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PHONOLOGICAL CODES IN ADVANCED SECOND LANGUAGE READING OF ENGLISH

By

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ABSTRACT

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In first language reading, there is considerable evidence that representations of phonological information for words (known as phonological codes) contribute significantly to word recognition and subsequent processing. In second language reading, there has been scant research on the role of phonological codes and there have been suggestions that they play a minimal role. This study attempts to investigate whether phonological codes contribute to second language reading and if so, whether there are implications of the second language reader's non-native phonological system. Subjects were native Thai, advanced second language readers of English. A comparison group of native English readers was also included. In the first task, subjects judged whether stimuli were correct exemplars of a category (e.g., an animal). The native Thai subjects made more errors to homophone foils (e.g., bare) in comparison to yoked orthographic control foils (e.g., belt) demonstrating that phonological codes contribute to the activation of semantic codes in word comprehension. In the second task, subjects judged whether sentences were sensible. The native Thai subjects made more errors to anomalous sentences containing homophone foils (e.g., He

guest who she was.) than to sentences containing yoked orthographic control foils (e.g., He gushed who she was.) demonstrating that phonological codes contribute to sentence comprehension.

Next, the study investigated whether phonological codes in second language reading may contain neutralizations of English phonemic distinctions. The first task included interlanguage (IL) homophone foils (e.g., code) and IL pseudohomophone foils (e.g., skird) which may sound like correct exemplars of the category (e.g., clothing) following the application of a common native Thai interlanguage devoicing rule for final stop consonants in English. The native Thai subjects made more errors to IL homophones in comparison to yoked orthographic control foils demonstrating that phonemic neutralizations affect word comprehension processes. In the second task, errors to sentences containing IL homophones (e.g., She hid me on my nose.) were elevated but not significantly different from orthographic controls after adjusting for spelling knowledge.

Finally, the study investigated whether phonemic neutralizations may result in increased processing times in word, sentence and passage reading. Response times to IL homophone category exemplars were higher than to controls. Reading times to a passage laden with IL homophones were higher than to a control passage.

Dedicated to

Mom and Dad,

who have supported me always,

my wonderful husband, Roger,

and my precious daughter, Stephanie.

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CHAPTER I

INTRODUCTION

In first language reading (FLR) research and theory, there is widespread agreement that skillful, text-driven lower level processes are the crucial foundation of skillful reading. Poor reading is strongly associated with deficiencies in lower level reading processes, which, in turn, are highly associated with deficiencies in phonological knowledge and awareness. This is not surprising in light of the widespread and crucial role phonology appears to have in skillful reading. Despite a history of considerable controversy, there is a growing body of research demonstrating that representations of phonological information for words, referred to as phonological codes, play a significant role early on in word recognition processes including the activation of semantic codes for words. In addition, phonological codes are widely believed to facilitate subsequent processing probably by providing a more stable means of maintaining information in working memory during higher level processes such as text integration. Thus, the role of phonology, particularly in lower level processes, has been a major focus of research on FLR.

In contrast, there has been very little research on lower level processes in reading in a second or subsequent language. The importance of these processes has often been minimized because of an emphasis on the role of top-down or knowledge-driven processes among researchers and practitioners in second language reading (SLR). Furthermore, some researchers have suggested that second language readers make limited use of phonological codes. However, there is very little research that addresses this issue, and among the limited studies that do, none are able to directly address the question of whether phonological codes play a role in the activation of semantic codes in early word recognition processes. The first purpose of this study, therefore, is to investigate whether phonological codes contribute to semantic activation in word reading among proficient readers of English as a second language as has been demonstrated among first language readers of English. A lexical semantic categorization task is employed to address this question. The second question addressed by this research is whether SLR is similar to FLR in that phonological codes are employed in sentence reading. A sentence judgment task is chosen to address this question. Both of these experimental tasks have been utilized to demonstrate substantial evidence of phonological coding in FLR.

If phonological codes play an important role in SLR, then the nature of the second language reader's phonological system becomes relevant to SLR. For instance, deficiencies in the second language learner's knowledge of second language phonemic categories may result in the neutralization of some phonemic distinctions in the second language. If phonological codes employed in SLR reflect such neutralizations, they would be expected to relate to orthographic codes with less specificity.

The third question addressed in this study, then, is whether SLR deviates from FLR as a result of deviations in the phonological system of SL readers. To address this question, an additional set of stimuli containing potentially troublesome phonemic distinctions is included in both the word and sentence tasks referred to above.

Given that deficiencies in phonological knowledge are highly associated with poor first language reading, there may be similar negative implications of the second language reader's deficient phonological knowledge. Thus, the final question addressed in this research is whether deficiencies in phonemic categorical knowledge are associated with decreased comprehension or speed in SLR processes dependent on phonological codes. Reading speed and comprehension for words, sentences and a passage containing potentially neutralized phonemic distinctions are compared with matched controls.

LITERATURE REVIEW

READING

Reading is one of the most avidly studied of all human socio-psycholinguistic activities. Psychologist, Edmund Huey (1968/1908), a pioneer in the modern study of reading wrote:

> And so to completely analyze what we do when we read would almost be the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind, as well as to unravel the tangled story of the most remarkable specific performance

that civilization has learned in all its history (p. 6).

Not only is the study of reading of great interest theoretically, but there are important practical reasons for studying reading as well. Reading is one of the most fundamental and crucial skills required for participation in many societies today. Yet, it is not as readily or broadly acquired as oral language is. Instruction may facilitate the acquisition of reading, but does not guarantee it and often is blamed for failures. Thus, reading is the ongoing focus of extensive research as attested to by the vast number of articles, journals and texts dedicated to the topic. The impressive collection of review articles in the Handbook of Reading Research (Volume 2) (Barr, Kamil, Mosenthal & Pearson, 1991) offers an overview of the wide range of topics currently the focus of reading research in a number of different disciplines.

Reading in a second language

Despite the high number of individuals who read in a second or subsequent language (SL)[1], the vast majority of reading research has been conducted on monolingual or first language reading (FLR) (Weber, 1991). However, second (or subsequent) language reading (SLR) is drawing increasingly more attention for good reason. Understanding SLR deepens our understanding of second language acquisition (SLA). SLA may be

[1]SL refers to a non-native language with no distinction intended between foreign and second language in this document unless specified.

particularly dependent on and shaped by reading because much of the available input for SLA in foreign environments is in the written form. Moreover, SLA is often observed through the window of reading in such experimental tasks as grammaticality judgments used to infer competence. The study of SLR also deepens our understanding of reading in general. The study of SLR presents the unique opportunity to study such things as reading in different languages and scripts and with different linguistic and reading abilities all within the same individual. Unlike FL readers, SL readers generally undertake the complex process of reading in the SL with nonnative competence in the SL and often have sophisticated metalinguistic knowledge and experience in reading one or more other linguistic and orthographic systems. Such facets of SLR pose a number of interesting research questions regarding their impact on reading and reading development. Ultimately, a complete theory of reading must be able to account for SLR.

SLR research is also motivated by practical considerations. Proficiency in reading in a SL is an important goal for many individuals. For many individuals, it is the only way to access valuable information which is not available to them in the literature of their first language. Moreover, since access to education, employment and other social privileges is often limited to those who are literate, the personal welfare and productiveness of many SL users depends on their ability to read in the SL. Unfortunately, many people do not attain the level of success in

SLR that they attain in FLR (Hatch, 1974; Segalowitz, 1986; Weber, 1991). Children learning to read in a SL have been found to lag behind those learning to read in their FL (Collier, 1987; Verhoeven, 1990). Older readers with FLR experience have also been observed to have considerable difficulties in SLR, sometimes persisting even when they have attained advanced levels of proficiency in other SL skills (Cohen, Glasman, Rosenbaum-Cohen, Ferrara & Fine, 1988; Favreau & Segalowitz, 1983; Haynes & Carr, 1990; Segalowitz, Poulsen & Komoda, 1991). Thus, SLR research is needed to better understand and address the problem of SLR.

VISUAL WORD RECOGNITION

Definitions

The complexity of reading resists any attempt to define it. In fact, reading is a cover term for a broad variety of complex interactions between readers, texts and social contexts. Some researchers point out that to understand reading, requires understanding it without detaching it from this complex picture (Weaver, 1988). Be that as it may, progress is apparently made by limiting the focus of a particular research program to a narrow portion of the event. The narrow approach adopted here focuses on reading as an information processing event in which input mental representations of information from texts and individuals are constructed and acted upon by processes resulting in some output such as comprehension. Within this approach, it is customary to divide reading into subcomponent processes to facilitate research and theory construction (Carr & Levy, 1990). Rayner and Pollatsek (1989) have noted that "the greatest advances in understanding reading will come through researchers working on each subcomponent process" (pp. 478-79). In keeping with this view, it is hoped that the narrow focus here may provide insights that can eventually contribute to a better understanding of a much larger understanding of reading.

The subcomponent processes of reading are broadly classified under two levels: higher and lower. Higher level processes have mainly to do with the integration of textual information and prior knowledge to build a representation of the whole text. Lower level processes have mainly to do with the perception of small individual units of the text or what is commonly called visual word recognition (WR).[2]

Some researchers have referred to the WR level of processing as *decoding*. However, this construct has come to be associated with different specific subprocesses in different models of reading. For instance, *decoding* has often been understood to mean the translation of graphic codes to phonological codes because this translation is the essential foundation of reading in some models. However, it is nonessential in others. Thus, some researchers have redefined the term in keeping with their model of reading. Goodman (1971) called

[2]WR in this document refers to visual WR in reading.

phonological translation *recoding* and defined *decoding* as the translation from graphic to semantic code. Thus, the term WR is preferred in this document because it does not refer to a specific type of code translation. Instead WR is the functional component of reading wherein written words are perceived, associated with internal representations and assigned information from memory according to the goals and processing demands in a particular reading event. The actual subprocesses and codes that are implicated in WR may vary. Subprocesses in which one type of abstract, mental representation or code is derived from another will be termed transcoding.

