAD	803	0	POAT	761	0
TUCH	680	1	PEMS	711	0
LERN	646	1	BROD	640	3
MERDER	698	0	JENIOR	819	0
VILLIGE	922	4	COMMIND	937	1
BURDS	772	0	MUNOR	870	2
BRETH	654	0	AFRID	828	1
FEERS	663	0	GREND	731	0
DERT	600	1	PENK	633	1

N = N-Count
RT = Reaction Time
E = Error Rate

Mean Reaction Times (msec) and Error Rates to each of the Nonwords Presented to Phoenician Style Readers in Experiment 7(a).

Pseudohomophones			Visual Controls		
	RT	E		RT	E
YEIRS	766	0	STITE	836	1
WERK	696	0	LENG	781	0
BOWTH	758	0	VEWRY	709	0
HARF	674	0	TERL	664	0
MUNEY	658	0	LUCAL	787	2
WHIFE	783	1	CHOST	891	0
LEEVE	748	1	CLESS	750	2
NEER	783	1	PLEN	613	2
THURD	743	1	CHULD	641	0
WERKING	744	0	FEREIGN	899	0
MUNTH	763	0	HUTEL	705	0
FEAD	984	0	POAT	702	0
TUCH	910	0	PEMS	681	0
LERN	690	1	BROD	726	0
MERDER	717	0	JENIOR	804	0
VILLIGE	910	3	COMMIND	934	0
BURDS	785	0	MUNOR	798	1
BRETH	719	0	AFRID	776	2
FEERS	756	1	GREND	702	2
DERT	714	0	PENK	666	0

N = N-Count
RT = Reaction Time
E = Error Rate

Word Set Presented in Experiment 7(a).

WORD SET					
AFTER	FIRST	THOSE	COULD	WORLD	STILL
BEING	ABOUT	MAKE	GOOD	CAME	LIFE
EACH	SAME	LAST	COME	UNDER	NEVER
MIGHT	SINCE	THREE	HOUSE	AGAIN	BODY
PAST	FEET	KEEP	HELD	SURE	FREE
SHALL	WORDS	FIELD	DEATH	HANDS	TODAY
ABOVE	HUMAN	VOICE	WOMEN	FRONT	FORCE
COURT	CLOSE	SOUTH	SOUND	BLACK	VALUE
CLEAR	NORTH	TOTAL	STOOD	SOON	ROAD
GONE	BOOK	HARD	TYPE	MEAN	IDEA
BASIS	SPACE	MOVED	LEVEL	SHORT	PARTY
MUSIC	WRITTEN	PURPOSE	RESULTS	PASSED	MEETING
SIMILAR	NATURAL	CAUSE	WRONG	FORMS	TRIAL
PRESS	TRUTH	PLANT	LOWER	GLASS	FIGHT
HAPPY	AWARE	SHAPE	RULES	NAMED	LOSS
ROSE	POST	KING	FILE	NECK	NINE
LADY	TRIP	GRAY	PAIN	BANK	SHIP
TEAM	EDGE	STAYED	CLAIMS	FAILED	REGION
MEMORY	BOTTLE	KILLED	SHELTER	ANCIENT	FASHION
POINTED	ASSUMED	WRITERS	BROTHER	SHOOK	TRUCK
TRULY	UNCLE	ROMAN	SMILE	STONE	AVOID
CHEST	CROWD	DEPTH	GRASS	ALIVE	APART
NOTES	HENCE	GRANT	HUMOR	OPERA	PRIOR
GUARD	HOPED	LIMIT	COUNT	COAT	IRON
PACE	TEND	MILE	POEM	SUIT	COOK

Filler Nonwords Presented in Experiments 7(a).

NONWORD SET					
YEITS	NERK	DOWTH	HIRF	MUNES	SHIFE
NEEVE	NEEK	THULD	SERKING	MUNTS	PLAEM
TUCE	JORN	FERDER	MILLIGE	GUNDS	FRETH
FEEMS	GERT	SICH	THAID	WOUT	WEP
WHOB	DAS	TAED	CENY	MALK	BURLD
JAIM	PRAIT	GARST	TAIB	CIRSE	LORTER
PITE	BORK	TERSED	SRUNT	NITH	GARL
LANT	HORT	INSTER	SEECHED	BEEL	TARMS
FLON	NAIPER	PLOO	RHIN	TRAIG	BRUBLE
DREND	LUNTH	MONG	WURTED	NOST	FEEP
THIDE	PIESH	FLAD	HAIM	TUPLE	KLUD
CHEEN	NAEN	WANDOE	SREAN	DOOT	CHOISP
STAP	DARS	HAVY	SPEET	FULM	JAIT
BEATH	KLAG	RARS	VAET	TRAIP	SHAIG
WOAST	HAIDY	ROTCH	FAMP	CRAIM	DIFE
FLOB	LURTH	NAIG	MUFE	PIRCLE	RAFE
SNOM	HINSE	PAEP	SANF	STOON	SHILD
THEAT	BROSS	KLITE	PRAVE	LAIF	SLOTE
MAIVED	DEVITE				

Practice Materials Presented in Experiment 7(a).