WR begins in the retina with the detection of visual signals for printed words. These signals are further organized in the visual cortex resulting in visual codes. This initial stage of WR is closely related to research in general visual perception and is not addressed here. The aspect of WR that is central to this research begins with visual codes and considers how they must be processed or transcoded if at all in order to activate relevant phonological, semantic and syntactic information stored in long term memory. This information then becomes available to ongoing higher level reading processes in which smaller units of text are syntactically parsed, encoded in propositions and integrated with the reader's growing representation of the text. This definition of WR is necessarily sketchy, since actual models of WR vary extensively and fundamentally.

Words are assumed to be discrete patterns of symbols in texts which represent one or more basic units of meaningful language. Words are linguistic symbols for concepts, ideas, entities and attributes. Readers may generate mental codes which represent visual, orthographic or phonological information associated with printed words. These codes may map on to stored mental representations of the properties that define words and the rules that constrain their use. Traditionally a reader's word-specific stored representations are collectively referred to as the *lexicon*. The mental lexicon is often roughly envisioned via a metaphor such as a library or dictionary (Aitchison, 1987).[3] Each word known by the reader is thought to have a relatively stable corresponding entry located in the mental lexicon. Each entry contains word specific representations of such information as word meanings, syntactic word class and phonological information. These representations may be composed of minimal basic units of language and thought.

A number of different classes of representations or codes are referred to in this work. Their precise nature is beyond the scope of this work. In brief, graphic codes are representations of the unique visual patterns formed by the graphic symbols that comprise a word. Orthographic codes are representations of the structural attributes of words within a particular orthography. They may be composed of abstract representations of word components such as graphemes and the rules that constrain their spatial ordering. Phonological codes are representations of the sounds of

3 This metaphor has been challenged in subsymbolic models (e.g., Besner, 1990; Seidenberg, 1990).

words. These could be articulatory or auditory codes, but are most often considered to be more abstract representations composed of abstract codes for basic discrete units of sound which cannot be generated by phonological rules. Semantic codes are representations of the meanings of words. Syntactic codes are abstract representations that define the functional and formal properties of words by setting constraints for the use and order of words. Presentation of a written word to a reader can result in the activation of one or more of these internal mental codes. When a code is activated, it becomes available to current processing perhaps because excitation levels rise above some threshold that separates inactive codes from active codes.

Theoretical frameworks

The central focus of the models discussed in this research is the process or processes by which orthographic codes lead to the activation of semantic codes. Models of WR vary in the nature of these codes and how they relate to one another; how the various subcomponents of reading develop, interact and vary according to the task demands and what the architecture of cognition is in which all of this is set (e.g., see Jacobs & Grainger, 1994). In the symbolic paradigm, models generally employ relatively stable, discrete codes and rules which are responsible for translating from one code to another. In contrast, in the subsymbolic paradigm, only the learning algorithm and the system of nodes, connections and weights which map inputs to outputs need be described. Information storage is distributed across a pattern of connections and weights rather than located in specific nodes, so there is no lexicon in the traditional sense within the symbolic paradigm (e.g., Seidenberg & McClelland, 1989).

Research

A wide variety of research techniques have been used to draw inferences about the nature of WR. One of the earliest and most widely used is the lexical decision task in which subjects view a list of printed stimuli and decide whether each is a word or not. Other tasks include ones in which subjects recognize letters within words, read words out loud, recall word lists, assign words to a semantic category, judge semantic sensibility of word strings, and identify spelling errors. The target stimulus words are manipulated according to such features as orthography, phonology, frequency, spelling regularity and legality. The exposure time, clarity and appearance of stimuli may be varied as well as the timing and presence of additional stimuli like primes or masks. Subjects may be selected for different qualities such as reading ability or age. Generally, the dependent variables are the response latency times and correctness. These various tasks and manipulations of them afford researchers many possible means of elucidating some of the intricacies of the processes entailed in WR. However, it is clear that minor variations in reading tasks can have a substantial and often underestimated impact on WR (Hummel, 1993). There is a danger in extrapolating observations and interpretations from a particular experiment to other types of reading events since they may be specific to the experimental task. Thus, tasks must be chosen carefully for the specific research question, and results must be interpreted within the context of the task that produced them. Models of WR should be informed by a variety of tasks including less intrusive empirical observations of such things as oral reading errors or miscues, eye movements, and recall protocols. However, these latter methods in themselves are inadequate indicators of WR since they implicate other component processes in addition to WR.

PHONOLOGY IN READING

It has been said that "the relationship between speech and reading is the single dominant theoretical issue in the psychology of reading" (Crowder & Wagner, 1992, p. 157). More than a mere theoretical concern, intense ongoing debate over this relationship has played a major and fundamental role in reading pedagogy and policy. Much of the debate focuses on the extent to which speech, or representations of the sounds of language, are implicated in low level WR processes.

Informal evidence

From informal and introspective evidence alone, it seems that the sounds of words are somehow implicated in reading, possibly at the level of WR. Children are often taught to recognize an unfamiliar printed word by first attempting to make its approximate sound based on symbol-to-sound rules. Beginning readers often read aloud. As reading skill improves, this overt behavior diminishes, but even skilled readers may still read aloud when the text is complex or they wish to remember it. Skilled readers also commonly experience what seems to be internal speech or subvocalization to various extents during reading. Huey (1908/1968) concluded that "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 people, as they ordinarily and actually read" (pp.117-18). However, much evidence has been put forward against notions that this "inner speech" must entail the use of some articulatory and auditory mechanism. These mechanisms can be suppressed without interfering with reading and they arguably require too much time (McCusker, Hillinger & Bias, 1981). Furthermore, Hansen and Fowler (1987) have also shown that profoundly prelingually deaf readers may use phonologic codes which are unlikely to be auditorily based. The speech sounds that are generally thought to be implicated in reading, are likely to be more abstract representations of sounds.

Linguistic evidence

There are also strong theoretical motivations for considering phonological codes to be implicated in WR. A longstanding question is whether written language can relate to meaning directly or only via a phonological code. Phonological transcoding is theoretically favored for two strong reasons: it offers a rule governed explanation of WR and it recognizes the primacy of phonological codes in linguistic theory. Chomsky (1959) criticized Skinner's (1957) explanation of language as resulting from discrete, modifiable links between stimulus-response pairs. Chomsky argued that classes of predictable linguistic behavior can be generated by the application of discrete rules. Like many psycholinguistic behaviors, WR also exhibits classes of regular behavior based on the speech sounds associated with printed words. For example, if asked to read aloud an isolated novel word like *mave*, readers of English will almost without exception pronounce the word so as to rhyme with the words *cave* and *shave* but not with the irregularly pronounced but similarly spelled, high frequency word, *have*. Such regularity may be described by a rule relating configurations of letters to sounds. Venezky (1970) and M. Coltheart (1978) have argued that the relationship between the majority of English words and their phonemic representations can be described by a set of grapheme-phoneme correspondence (GPC) rules. (Graphemes are abstract representations of one or more letters). Thus, it may be theoretically parsimonious to hypothesize that WR occurs via rule governed transcoding from orthographic to phonological codes. Explaining WR as a result of a discrete association between each word and its corresponding information in memory resorts to case by case explanation of WR as Van Orden, Pennington & Stone (1990) have argued.

Secondly, phonological codes are primary to language. Chomsky (1970) describes language as a rule governed association between sounds and meaning. Modern orthographic systems are developed based on oral language and to a varying extent encode the sounds of oral language. Moreover, individuals almost always learn to read subsequent to learning to *aud,* that is to comprehend oral language. From a linguistic perspective, learning to read is traditionally identified as learning to associate a new visual signal modality to language already associated with a phonological signal. In a very rough first approximation of this relationship, Fries (1962) noted:

> The process of learning to read in one's native language is the process of transfer from the auditory signs for language signals, which the child has already learned, to the new visual signs for the same signals. This process of transfer is not the learning of the language code or of a new language code; it is not the learning of a new or different set of language signals. It is not the learning of new "words," or of new grammatical structures, or of new meanings. These are all matters of the language signals which he has on the whole already learned (p. 120).

Perfetti (1988) agrees with the basic premise that "in principle, the comprehension of written language follows from the ability to understand spoken language plus the ability to identify written words" (p. 114).

Indeed, for the sake of cognitive efficiency and theoretical parsimony, written language comprehension can be expected to be based on speech comprehension. This suggests that WR could entail transcoding orthographic codes into speech based codes which are then understood via processes common to aural comprehension.

This rudimentary view of reading of course fails in at least two ways. First, it is not the case that one only reads language that one has previously acquired through listening. This grossly overlooks the contribution of reading to language acquisition.[4] It is also clear that written text cannot possibly be viewed as "speech made visual." Written and spoken language have many distinct features arising at least from differences in the physical signal and the social rules governing the relationship between message sender and receiver. These differences give reason to question how feasible it is for lower level reading processes to be viewed as merely some peripheral modality translation system appended to listening.