PH	VC	NONWORDS	WORDS
LEEF	DEEF	GEEF	GAZE
SAIVE	VAIST	TAIVE	LIMP
YOOTH	TROCK	LOOTH	CANE
STEDY	OBTIN	STIDY	BEACH
DED	NER	DOD	ARMED
		DEET	SHORE
		RAIST	TRAIN
		SROCK	FRESH
		OBAIN	TRULY
		NUR	SMOKE
			HARDY
			PRIDE
			LOW
			PAY
			RED

PH = Pseudohomophone

VC = Visual Control

Mean Reaction Times (msec) and Error Rates to Each Word Presentedto Phoenician Style Readers in Experiment 7(b).

Materials and Item RT for "Phoenician" Readers

EX	RT	E	R-ex	RT	E
VASE	655	0	VENT	704	0
THREAT	722	0	THROAT	674	0
DOSE	676	1	DASE	720	1
LEVER	749	0	LEVEL	585	0
MONK	660	1	MIST	681	0
PINT	668	0	PILL	620	0
CLERK	642	1	CLICK	735	0
BEAR	812	2	BOAR	674	0
SIEVE	746	0	SURGE	811	0
BOWL	695	0	BELT	609	0
SWEAT	629	0	SWING	681	0
BROAD	676	0	BRIEF	815	0
ROUTE	765	1	RINSE	649	0
TOLL	704	1	TANK	704	0
MARINE	853	0	MARBLE	676	0
HOVER	710	1	HOBBY	825	1
DEMON	631	0	DELTA	788	0
FEVER	825	0	FOGGY	684	1
LAGER	614	1	LATIN	687	0
NAKED	749	0	NUTTY	795	2
HALVE	683	0	HITCH	660	1
BREAST	673	0	BREEZE	732	0
STEAK	799	0	STING	650	0

(continued)

Materials and Item RT for "Phoenician" Readers					
EX	RT	E	R-ex	RT	E
POUR	651	0	PIPE	694	0
SOUL	742	0	SEED	676	1
BREAK	838	4	BRAIN	658	0
GROSS	648	0	GRACE	689	0
GREAT	709	3	GREEN	654	0
SOOT	662	0	SEEP	885	4
TOUCH	662	0	TRUCK	754	1

EX= words that have unique or unusual pronunciations.

R-ex= words with regular pronunciations that were matched to EX words.

RT= Reaction Time.

E= Error Rate.

Mean Reaction Times (msec) to each of the Words Presented to Phoenician Style Readers in Experiment 7(b).

Materials and Item RT for "Phoenician" Readers					
MI	RT	E	R-mi	RT	E
HOOK	717	0	HIKE	869	0
WASP	619	1	WIPE	651	0
WEALTH	674	0	WITHER	728	3
HOOD	656	1	HEAL	748	0
WORM	687	0	WINK	723	0
PALM	676	0	PAIN	663	0
SWAP	773	1	SWIG	904	4
SQUAT	814	0	SQUID	817	3
BLOOD	652	0	BLOCK	861	0
FLOOD	648	0	FLOAT	646	0
WATCH	660	0	WHEEL	597	1
WARP	751	3	WEED	722	2
SHOE	671	0	SHED	788	3
EARN	703	0	EASE	673	2
HEAD	657	0	HELP	580	0
WART	741	3	WAIL	776	1
LOVE	710	0	LINK	656	0
SWALLOW	747	0	SWINDLE	770	1
ROOK	828	0	ROOT	765	0
WAND	657	0	WELD	949	2
BULL	657	0	BOIL	652	1
BUSH	633	2	BULB	699	0
DREAD	824	0	DREAM	573	2
SIGN	721	1	SIDE	675	1

(continued)

Materials and Item RT for "Phoenician" Readers

MI	RT	E	R-mi	RT	E
SWARM	709	0	SWISH	831	3
WORD	624	0	WILT	667	0
MONEY	669	0	MINOR	670	0
GLOVE	829	0	GLIDE	668	1
DOVE	656	0	DOPE	683	0
HEALTH	678	0	HAMMER	665	0

MI = words with regular pronunciations when examined according to some higher order rule or which have divergent but common pronunciations.