Furthermore, linking the two signal modalities to a common abstract phonological code comprised of segments such as phonemes, is not a straightforward matter. Written languages like English, are only abstractly related to sound. Many irregularities bewilder attempts to

---

[4]To the extent that written texts provides new language input, reading must contribute to pragmatic, semantic, lexical and syntactic acquisition. In addition, there is considerable evidence that the difference in modality contributes to metalinguistic awareness and linguistic processing. For example, use and awareness of the phoneme as a processing unit may be developed by learning to read an alphabetic script.

construct a set of adequate grapheme-phoneme correspondence rules to describe this mapping. For example, English contains words like *one*, *two* or *shoe* whose phonological encodings are irregular compared to normative generalities and some words contain series of letters that have no normative generality like *ough* in *rough, dough, bought, drought* (Carr & Pollatsek, 1985). Furthermore, in English, printed words specify their corresponding lexical entry with considerable accuracy and stability. There are quite a few words that are distinguished in writing but homophonic in speech (i.e. *know* and *no*). Once phonologically transcoded, they lose this distinction.

The relationship between speech and abstract phonological codes is not straightforward either. There is extensive variation in segment realization across and within speakers, different word environments and different situational variables. Speech processes of inter- and intra-word neutralization and deletion result in surface forms whose phonetic representations are not readily related to abstract phonological codes (Frauenfelder & Lahiri, 1989). It is difficult to encode the speech wave form into a code composed of a series of segments such as phonemes that would match an orthographic code assembled from the string of letters comprising the printed word. In addition, if this encoding is conducted prior to matching with codes stored in the mental lexicon, much of the distinguishing information contained in the speech wave form will be discarded and ambiguity is further elevated.

Chomsky (1970) attempted to bring speech and text perception together by relating both to a common underlying phonological representation made up of abstract segments (but not phonemes). These segments represent the information not predictable by phonological or syntactic rules which determine the surface structure (Chomsky and Halle, 1968). Chomsky (1970) argued that English orthography represents words so closely to these abstract series of phonological segments that nothing like grapheme-phoneme correspondence rules are needed to relate orthographic codes to these codes. However, all codes comprised of a series of segments have difficulty adequately accounting for both speech and text perception because of such problems as those discussed above. To recognize spoken words, some speech perception models employ multiple possible representations of words or rely on more abstract lexical codes which are recoded prior to matching with input speech codes (see Klatt, 1989 for a review). Some phonological theories employ multi-level representations in which different levels separately condition distinct phonological processes (Frauenfelder and Lahiri, 1989). If the structure of the phonological codes shared by both speech and text recognition processes are too abstract from their phonemic representation, it becomes difficult to say whether they are phonological codes at all and thus it is unclear whether visual word recognition involves word sounds or not.

Some models of WR do draw upon models of speech perception to suggest potential ways in which phonological information or processes could become available to visual WR processes. In the symbolic paradigm, Coltheart, Avons, Masterson & Laxon's (1991) model of visual word recognition explicitly shows connections to speech recognition and production. This model indicates possible pathways for speech based codes to become activated and participate in visual word recognition. Other models within the subsymbolic (connectionist) paradigm aim to explain both oral and orthographic language perception and possibly production (e.g., Seidenberg, 1989). Interaction arises as an inherent result of the design of the network of interconnected units. Thus, despite the difficulty of defining a specific mechanism that relates print to sound, there remains strong linguistic motivation for incorporating this relationship into models of WR.

Empirical evidence

There is a large body of empirical evidence indicating that phonological codes are implicated in reading single words (e.g., see McCusker, Hillinger & Bias, 1981; Van Orden et. al., 1990 for reviews) and sentences and texts (e.g., Coltheart et. al., 1991; Coltheart, Laxon, Rickard & Elton, 1988; Davidson, 1986; Doctor, 1978; Treiman, Freyd & Baron, 1983). Readers fail to reject semantically incorrect sentences containing homophones that are orthographically incorrect, but sound correct (i.e. Tie the not) (e.g., Coltheart et. al., 1991; Coltheart et. al., 1988). Readers fail to correct homophonic errors more often than orthographic errors in proofreading experiments (e.g., VanOrden, 1991). Concurrent articulation, an experimental means of purportedly occupying phonological memory so that it is unavailable for simultaneous reading tasks, has a significant negative effect on text comprehension which cannot be explained by the task demands alone (e.g., Besner, Davies & Daniels, 1981; see McCusker et. al., 1981 for a review of others). Comprehension is decreased when phonological information is made unavailable by using an unfamiliar script or by using words that are unpronounceable to readers (e.g., Cunningham & Cunningham, 1978; Koda, 1990). Silent reading times for sentences with repeated word-initial phonemes (tongue-twisters) are slower than for semantically controlled normal sentences (e.g., McCutchen & Perfetti, 1982; McCutchen, Bell, Fance & Perfetti, 1991). Most of this evidence pertains to reading in alphabetic languages, mainly English. However, even in logographic languages, the tongue-twister effect in text reading and phonological based confusions in memory tasks have been found (Lam, Perfetti & Bell, 1991; Perfetti & Zhang, 1991; Tzeng, Hung & Wang, 1977; Zhang & Perfetti, 1993). This substantial body of evidence rules out the possibility that phonological codes are not employed in reading. Although the task demands may certainly influence the extent to which phonological codes are implicated, these studies demonstrate that phonological codes are definitely employed in reading processes.

Phonology in higher level reading processes

Phonological codes may be implicated in reading because they may provide buffer storage for words during higher level processing (Baddeley & Lewis, 1981; Conrad, 1972; Perfetti, 1985; 1988; Van Dijk & Kintsch, 1983). Once semantic codes for words are activated, they are prone to memory loss. The relatively greater stability of phonological codes enables them to persist longer in short term memory and thus serve higher level comprehension processes like text integration. This is vital to efficient reading comprehension because indeterminacy in basic codes for words can be encoded into semantic propositions which are then integrated perhaps incorrectly with other propositions and finally used in the construction of a faulty model of the text. Thus, an unstable or indeterminate code may have an increasingly broad negative impact as processing moves to higher levels. The stability afforded by phonological codes may be a useful means of averting such costly errors particularly as reading tasks require more time and resources. Thus, there is almost universal agreement that phonological codes play a critical role in these higher level reading processes.

Phonology in lower level reading processes

However, the types of studies cited above do not clarify whether phonology also plays a significant role in lower level WR processes, in particular, in the activation of semantic codes for words. Figure 1.1

depicts a rudimentary model of how phonological codes may be entailed in reading processes.

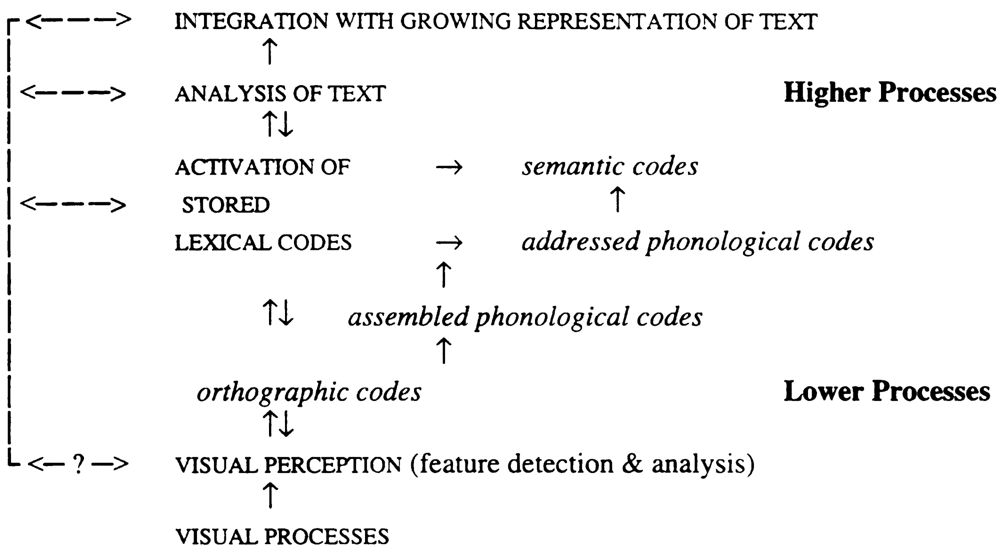

Figure 1.1 The role of phonology in reading processing

Much debate has centered around whether phonological codes mediate the access of entries for words in the lexicon. In a landmark study, Rubenstein, Lewis & Rubenstein (1971) found that phonological variables of words and pseudowords (pronounceability and homophony) significantly affected decision latencies in a lexical decision task. They concluded that visual codes generated from printed words are always recoded into phonological representations which are used to search the lexicon for a match. A number of models therefore incorporated obligatory phonological mediation (e.g., Gough, 1972).

These phonological codes were generally thought to be generated via some rule governed relationship between letters-to-sound, or grapheme-phoneme correspondence (GPC) rules (M. Coltheart, 1978). However, without some significant modifications, GPC rules prove inadequate in themselves to account for the reading of all English words. They do not produce the correct pronunciation for irregularly spelled words like *one* and *two*. Moreover, the application of such rules does not predict for observed consistency effects: that is the increase in naming times for GPC regular words like *cave* which have one or more similarly spelled, but different sounding neighbors like *have* in comparison to words like *cake* which have only similar sounding neighbors like *make* (Glushko, 1979). In addition, deep orthographies in which the relationship between sound and orthography is obscure, such as the unvowelized form of Hebrew or logographs like Chinese appear to demonstrate that semantic codes may be accessed without assembled phonological mediation. In logographs it is argued that there is no apparent means of assembling a word's phonological code based on graphic subfeatures. Even Chinese radicals (distinct parts of characters, some of which represent the sound of the word) are themselves logographs (although see Wydell, Patterson & Humphreys, 1993). In addition, impairment of phonological processing does not appear to prevent reading as evidenced by the class of aphasias known as acquired phonological dyslexia--brain damage induced selective impairment in previously literate readers to the ability to read aloud nonwords but not words (Beauvois & Derouesene, 1979; Funnell, 1983).