R-mi= regular words matched to words with MI pronunciations.

RT= Reaction Time.

E= Error Rate.

Mean Reaction Times (msec) and Error Rates to each of the WordsPresented to Chinese Style Readers in Experiment 7(b).

Materials and Item RT for "Chinese" Readers					
EX	RT	E	R-ex	RT	E
VASE	780	1	VENT	720	2
THREAT	734	0	THROAT	626	0
DOSE	870	0	DASE	761	0
LEVER	654	0	LEVEL	705	0
MONK	646	0	MIST	695	0
PINT	709	0	PILL	666	0
CLERK	702	0	CLICK	648	0
BEAR	845	2	BOAR	878	0
SIEVE	703	0	SURGE	788	1
BOWL	689	0	BELT	629	0
SWEAT	630	0	SWING	793	0
BROAD	775	0	BRIEF	616	0
ROUTE	943	2	RINSE	659	2
TOLL	762	1	TANK	655	0
MARINE	743	0	MARBLE	666	0
HOVER	724	0	HOBBY	715	0
DEMON	658	0	DELTA	925	3
FEVER	710	0	FOGGY	695	0
LAGER	734	0	LATIN	778	1
NAKED	765	0	NUTTY	838	2
HALVE	680	0	HITCH	654	1
BREAST	695	0	BREEZE	577	1
STEAK	716	1	STING	815	1

(continued)

Materials and Item RT for "Chinese" Readers					
EX	RT	E	R-ex	RT	E
POUR	659	0	PIPE	664	1
SOUL	670	0	SEED	801	0
BREAK	899	2	BRAIN	573	2
GROSS	616	0	GRACE	789	0
GREAT	772	2	GREEN	745	0
SOOT	640	0	SEEP	886	5
TOUCH	639	0	TRUCK	631	0

EX= words that have unique or unusual pronunciations.

R-ex= words with regular pronunciations that were matched to EX words.

RT= Reaction Time.

E= Error Rate.

Mean Reaction Times (msec) and Error Rate to each of the Words Presented to Chinese Style Readers in Experiment 7b.

Materials and Item RT for "Chinese" Readers

MI	RT	E	R-mi	RT	E
HOOK	604	1	HIKE	788	1
WASP	669	0	WIPE	719	1
WEALTH	799	1	WITHER	910	1
HOOD	662	0	HEAL	706	0
WORM	649	1	WINK	865	0
PALM	624	1	PAIN	579	0
SWAP	855	2	SWIG	941	6
SQUAT	829	2	SQUID	782	1
BLOOD	581	0	BLOCK	696	0
FLOOD	730	0	FLOAT	706	0
WATCH	718	0	WHEEL	620	1
WARP	753	1	WEED	714	1
SHOE	811	1	SHED	748	1
EARN	800	1	EASE	743	0
HEAD	608	1	HELP	597	0
WART	831	1	WAIL	900	1
LOVE	555	0	LINK	637	0
SWALLOW	728	1	SWINDLE	762	0
ROOK	808	0	ROOT	663	0
WAND	813	1	WELD	713	6
BULL	619	1	BOIL	707	0
BUSH	630	0	BULB	764	1
DREAD	736	1	DREAM	712	0
SIGN	659	0	SIDE	783	0

(continued)

MI	RT	E	R-mi	RT	E
SWARM	798	1	SWISH	740	4
WORD	669	1	WILT	985	4
MONEY	562	0	MINOR	758	0
GLOVE	586	1	GLIDE	817	0
DOVE	705	0	DOPE	754	1
HEALTH	697	0	HAMMER	706	0

MI = words with regular pronunciations when examined according to some higher order rule or which have divergent but common pronunciations.

R-mi= regular words matched to words with MI pronunciations.

RT= Reaction Time.

E= error Rate.

Nonword Set Presented in the Test of Spelling Regularity Presented in Experiment 7(b).