The additional fact that many studies have failed to find evidence of phonological mediation has also been used as evidence against phonological mediation (for a review see McCusker et. al., 1981). Such arguments lead some researchers to conclude that semantic codes for words are directly activated on the basis of visual codes without phonological mediation (e.g. Baron, 1973; Bower, 1970; Smith, 1971).

Whether semantic codes are activated directly on the basis of visual codes or via phonological mediation is difficult to determine. The failure to demonstrate evidence of phonological mediation in all cases does not rule out the possibility of it. Similarly, the ability to demonstrate phonological effects in a particular task, does not prove that phonology plays a role in other tasks. In fact, small modifications in experimental design may determine whether phonological effects are observed or not (Bower, 1970; McCusker et. al., 1981). For instance, Davelaar, Coltheart, Besner & Jonasson (1978) found the same effect that Rubenstein et. al. (1971) found when they used the same type of stimuli, but the effect disappeared when they included pseudohomophones (nonwords that sound like real words) in the stimulus set. McCusker et. al. (1981) reviewed numerous such studies and concluded:

> we found them about equally divided between those showing that word recognition is subject to the influences of phonology and those showing that word recognition occurs without any apparent involvement of phonology. Indeed, we found a good deal of evidence that subjects possess the capability of using both phonological recoding and visual mediation as routes from print to meaning and that they have a fair amount of flexibility in determining when they will use

one or the other (p. 241).

Not only task variables, but also differences in theory can justify entirely different interpretations of results: either implicating phonological mediation or not. For instance, Seidenberg & McClelland (1989) and Van Orden et. al. (1990) have offered opposite interpretations of some of the same results and arguments previously held as evidence against phonological mediation.

Dual route models

One possible means of resolution is to allow for the option of either indirect, phonologically mediated or direct, non-phonological activation of semantic codes. These *parallel coding system* models (Carr & Pollatsek, 1985) including *dual-route* models contain two independent processes or routes which operate in parallel (Carr and Pollatsek, 1985; Coltheart, 1978; Coltheart, Curtis, Atkins & Haller, 1993; Humphreys & Evett, 1985; McCusker et. al., 1981; Paap & Noel, 1991; Van Orden et. al., 1990). A general schematic of dual-route models is presented in figure 1.2. In the direct or orthographic route, orthographic codes are mapped directly on to their corresponding semantic codes in the lexicon. In the indirect or phonological route, orthographic codes are transcoded into phonological codes which are then mapped on to their corresponding semantic codes in the lexicon. Which of the two routes determines semantic code activation in a particular instance of word recognition depends on which route is amenable to the specific characteristics of the input word as well as inherent features of the processing system. For instance, if phonological transcoding is carried out via GPC rules, phonological codes can only be accurately generated for regularly spelled words. Thus, regular words might be processed by the indirect route, whereas, irregular words could only use the direct route. If the direct route is faster and the mechanism for selecting among multiple candidate activations arriving from the two routes is dependent on their relative speed, the direct route may also lead to semantic code activation for even highly regular words if they are highly familiar . Thus, the choice of routes could depend upon word familiarity and spelling regularity and the transcoding and selection mechanisms.

FEATURE DETECTION (GRAPHIC CODES) → ORTHOGRAPHIC CODES → SEMANTIC CODES   DIRECT ROUTE

ORTHOGRAPHIC CODES ↓ PHONOLOGICAL CODES ↑ SEMANTIC CODES   INDIRECT ROUTE

Figure 1.2 Dual-route models

Dual route models can accommodate many of the mixed findings of previous experiments by allowing different stimuli and tasks to make varying use of the two routes. They offer a ready explanation for differences in lexical decision latencies between regular and irregular words. Moreover, they can explain experimental and neurological evidence which indicates dissociation between the two routes (Patterson

& Coltheart, 1987; Patterson, Marshall & Coltheart, 1985; Posner & Carr, 1992; Shulman, Hornak & Sanders, 1978). Symptoms of some developmental dyslexias evidence independent developmental rates between the two routes of processing (M. Coltheart et. al., 1993; Marshall & Newcombe, 1973). Moreover, in the form of acquired dyslexia known as surface dyslexia, regular words and nonwords are read aloud accurately, while irregular words are often incorrectly regularized according to GPC rules. Dual route models can readily account for these findings by suggesting that the impairment is selective to the direct route while the viability of the indirect route is maintained (Patterson et. al., 1985).

Obligatory phonological mediation models

However, Van Orden (1991) and Van Orden et. al. (1990) contend that any failure to demonstrate phonological transcoding empirically does not constitute evidence that there is an independent direct access route. Other processes subsequent to phonological transcoding could explain these nonresults. Errors to homophones, which are frequently taken to be the hallmark of phonological mediation, may not always be observed because of the subsequent application of an orthographic verification procedure. Such a procedure could eliminate incorrect sound alike candidates by cross checking orthographic codes. Furthermore, they repudiate arguments based on the symptomatology of phonological dyslexia because they find very few pure cases, and they argue that preexisting conditions cannot be ruled out as explanations for these few.

Van Orden et. al. (1990) criticize the underlying assumptions of independent dual processes in WR: namely the independent routes, viability of GPC rules, delayed indirect phonological transcoding and phonological bypass. They argue that in dual route models where the processing route is determined by whether the input word is regular or irregular with respect to GPC rules, we should see a categorical difference in processing times for these two classes of words. In other words, processing time data should classify words by spelling-to-sound regularity in a dichotomous way. However, naming time experiments in particular do not support such a dichotomous version of spelling-to-sound regularity. Instead, they feel that the consistency and word frequency effects often observed are better accommodated by a "continuous, possibly statistical version of regularity" (p. 490). Such a version is not so readily explained by dual route models. They further reject recent ad hoc attempts to add provisions that cause GPC rules to behave more like the data exhibits, and they find lexical analogy to be an unsatisfactory resolution to the inherent problems in GPC rule-governed routes.

In addition, they argue that there is substantial evidence that phonological codes are not too slow to be implicated in the access of semantic codes. Van Orden (1987, experiment 1) employed a semantic categorization task in which college level readers had to determine whether each target word was an exemplar of a semantic category (e.g., ROSE for A FLOWER). Subjects made a significant number of false positive errors to homophone foils (e.g., ROWS) in comparison to orthographic control foils (e.g., ROLE). The effect was smaller for less similarly spelled homophone foils (e.g., ROWS and ROSE). However, the number of false positives increased to nearly 50% of all homophone foils and the difference in spelling similarity disappeared under a brief-exposure pattern-masking condition. They interpret this as evidence that phonological codes have an early and pervasive influence on WR. Spelling similarity effects the unmasked error rates because subjects conduct an additional spelling verification process subsequent to phonological transcoding. This verification process overlooks more errors to similarly spelled homophones than to less similarly spelled homophones, thus the difference in categorization error rates to similarly and less similarly spelled homophone foils This difference disappears under masking conditions because there isn't sufficient time to conduct the additional verification processes.

Recently, a number of priming studies have offered additional evidence that phonological codes have a widespread, automatic, early influence on word recognition processing (e.g., Ferrand & Grainger, 1994, Lukatela, Savic, Urosevic & Turvey, 1997; Lukatela & Turvey, 1991, 1994; Rayner, Sereno, Lesch, & Pollatsek, 1995). In a landmark study of this type, Lesch and Pollatsek (1993) found that the naming of target words (e.g., *nut*) was facilitated more when the prime was a homophone (e.g., *beach*) of a semantic associate (e.g., *beech*) than when the prime was a visually similar control (e.g., *bench*). This effect occurred when the prime word was exposed for 50 ms before a pattern mask but not when it was exposed for 200 ms before the pattern mask. However, the appropriate prime (e.g., *beech*) facilitated naming at both exposure durations.

Masking studies have also offered similar evidence that phonological codes have an early influence on word recognition processes. Perfetti, Bell & Delaney (1988) and Perfetti & Bell (1991) found that when a target word is immediately followed by a similarly spelled or pronounced masking word or pseudoword, the disruptive effect of the mask is reduced more by homophone masks than orthographic and control masks. Effects were observed between target durations of 35-55 ms. They concluded that "a high degree of phonetic activation always occurs during lexical access, never being wholly delayed until some 'moment of access' and never being omitted" (p. 68).

The dual route assumption that reading experience causes the phonological route to be bypassed is also challenged. Van Orden, Johnston & Hale (1988) found the same results for pseudohomophone (similar sounding nonword) foils (e.g., HARE for A PART OF THE HUMAN BODY). If pseudowords are representative of unfamiliar words, this finding runs contrary to the dual process theory which predicts a difference in phonological recoding between familiar and unfamiliar words. Van Orden et. al. (1990) conclude that these results are "consonant with a theory in which phonologic coding operates in every instance of word identification, irrespective of a reader's familiarity with the word being read" (p. 493). Bosman & deGroot (1996) found evidence of phonological coding in both advanced and less advanced children. They concluded that differences in the error patterns did not indicate a difference in the use of phonological codes, but rather a difference in spelling verification skills.

However, Jared and Seidenberg (1991) have suggested that semantic categorization error rates to phonological foils for higher frequency words may be due to semantic priming and perhaps even expectancy based predictions for exemplars of narrow class categories as were used in the VanOrden (1987) experiment. When they conducted a similar task using broad based categories (*living thing* and *object*), only the low frequency words demonstrated phonological mediation. In addition, in a replication of VanOrden's (1987) non-masked experiment 1, Coltheart et. al. (1991), found a lower rate of false positive errors to homophone foils. There was a significantly higher error rate to pseudohomophone but not homophone foils in comparison to orthographic control words. In addition, they found that errors were not evenly distributed across items, but were concentrated on homophone foils in which *ea* was replaced by *ee* or vice versa. In a series of manipulations intended to further investigate the effect of orthographic similarity and other factors on errors to homophone foils, Coltheart, Patterson and Leahy (1994) found strong evidence that error rates in these semantic categorization tasks are sensitive to an interaction between phonological similarity and orthographic similarity. They concluded that access to meaning occurs via graded activations of both phonological and orthographic codes. However, they noted that they could not rule out Van Orden's (1987) interpretation.

Such findings suggest that phonological codes do not serve as a sort of way station between spelling and meaning. Phonological codes appear to have a highly significant influence, but the amount of influence may vary depending on such factors as word familiarity and spelling similarity.

The phonological coherence hypothesis

Van Orden et. al.'s (1990) phonological coherence hypothesis maintains that phonological and orthographic codes can have a variable influence on WR processes as a natural consequence of the interaction that may occur in subsymbolic connectionist networks as a result of its development through individual learning experience. The hope proffered by connectionist architectures is that linguistic feats like WR can be modeled within a single dynamic mechanism rather than resorting to two separate pathways: one governed by discrete, explicit rules and a second based on case by case mappings (see discussions in Besner, Twilley, McCann & Seergobin, 1990; Carelo, Lukatela & Turvey, 1994; Hulme, 1995; Seidenberg & McClelland, 1989; VanOrden et. al., 1990).

In this framework WR is construed as a dynamic process that occurs via "soft constraint satisfaction." That is, the activation values of various stimulus and contextual subsymbolic representations interact to constrain the formation of lexical representations. Representations are not dedicated or localized, but instead arise from the activation of highly distributed features or subsymbols that reside in connectionist networks. Over time, with repeated learning trials and crosstalk between subsymbols, the strength of the connections between covarying subsymbols and covarying sets of subsymbols are adjusted in a process referred to as covariant learning.

They argue that in comparison to other lexical codes, the relationship between phonological codes and orthographic codes is relatively invariant or noise free. The semantic values and syntactic functions of a particular written word may vary extensively with different contexts. In contrast, there is relatively little variation in the phonemic form corresponding to a particular spelling within a particular speaker (homographs are one exception). Thus, phonological codes covary with orthographic codes less than other codes. Through the process of covariant learning, orthographic codes become more precisely associated with phonological codes than with other codes. Consequently, phonological codes "initially provide a dynamic frame which will constrain (through interactive-activation or relation) the eventual form of other less initially coherent (more noisy) lexical codes" (Van Orden, 1991, p. 78).

In this framework, phonological codes are not constructed on the basis of rule-governed relationships between orthography and sound in order to provide passageway to stable lexical representations. Instead, as representations for various phonological features and groups of features become activated, they serve as a major source of constraint on processing resulting in the activation of semantic codes. Van Orden et. al. (1990) claim that these design features can explain the statistical rather than dichotomous regularity effects which emerge as a function of the relative consistency and frequency with which spelling and phonology covary. However, sub-symbolic models face a number of challenges including serious failures to mirror the performance of real learners who demonstrate both rule-like behavior in response to novel stimuli like nonwords as well as accuracy in response to exceptions to those rules like irregularly spelled words (Besner, Twilley, McCann & Seergobin, 1990; M. Coltheart et. al., 1993; Deidenber & McClelland).[5] Recently, Stone and VanOrden (1994) have reframed this model in an adaptive resonance model of WR in which rapid cycles of feed forward and feedback activation eventually converge. The model retains the basic tenet that WR depends on the evolution of a unique stable phonological code.

In conclusion, there is considerable evidence that phonological codes

[5]Pinker and Prince (1988) offer parallel criticisms of Rumelhart and McClelland's (1986) PDP model of past-tense learning.

plays a significant role in the activation of semantic codes in WR and this is reflected in currently viable models of WR. However, the extent of that role and the conditions determining it vary across models of WR. In the dual route models discussed here, semantic codes for words can be activated either via mediating phonological codes or directly on the basis of orthographic codes. Whether phonological codes contribute significantly to semantic activation depends on which processing route is responsible for semantic activation in a particular instance of WR and this depends on the reader's learning experiences as well as characteristics of the input word. In the phonological coherence model, phonological codes fundamentally influence the activation of semantic codes for all words. Thus, although the two types of models would not always predict the same level of phonological influence in a particular instance of WR, they do agree that a significant involvement of phonological codes is likely to contribute to the activation of semantic codes for less familiar, regularly spelled words.

THE FUNDAMENTAL ROLE OF WORD RECOGNITION IN READING

The foundation of reading

Both Gough (1984) and Stanovich (1991) opened their review chapters on WR in the Handbook of Reading Research (Volumes 1 and 2 respectively) with the assertion that WR is the "foundation" of reading.

This is not to suggest, however, that WR equals reading or that other aspects of reading are insignificant. Certainly, in most reading events, a great deal of higher level processing is required to accomplish the reader's goals. A full theory of reading will incorporate much more than WR. However, WR is the foundational component upon which other reading components and ultimately the success of the whole reading event crucially depend (Chard, 1995). Stanovich (1991) summarizes:

> If processes of WR do not quickly activate the appropriate lexical entry and produce a phonological representation of sufficient quality to sustain the identified word in working memory, then comprehension processes do not have the raw materials to operate efficiently and understanding of the text will be impaired (p. 443).

Similar statements can be found throughout the literature on reading. For example, in Perfetti's (1985, 1988) Verbal Efficiency Model, text comprehension entails local processes of encoding the appropriate meanings of individual words (WR), encoding the basic propositions of the text and integrating these propositions. On the basis of these local processes, the reader uses ongoing application of schematic knowledge and inference processes to construct a model of the text. Perfetti (1988) summarizes: "To the extent that lexical access is resource efficient, the encoding of propositions in working memory can be achieved more efficiently" (p. 121). Constructing a good quality model of the text depends crucially on the quality and efficiency of these local processes.

Previously, some models of reading have considered WR to be the more difficult, resource demanding component of reading (e.g., Goodman, 1967; Smith, 1971). In these models, reading speed and efficiency depends critically upon avoiding text driven WR and increasing dependence on higher level knowledge driven processes to make predictions about words in texts and to guide the selection of minimal portions of the texts to be processed in order to verify these predictions. In contrast, current models of reading generally hold these higher level, knowledge based processes to be the more difficult, resource demanding processes in reading (e.g., Perfetti, 1988). Reading speed and efficiency depend not on the extent to which WR can be avoided, but rather on the extent to which WR can be developed to function with greater speed, efficiency and accuracy. In this way, the bulk of the processing resources can be dedicated to the more difficult higher level processes. This is accomplished by attributing to WR subcomponent processes the capacity to become automatic. Pollatsek (1989) states that most researchers would now agree that:

> Word recognition is relatively automatic, and "higher order processes," such as constructing the correct syntactic structure, relating word meanings, and fitting the text into what the reader understands about the world, are what takes most of the reader's processing capacity.

Automaticity is a widely used construct which formalizes a longstanding intuitive observation: with practice some skills can become faster, more accurate, easier to perform and less subject to control. Automaticity has long been a favored tenet in theories of reading. Huey (1908/1968) noted:

> To perceive an entirely new word or other combination of strokes requires considerable time, close attention and is likely to be imperfectly done, just as when we attempt some new combination of movements, some new trick in the gymnasium, or a new serve at tennis. In either case, repetition progressively frees the mind from attention to details, makes facile the total act, shortens the time, and reduces the extent to which consciousness must concern itself with the process" (p. 104).

With the dawn of cognitive psychology, LaBerge and Samuels (1974) argued that WR entails stages of information processing which transform written stimuli into semantic meaning. In a set of landmark experiments in which they measured the time required to switch attention to a new task during WR, they demonstrated evidence that automaticity develops in WR processes.

Posner and Snyder (1975) and Shiffrin and Schneider (1977) posited two types of processes. *Controlled processes* are voluntary, require attention and are relatively slow. Novel tasks are carried out via controlled processes. With extensive practice, some processes can become *automatic*. They occur quickly, are not interfered with by other concurrent processes, and in turn do not interfere with other concurrent processes because they make no demands on the pool of limited attentional resources available for carrying out cognitive processes at any given time. There is growing evidence that the properties associated with automaticity are dissociable properties that develop gradually along a continuous gradient toward, but not likely ever reaching an absolute endpoint such as complete independence of attention (e.g., Cohen, Dunbar

& McClelland, 1990; Paap and Ogden, 1981).

Despite problems in defining automaticity and a history of various adjustments, the notion continues to be widely incorporated in information processing theories of reading. This is because automaticity offers a powerful means of explaining or at least describing how such a complex act as reading can be carried out so quickly, accurately and efficiently: that is by automatizing some subcomponent processes. Automaticity has been theorized to develop in two major types of processing (LaBerge, 1981; Shiffrin & Schneider, 1977). One type is processing entailing many basic representations or codes in which common patterns can be reorganized or unitized into more inclusive codes. These unitized codes are processed more quickly with less attention. In WR, visual codes resulting from feature detection are a prime candidate for this type of automatization because the many simple visual features of letters (lines of various orientations and curvature) can be reorganized into larger visual codes representing letters, and common patterns of letters can be reorganized into more inclusive subword features. The second type of processing that may be automatized is the mapping of stimulus to response codes. When two codes are repeatedly and consistently associated with one another in close temporal contiguity, the association becomes reinforced, and as a result, less subject to the competition of other associations and less attention demanding to execute. Alternatively, when a mapping of input to output codes is initially mediated by one or more additional codes, the input and output codes may become directly associated. This restructured direct mapping is faster or more automatic (McLeod & McLaughlin, 1986). In WR processes, visual, orthographic, phonological and semantic codes are repeatedly and temporally associated with each other--favorable conditions for automaticity to develop. Evidence that semantic codes may be activated relatively automatically on the basis of orthographic codes has been offered on the basis of performance on Stroop tasks (e.g., Mcleod and Dunbar, 1988; Posner and Snyder, 1975; Stroop, 1935) and masked semantic priming tasks (e.g. Neely, 1991).