NONWORD SET					
TASE	HENT	VOOK	HOKE	PHREAT	THROAM
LASP	GIPE	DESE	KAZE	NEALTH	MITHER
MEVER	LEMEL	HOID	BEAL	MANK	NIST
WOMM	NINK	CINT	PELL	PELM	HAIN
CHERK	GLICK	SWUP	SWOG	BEAL	BLAR
SQUET	SHIG	KIEVE	SORGE	PLOOD	BLUCK
BOOL	ZELT	SLOOD	FLOIT	SWEAN	SWENG
NATCH	THEEL	TROAD	CRIEF	BARP	GEED
GOUTE	BINSE	SHOB	SHAD	WOLL	JANK
MARN	EASH	MARANE	MIRBLE	RART	RELP
HAVER	DOBBY	BOVE	WAIP	DELON	SELTA
SWILLOW	BINK	KEVER	LOGGY	DOOK	SWANDLE
LAPER	CATIN	DAND	NOOT	NASED	JUTTY
SUSH	BELD	PALVE	FITCH	RULL	MOIL
BREEST	DREEZE	SIRN	TULB	STEAB	STONG
SWARN	DREAP	PHUR	PUPE	WOID	JIDE
WOUL	SERD	MONEL	SWOSH	TREAK	BROIN
GLONE	WOLT	GRISS	GRICE	FOVE	KINOR
SOAT	FREEN	PEALTH	BLIDE	LOUCH	SEEB
DREED	FOPE	BREAT	TROCK	HEAN	PAMMER

Practice Trials Presented in the Test of Spelling Regularity.

IRREGULAR	REGULAR	NONWORDS
AISLE	SIEGE	DISLE
BISCUIT	BITTER	NISCUIT
CHUTE	THIMBLE	CHATE
SWORD	GLOBE	SWIRD
REGIME	GRILL	REGILE
GAUGE	VERB	PAUGE
ACRE	SLOT	ACRA
CAFE	PUPPET	LAFE
YOLK	PLUG	YOLT
PLAIT	FILM	PLOIT
		BIEGE
		BINTER
		SHIMBLE
		FLOBE
		GRULL
		VARB
		SLET
		RUPPET
		FLUG
		SILM

APPENDIX IV

STIMULUS MATERIALS FOR EXPERIMENT 8.

Mean Reaction Times (msec) and Error Rates to each of the Low-Frequency Words Presented in Experiment 8.

L. F. HOMOPHONES			L.F. CONTROL WORDS		
	RT	E		RT	E
ALOUD	628	0	ALOOF	697	4
ALTAR	695	3	ASSET	674	1
BEECH	693	1	GUISE	783	12
BOARDER	700	3	BORDEAU	932	13
SELLER	623	3	SENTRY	786	6
KERNEL	840	3	KENNEL	642	5
URN	735	7	VOW	738	8
FLOUR	564	1	FRAIL	723	5
GUESSED	590	0	SMASHED	597	1
HARE	656	3	HARP	639	1
HIRE	630	0	PITY	601	0
LONE	612	2	SANE	731	3
MANOR	590	0	OLIVE	587	1
PACT	718	1	PULP	706	5
PAWS	673	2	RATS	604	4
SALE	558	3	SILK	576	0
SEAM	593	2	SLAB	625	1
SIGHED	703	1	YELLED	661	0
STEAL	654	2	TREAD	627	3
SUITE	681	2	SHIRT	663	1
TIDE	571	1	STITE	597	2
WAIST	638	0	GRIEF	609	1
WEAK	553	1	CURT	741	11
WHINE	706	5	WHARF	801	7

(continued)

L. F. HOMOPHONES			L.F. CONTROL WORDS		
	RT	E		RT	E
HAUL	697	0	MINK	663	3
HEAR	609	0	FIRE	539	1
HERD	712	3	HIDE	528	0
HYME	875	18	MASK	548	0
LEASED	678	3	CRAVED	701	0
SUM	688	5	FUN	570	0
THRONE	602	5	KITTEN	616	0
MAID	567	1	HORN	567	0
SHORE	646	1	SCALE	535	2
HOUR	566	2	FOOD	525	0
SCENE	600	0	DRIVE	578	0
SEA	569	2	ARM	587	0
SIGHS	697	5	SLAPS	636	3
TAUT	759	9	VOID	650	4
WITCH	622	3	TWEED	633	2
WOOD	559	1	CROSS	613	1
HOARSE	738	7	CRUNCH	649	0
NUN	682	1	OWL	606	1
BLEW	667	5	SPED	669	12
ATE	579	1	DUG	767	4
KNIGHT	560	0	PRIEST	635	2
THREW	595	4	SWUNG	707	9
WRITE	600	0	SHARE	665	3
RODE	661	6	CAST	662	1

(continued)

L. F. HOMOPHONES			L.F. CONTROL WORDS		
DEER	596	0	HULL	552	2
GILT	641	6	SUNK	723	2
FEAT	664	3	GOAT	540	0
GRONE	682	0	GRAZE	629	0
REIGN	671	3	PLANK	652	1
PEAR	677	1	ROBE	693	1
CHUTE	654	3	VALVE	647	2
WEIGH	636	2	BROOK	635	1
SOLE	650	3	POLE	632	3
SCENT	647	2	SIEGE	577	2
GRATE	678	1	GRAPE	603	0

RT = Reaction Time

E = Error Rate

L. F. HOMOPHONES = Low-frequency Homophones

L. F. CONTROL WORDS = Low-frequency Control Words

High-Frequency Words Presented in Experiment 8.