Encapsulation

In order to circumvent some problems that have been encountered in the operationalization of the concept, automaticity, Stanovich (1990, 1991) prefers to reframe the phenomenon in terms of information encapsulation, the defining aspect of modularity (e.g. Fodor, 1983). The idea of information encapsulation is that low level component processes can to various extents become functionally autonomous or impenetrable to the knowledge or processing of other components. Fast, efficient and obligatory execution should follow because the amount of higher level information that can enter into and encumber these autonomous or semiautonomous processes is restricted.

One advantage of information encapsulation in WR is that it diminishes the risk of the reader being mislead by contextual and knowledge based expectancies. In more complex texts, such expectancies have only a weak chance of agreeing with the actual text and, therefore, a high probability of misleading readers to read into the text an inappropriate meaning. Such errors are costly. Time and processing resources have to be expended to detect the error, backtrack to the appropriate place in the text and process the text. The stimulus information contained in the text is arguably a more reliable and efficient route to WR. Thus, in this view, skillful reading, is made possible via the modularization of WR.[6] Stanovich (1991) summarizes:

> We have in reading precisely the situation where an enormous advantage accrues to encapsulation: the potential specificity of stimulus-analyzing mechanisms is great relative to the diagnosticity of the background information that might potentially be recruited to aid recognition. In short, a consideration of the stimulus ecology of the reading task has lead an increasing number of investigators to endorse the idea of the acquired modularity of the word

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[6]Like automaticity, modularization also runs into serious difficulties when attempting to define it operationally in a particular model of WR. For instance, in Van Orden et. al.'s (1990) subsymbolic model of WR, context is considered to exert constraint throughout the process of WR, not simply in selecting among candidate outputs of WR processes. This is especially important in arriving at the right meaning for polysemous words. In order to determine whether this contradicts the tenets of modularity, modularity itself needs to be defined within such subsymbolic architectures.

recognition module (p.431).

Whether via processes best understood as automaticization or encapsulation, the important implication to this discussion is that subcomponent processes within WR have the unique potential to become relatively fast, efficient and accurate. And this may be the keystone to skillful reading.

The unique problem of learning to read

There is considerable empirical evidence that skillful WR is key to skillful reading (see reviews by Stanovich, 1992; Chard, 1995). In multivariate analyses of component skills in reading, WR often accounts for a substantial amount of the variance in performance on broader measures of reading comprehension in children (Carr, Brown, Vavrus & Evans, 1990; Perfetti, 1985; Shankweiler, 1989; Stanovich, 1986). Even among adult skilled readers, WR efficiency accounts for a smaller but still significant portion of the variance and is an independent predictor of performance on broader measures of reading fluency and comprehension (e.g., Cunningham, Stanovich & Wilson, 1990). There is simply no comparable substitute for skillful WR. When WR component processes are deficient, there are serious implications for the larger reading event. Saarnio, Oka and Paris (1990) emphasize that "regardless of children's level of metacognitive awareness, strategy use, and positive reading attitudes, an inability to decode words and retain them in memory undermines the ability to read" (p. 74). Stanovich's (1980) Interactive Compensatory model of reading suggests that when basic WR processes are undeveloped or impaired (lack encapsulation), information from higher level processes can enter into the processing in WR. WR can then be carried out by resorting to dependency on other higher processes which offset this handicap. However, there is a substantial cost in terms of speed and accuracy and this has negative ramifications on reading performance as a whole.

Most children learning to read in their FL are already fairly proficient in comprehending oral language.[7] Thus, the foremost problem of learning to read is learning to access previously acquired linguistic knowledge through a new signal modality: that is to acquire skill in visual WR. Both informal observation and extensive research indicates that this is indeed a formidable task and one that is not immediately obvious to children. Children approach the task of WR through various and gradually more sophisticated strategies. It takes a long time before their strategies begin to resemble the more efficient and successful strategies characteristic of skilled adult reading and this may require some form of instruction (e.g., see discussions in Ehri, 1991; Vellutino & Scanlon, 1987).

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[7]Although there is good reason to believe that learning to read contributes further to the acquisition of language and metalinguistic knowledge.

A significant proportion of readers have considerable difficulty learning to read as evidenced by performance on various measures of reading that is markedly below their peers. There is a large body of converging evidence suggesting that a significant proportion if not the majority of these cases of poor reading can be attributed to slow or deficient development in WR processes (e.g., Bruck, 1988, 1990; Perfetti, 1985; 1988; Snowling, 1991; Stanovich, 1986, 1992, 1994). Stanovich (1991) concludes an extensive review on WR by stating that "skill in WR is always a reasonable predictor of difficulties in developing reading comprehension ability" (p. 418).

Deficits in phonological coding

Substandard performance on measures of WR has been attributed to underlying deficits in fundamental skills such as visual perception, visual memory, orthographic coding, cross-modal transfer, and memory (e.g., see references in Vellutino & Scanlon, 1987). It has been suggested further that many of these deficits are actually epiphenomenon of one basic underlying deficit that is the ultimate cause of a large proportion of WR and reading comprehension problems: deficits in phonological processing (Elbro, 1994; Perfetti and Marron, 1995; Shankweiler & Crain, 1986; Shankweiler, Crain, Brady & Macaruso, 1992; Stanovich, 1986, 1992, 1994; Torgesen, 1994). In fact, a substantial number of studies find that measures of phonological coding such as pseudoword naming tests offer the most robust indication of deficits in WR and reading ability in both young and experienced readers (Bruck, 1988, 1990; Fletcher, Shaywitz, Shankweiler & Katz, 1994; Goswami & Bryant, 1990; Manis, Custodio & Szeszulski, 1993; Shankweiler, Crain, Katz & Fowler, 1995; Shankweiler, Lundquist, Dreyer & Dickinson, 1996; Share, 1995; Snowling, 1991; Stanovich, 1988). As a result, Shankweiler and Crain (1986) and Shankweiler et. al. (1992) have formulated the phonological limitation hypothesis. This hypothesis states that phonological coding problems are the underlying unitary cause of many of the comprehension problems poor readers exhibit both in spoken and written language at both the word and sentence level. In fact, efficiency in phonological processing at the level of WR appears to be one of the strongest if not the strongest measure of skill in reading comprehension. A number of studies have reported that the variance in reading ability predicted by measures of such abilities as working memory and syntactic coding is much smaller than or overlapping with that of phonological processes (e.g., Bar-Shalom, Crain & Shankweiler, 1993; Gottardo, Stanovich & Siegel, 1996; Hansen & Bowey, 1994; Leather & Henry, 1994; McDougall, Hulme, Ellis, & Monk, 1994). The most important source of these phonological difficulties in turn may be a deficit in segmental language skills or what is often referred to as phoneme awareness skills (Hoien, Lundberg, Stanovich & Bjaalid, 1995; Pennington, Van Orden, Kirson & Haith, 1991). Fowler (1991) has suggested that the phonological representations of poor readers are less differentiated than those of better readers and this inhibits the emergence of phonological awareness which is necessary to develop a systematic understanding of letter-sound correspondences.

In summary, In FLR it has been argued that WR is the fundamental component process of reading as well as the unique problem in learning to read. Reading skill is strongly associated with skill in WR, and skill in phonological coding appears to be a major component of that. The far-reaching effects of deficits in phonological coding skills may reflect the importance of phonological codes in reading.

WORD RECOGNITION IN SECOND LANGUAGE READING

Traditionally a peripheral consideration

Lower level processes have not been the focus of much research in SLR. In recent texts on SLR, WR or a related term like decoding or bottom-up processing is only briefly touched on while the bulk of attention addresses issues related to higher level processing (Cumming, 1995; Alderson & Urquhart, 1984; Barnett, 1989; Carrell, Devine & Eskey, 1988). Although SLR has long been said to be similar to FLR (Goodman, 1970) and poor SL readers are thought to share commonalities with poor FL readers (e.g., Hultstijn & Matter, 1991; Segalowitz et. al., 1991), WR is rarely attributed a significant role in explaining the development of or problems in SLR, and is only rarely the focus of systematic research in SLR. Haynes and Carr (1990) have noted that there is little understanding within the field of SLR that "lower level component processes involved in visual perception and lexical access may set limits on the efficiency of higher level processing" (p. 376).

The central problem of linguistic competence

Lado (1964) stated that "learning to speak and understand means learning the language, whereas reading and writing imply that the language is known and that we are learning a graphic representation of it" (p. 131). Thus, the Oral Approach to SL instruction attempted to enforce this sequence in SLA: new language was always to be acquired orally first so that the subsequent reading of it should then be a simple matter of learning to recognize it in print (Fries, 1962, 1972). However, SL learners often read language they have not yet adequately acquired aurally. Consequently, the explanation for SLR problems appears to be a problem with language, not reading, which conceived of as a simple nonlinguistic translation or decoding system.

Despite the fact that native speakers have considerable difficulty and require a long time to learn to read in their FL, learning to read in a SL is often thought to be rather simple. Many SL learners are already literate in their FL. As a result of their FL reading experience they approach SLR with considerable knowledge about such things as how series of symbols may relate to speech sounds and meanings. In comparison to a child learning to read for the first time, these experienced SL readers start off with much more sophisticated strategies for addressing the printed modality of a second language. With little explicit instruction, they seem to know how to get on with the problem of WR in the SL. Hatch (1974) stated that learning a new SL code should be a relatively easy task. "Once having learned that a stands for /a/ in Spanish, it won't be insurmountable to learn it can stand for /æ/, /a/... in English" (p.54). In the classroom she also found that isolated letter pattern exercises (Harris, 1966), which she felt reflected WR skills, did not seem to be problematic for SLR students. Similarly, Thonis (1970) argued that once children learn to read in their FL, learning to read in a SL was a simple matter of learning a new code. Thus, WR appears to be a minor issue in SLR. But, only if we believe that reading is a simple letter to sound translation system, can we make such an assumption. Models of FLR and WR in particular are far from this.

The central problem of background knowledge

The importance attributed to WR processes in the development of SLR has been even further diminished as a result of a class of models now generally referred to as top-down or knowledge-driven models of reading. These models, in particular those of Goodman (1967) and Smith (1971), have had a large impact on SLR research and theory. Goodman's (1967) model of reading has often been cited in the literature on SLR and is reprinted in chapter one of Carrell et. al's. (1988) collection of articles on newer, interactive approaches to SLR. In top-down models, processing the visual information contained in the text is considered to be one of the most cumbersome aspects of reading. Efficiency is improved, not by making WR more automatic, but by circumventing text driven WR as much as possible by relying on higher level knowledge. "Reading is accelerated...by reducing dependency on visual information" (Smith, 1971, p. 41). Skillful readers reading familiar, well written texts use linguistic, orthographic and background knowledge in conjunction with contextual cues from the text to make hypotheses about the upcoming content of the text. These hypotheses then guide the sampling of minimal portions of the visual information in the text in order to confirm or modify these hypotheses.

These top-down models of reading are motivated in part by a theoretical concern that meaning be understood to be composed by the reader through active interaction with a text as opposed to being a fixed entity contained in the text which is passively transmitted to the reader through visual perception or decoding of the text (Rosenblatt, 1978). Thus, top down models of reading maximize the role of the reader's background knowledge and ability to make meaning in every aspect of reading, even WR. Reading is first and foremost dependent on what a reader knows and expects before processing the text.

Empirical support for these models has been drawn largely from general measures of reading performance, especially oral reading miscue data, which are observable deviations from a verbatim oral reading of the text. The miscues of good readers generally are still plausibly meaningful, whereas the miscues of poor readers often are not (Goodman, 1976; Rigg, 1988). Recall protocols demonstrate that the reader's background knowledge influences the picture of the text constructed by the reader. The inference that has been drawn from such findings is not that good readers are good at WR, but that they do less of it. They are able to construct meaning without decoding much of the text because they use their background knowledge.

Much evidence has been offered to show that SL readers lack culturally appropriate background knowledge and that this impedes SLR comprehension. In a seminal study, Steffensen, Joag-Dev & Anderson (1979) found that when reading a culturally loaded passage in a SL, SL readers added and deleted information according to their own nonnative cultural experience. Similar studies since then have concurred and have demonstrated that training in "strategic use of schema" improves SLR (e.g., Barnett, 1988; Carrell, 1989; Carrell, Pharis & Liberto, 1989). Thus, the obvious remedy for the problem of SLR is the fortification of higher level linguistic and general knowledge. Poor SL readers have been encouraged to look less and guess more.

One tenet of these top-down models of reading is that they are universal to all languages (Goodman, 1970; Rigg, 1988). Background or cultural knowledge and language-specific knowledge crucially inform the strategies, but the strategies themselves: making, confirming and correcting hypotheses, can be dissociated from language specific features. Consequently, individuals can use the same strategies learned in FLR in order to read in the SL. They do not need to learn new strategies. They only need to acquire the new linguistic cues and general knowledge system which supports these strategies. As a result, the problem of SLR is again misconstrued as composed of two discrete elements: language-specific cultural and linguistic knowledge and non-language specific reading strategies. This view of reading is evident in Alderson's (1984) well known dichotomous categorization of the possible causes for poor SLR: either a linguistic or reading problem. To understand this incredible statement, one must understand *reading* to be a non-linguistic process. Again, the reading half of the equation is a minimal challenge for FL literate SL readers because they can transfer the necessary skills from FLR experience. Thus, the major problem for SLR is acquiring the necessary linguistic and cultural knowledge that informs these strategies. Alderson adds that when there is a problem with the *reading* half of this equation among FL literate SL readers, the problem is rooted in insufficient SL competence which prevents the transfer of good FLR strategies to SLR. Similarly, Clarke's (1980) short circuit hypothesis suggests that SL readers initially resort to using poor reading strategies because their low SL linguistic proficiency prevents them from transferring their good FLR strategies to SLR. Once the threshold level of SL proficiency is attained, the reader can apply FLR strategies to SLR. Thus, the study of SLR has focused on the role of linguistic and cultural knowledge.

There is little reason to study text-driven WR, which in the extreme application of this view, is a poor temporary strategy that SL readers only resort to until they have sufficient knowledge to use more efficient top-down strategies from their FLR experience. Text driven WR processes are not understood to be fundamental processes to be developed in support of good reading, but rather are inferior temporary crutches to be minimized as soon as linguistic knowledge is sufficient to support the correct top-down strategies. Evidence that a SL reader is relying heavily on bottom-up processing is considered symptomatic of a reading problem. "Readers who do not expect target language texts to make sense, who read words individually, and who do not think about what words mean together may well be using a bottom-up approach to reading" (Barnett, 1989, p. 19).

In a very influential early study, Hatch, Polin & Part (1970) asked SL readers to cross out all the letter e's in a reading passage. In comparison to FL readers, they crossed out more e's and did so more indiscriminately. Unlike the FL readers, their responses suggested that they did not differentiate between content and function words or stressed and unstressed syllables. These results have been interpreted as evidence that poor SL readers rely heavily on more dense visual processing due to limited linguistic and orthographic knowledge. Eye movement research indicates that less proficient SL readers fixate on individual words for a longer time than proficient native readers (Bernhardt, 1987; Oller, 1972). Instead of interpreting this as evidence of less proficient WR, it is interpreted as evidence that low level processes are inherently inefficient and SLR is slow because of over-reliance on these inferior processes.

Resolution

In the last decade or so, SLR researchers have often referred to their approach to reading as neither strictly top-down or bottom-up, but *interactive*. The aim has been to correct for what Carrell (1988) has called an overemphasis on top-down, knowledge-driven processes in SLR to the extent they have often been seen as a "substitute" for bottom-up, text-driven processing (p.4). It is often noted that in interactive approaches, processing proceeds in both directions and the two are considered "complementary" to each other (p.4). However, it is difficult to imagine any reading theory that isn't at least in some sense interactive--that is in which input can come from both the reader's knowledge and the text. In fact, the Goodman/Smith model has been referred to as interactive by its proponents. Thus, to simply claim that interactive means that both top-down and bottom-up processing occurs is not informative. At some point, top-down and bottom-up reading strategies as they have been described appear to be mutually exclusive, contradictory strategies. The reader cannot both minimally sample the text based on background knowledge and also process the text in detail without the bias of background knowledge. Specification of the nature of these processes and their domains is needed in order to make sense of the term *interactive*. Although many SLR researchers now speak of interactive reading, the underlying view of reading remains stubbornly top down. For instance, Barnett's (1989) summary of "state of the art" understanding of SLR appears to represent mainly the tenets of the top-down approach, only with less clarity:

> Our understanding of reading has been revolutionized in the past decade. We recognize the primary role of the reader. Foreign language reading can no longer be seen as simply the decoding of more or less unknown vocabulary and grammar. The text, of course, is still essential. Comprehension, however, truly depends on the reader's expectations as defined by his or her content and formal schemata, linguistic proficiency, first language reading skill, reading strategies, and interest and purpose in reading the text (p. 111).

In a recent article on bringing reading research into the SL classroom, Auerbach and Paxton (1997) state that:

> although readers with limited L2 proficiency may revert to bottom-up strategies (e.g., word-for-word reading, translation), they can compensate for a lack of L2 proficiency by invoking top-down and interactive strategies (e.g., making predictions, accessing prior knowledge).

The popularity of the top-down approach in SLR, is partly fueled by a misguided debate that pits the reader's background knowledge against the information encoded in the text, higher level processes against lower level processes. However, this controversy is best resolved, not by theoretical debate over the relative importance of the reader compared to the text, but rather by empirical investigation into the component processes of reading. In a component process approach, it is possible to delineate the means by which both input from text perception and input from a reader's background and contextual knowledge can influence processing. The specific nature and locus is worked out by empirical investigation and specified in the model's design features. The relative contribution of text based and reader based knowledge in reading depends on the operation of these component processes rather than theoretical arguments.