H.F. HOM	H.F. WORDS	H.F. HOM	H.F. WORDS
ALLOWED	PROPOSED	SOME	THEY
ALTER	BOOST	THROWN	SHARED
BEACH	COAST	MADE	SAID
BORDER	ATTAIN	SHORE	GREEK
CELLAR	LEGEND	OUR	WHO
COLONEL	CHICKEN	SEEN	GAVE
EARN	FLAG	SEE	GET
FLOWER	FARMER	SIZE	DEAL
GUEST	JOINT	TAUGHT	ROLLED
HAIR	FALL	WHICH	FIRST
HIGHER	SINGLE	WOULD	COULD
LOAN	SALT	HORSE	GREEN
MANNER	DEGREE	NONE	WIDE
PACKED	LACKED	BLUE	FINE
PAUSE	CRACK	EIGHT	REACH
SALE	PATH	NIGHT	POINT
SEEM	TURN	THROUGH	STRANGE
SIDE	ROOM	RIGHT	MIGHT
STEEL	SHEET	ROAD	MEAN
SWEET	QUICK	DEAR	HUGE
TIED	CALM	GUILT	GRAVE
WASTE	YIELD	FEET	HELD
WEEK	HALF	GROWN	SAVED
WINE	HILL	RAIN	FOOT

(continued)

H.F. HOM	H.F. WORDS	H.F. HOM	H.F. WORDS
HALL	TALK	PAIR	SICK
HERE	LONG	SHOOT	RANCH
HEARD	KNOWN	WAY	MAN
HIM	HER	SOUL	RING
LEAST	GIVEN	SENT	PAID
GREAT	STATE		

H. F. HOM = High-Frequency Homophones.

H. F. Words = High- Frequency Words .

Nonword Set Presented in Experiment 8.

CEST	BUKE	DREE	FEVE	NUCK	TINK
FUTE	THALK	NER	GAND	RESORDS	THELL
PLENT	SOUNTRY	STRIN	PESH	SLOSER	GREE
TING	THOT	SWOME	SMAL	MOIOD	MUGHT
FECT	THAS	SHOME	COLM	FRUM	DEKIDE
ONKE	SOST	HOIME	ALUNG	LOAK	DOINE
SUCIAL	LOICAL	BROAN	LAIND	SIUND	FUTERE
KEIPT	WROITE	COIMING	SPECIL	ACTULLY	INSREASE
GOAF	SERL	PLEN	SUDAY	LUNGTH	SURCE
TREAL	THRAE	WRETE	HEUL	KENG	STAP
PRASS	SOPPLY	CLIM	LAVELS	DUCTOR	DAINCE
SLEM	CHEICK	COLLS	TWECE	GRAW	CULUMN
CLIMS	ABROED	COPLE	LOISE	KIUL	SCURE
DEZEN	SORNDS	LENG	TERL	LUCAL	PLEN
FEREIGN	HUTEL	BROD	JENIOR	COMMIND	STITE
VEWRY	GREND	CHULD	PEMS	MUNOR	AFRID
PENK	POAT	CHOST	CLESS	GREM	SOEM
SLABE	TWOE	NURTH	DOY	SHOAK	TREP
SKEN	JUB	SPUT	ADMET	ASEA	HEWP
CAISH	VEEN	ZURO	VARI	DAUSH	GLAE

Practice Materials Presented in Experiment 8.

PH	VC	NONWORDS	WORDS
LEEF	DEEF	GEEF	GAZE
SAIVE	VAIST	TAIVE	LIMP
YOOTH	TROCK	LOOTH	CANE
STEDY	OBTIN	STIDY	BEACH
DED	NER	DOD	ARMED
		DEET	SHORE
		RAIST	TRAIN
		SROCK	FRESH
		OBAIN	TRULY
		NUR	SMOKE
			HARDY
			PRIDE
			LOW
			PAY
			RED

PH = Pseudohomophone

VC = Visual Control

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