This approach depends on research techniques aimed at elucidating processing in specific components or subcomponents. Thus, any one task is not likely to be used to infer the nature of reading as a whole. In this approach, much evidence has been amassed which indicates that skillful WR is not a matter of sampling minimal portions of texts guided by higher level expectancies. For instance, more carefully designed eye fixation research indicates that skilled readers fixate on the words in texts in a much more dense way than previously thought. The number of fixations per amount of text changes very little with increasing reading skill. Content words are very rarely skipped and even short function words and highly predictable content words which are more often skipped may be at least partially processed in parafoveal vision (Just & Carpenter, 1987; Rayner & Pollatsek, 1989; although for a discussion about eye fixations and WR see Carr & Pollatsek, 1985). Words are recognized in context more quickly than in isolation, and WR in context occurs faster than would be predicted if it were driven solely by information from visual features of words (Marslen-Wilson, 1989; McClelland, 1987; Neely, 1991). However, measures of early, processing in such tasks as primed lexical decision tasks, have indicated that the magnitude of context effects on skilled WR are extremely small and appear to result from automatic spreading activation from related codes within the WR component rather than from conscious expectancy based predictions (e.g., Foss, 1988; Stanovich, 1981). Thus, the significant context effects observed in oral miscues and recall protocols may in fact arise from relatively late occurring higher level processes. Perfetti (1988) concludes that

> "the idea of the skilled reader as one who uses context to guide word encoding may be correct only in a restricted sense. There is some suggestive evidence that, compared with less skilled readers, skilled readers more quickly "discard" the inappropriate meaning of a word (Merrill, Sperber, & McCauley, 1981). At the same time, the skilled reader will have a word-identification process of such strength that lexical access will automatically trigger word meanings independent of context (pp. 110-111).

In most current models of skillful FLR of familiar text, knowledge based expectancies can play an important role in higher level comprehension processes, but are generally restricted from influencing lower level processes in which semantic codes are activated on the basis of print (Just and Carpenter, 1987; Perfetti, 1985; Rayner & Pollatsek, 1989).

Expectancies are not used to reduce the amount of visual processing. Expectancies generally only come into play when WR processes are slow, as in the reading of unfamiliar words or in unskilled reading. Thus, poor readers rather than good readers make more use of expectancy processing in WR (Durgunoglu, 1988; Perfetti, 1985; West & Stanovich, 1978; see Stanovich, 1991 for an extensive review).

Text-based word recognition in second language reading

In SLR there is also some empirical evidence that expectancies have a decreasing influence on WR with increasing skill in basic WR processes. Favreau and Segalowitz (1983) found evidence that knowledge based expectancy processing influences WR more in slower proficient SL readers than in faster proficient SL readers. They used a primed lexical decision task in which bilingual subjects' high-level slower expectations of the target were set against low-level faster priming effects due to automatic spreading activation from the prime to the target. They then measured how impenetrable to expectancies these automatic priming effects were on WR. They predicted that highly skilled readers would process words so quickly that only automatic spreading activation would affect processing, expectancies would not. Slower readers, however, would be expected to process words more slowly giving expectancies an opportunity to penetrate processing. When contrary to the prime, they would interfere with semantic priming facilitation. Indeed, conflicting expectancies had a greater inhibitory effect on priming facilitation in slower readers. They concluded that WR processing in the slower SL readers was much more penetrable or less automatic. There was no apparent reliance on compensatory contextually based expectancy processing to facilitate WR in any of their subjects. The implication is that expectancies may have a decreasing rather than increasing impact on WR with increasing skill in SLR as has been demonstrated in FLR.

As SLR researchers recognize the limitations of top down processing in WR, more recognition is accorded to the importance of skillful, automatic WR (Koda, 1994, 1996). It is not a crutch to be avoided, but a crucial fundamental skill to be developed in order to enable skillful SLR. Eskey (1988) notes that

> fluent reading entails both skillful decoding and relating information so obtained to the reader's prior knowledge of the subject and the world. Thus, the fluent reader is characterized by *both* skill at rapid, context-free word and phrase recognition and, at higher cognitive levels, the skillful use of appropriate comprehension strategies. For the proper interpretation of texts the latter skills are crucial, but such lower-level skills as the rapid and accurate identification of lexical and grammatical forms are not merely obstacles to be cleared on the way to higher-level "guessing game" strategies, but skills to be mastered as a necessary means of taking much of the guesswork out of reading comprehension (p. 98).

This view aligns itself with currently viable models of first language word recognition (FLWR) such as have been referred to above. In this view, WR is fundamentally a linguistic process. Therefore, the development of accurate efficient second language word recognition

(SLWR) depends crucially on the acquisition of the SL along with relevant experience of its printed modality. Language specific knowledge of graphic, orthographic, phonological and semantic codes and how they relate to one another is essential to the development of skillful SLWR. The text is not processed via a set of universal strategies which can be dissociated from linguistic knowledge and transferred across languages. Proficient SLWR does not follow as a natural consequence of FLWR experience. Certainly, experience learning to read in a FL may develop such things as phonological awareness and knowledge about how orthography may relate to sound and meaning. These may in turn facilitate the development of SLWR (Faltis, 1986; Kendall, Lajeunesse, Chmilar, Shapson & Shapson, 1987). For example, Durgunoglu, Nagy and Hancin-Bhatt (1993) found that the word recognition performance of children beginning to learn to read in a SL was predicted by their level of FL phonological awareness and word recognition skills. Thus, the FL literate SL reader may enjoy some initial benefits arising from transfer from FLWR experience. However, these benefits do not extend across the full scope of the problem of developing skillful SLWR. In some cases, transfer from FLWR experience may even negatively inhibit the development of skillful SLWR (Brown & Haynes, 1985, Haynes & Carr, 1990).

Lado (1964) hypothesized that

> the habits involved in reading and writing the source language tend to be transferred to the target language with

resulting interference where the two systems differ and with facilitation where they are parallel. The force of this transfer is much stronger than we realize, and it persists into advanced stages of mastery (pp. 133-4).

In this view, the development of SLWR will be inhibited by FLWR experience in a different type of orthography. More recently language transfer in SLA has been shown to be a much more complicated matter than this characterization suggests (Gass & Selinker, 1983). Durgunoglu and Hancin-Bhatt (1992) review a number of recent studies on transfer effects in SLWR. These studies indicate that transfer effects are mixed and complicated. In a multiple regression analysis of various component skills in reading among SL readers of English who were FL readers of a substantially different orthography, Chinese, Haynes and Carr (1990) found that it takes these SL readers a long time to develop the complex procedural and declarative knowledge about the orthographic system in English. They concluded that

> writing-system knowledge is important to visual word processing among L2 [SL] readers, just as it clearly is among L1 [FL] readers. Furthermore, individual differences in such knowledge continue to influence reading success among intellectually talented native speaker-readers of Chinese who have been studying English for many years and using English-language textbooks in university coursework. This is striking in light of the common assumptions among L2 reading researchers and teachers that the writing system is mastered easily and rapidly, quite early in the study of a new language, and that semantic vocabulary knowledge and higher order linguistic and conceptual competencies should be the focus of instructional effort and theoretical interest (p. 414).

Thus, the development of SLWR is certainly not an automatic consequence of FLWR experience, nor is it quite the same as the development of FLWR because of that same experience. It is complex process which, if it is to be understood, requires empirical investigation.

Clearly, the development of accurate efficient WR in a SL is also not simply a matter of working out a translation for a new orthographic code to an already acquired linguistic system as is implied in Lado's (1964) simplistic characterization. As has been shown in the FLWR models discussed above, the problem of WR is much more complex than this. As in FLWR, the complex system of interconnected codes and processes necessary to skillful SLWR can be expected to develop only slowly through SLR experience. Development may even be inhibited by negative transfer. And the development of SLWR may be even more complicated because in many cases SLWR does not begin subsequent to the oral acquisition of the SL. In many cases of SLA, as in foreign language learning after early childhood, learners have little SL competence when they begin to learn to read in the SL. Much of the input for SLA is presented to the learner in the written modality before or around the same time as it is presented aurally. In order to intake this SL input, the learner must read it. Unlike most FL readers, many SL learners are learning to read in the SL at the same time as they are acquiring the linguistic competence which is necessary to developing skillful reading. These unique complications suggest further reasons why an understanding of SLR must be informed by research on SLWR.

Finally, SLWR processes require empirical study because of their potentially crucial role in SLR. As argued above, in FLR, WR is considered to be the crucial component process which can be automatized or encapsulated in order to speed up and facilitate reading. Given the fact that reading is an especially demanding task in a incompletely acquired SL, the speed, efficiency and accuracy of WR may be especially crucial to the success of SLR. When WR is resource demanding and slow, resources may be insufficient for higher level processes like syntactic parsing and the semantic integration of units of text into larger representations of the text. These processes are likely to be particularly demanding in SLR because of the reader's limited linguistic and cultural knowledge. SLR readers often report that after laboriously reading through a passage, they are unable to recall what they have just read, despite feeling that they understood it while they were reading it. Such experiences may not indicate that readers don't engage in enough expectancy based processing, but rather that low level processing is resource demanding resulting in insufficient resources for higher level processing. Empirical investigation is necessary to determine this.

In fact, a handful of studies have associated poor SLR with poor WR, similar to the link drawn in FLR research. Several researchers have advocated that poor WR is a significant determinant of poor SLR as it is in FLR (e.g., Eskey and Grabe, 1988; Segalowitz et. al., 1991). MacNamara (1967) hypothesized that his ESL readers took longer to read in English than in their first language, in large part because of slower decoding. Whereas proficient FL readers usually recognize letters embedded in words more quickly than in random strings of letters, Favreau, Komoda and Segalowitz (1980) found less or no such word superiority effect in advanced bilinguals who read more slowly in their SL. Some data previously used to support top down models of reading, may be reinterpreted within newer models of reading. For example, eye fixations are longer in duration for lower level SL readers in comparison to FL or highly proficient SL readers (Bernhardt, 1987; Oller and Tullius, 1973). Assuming that processing occurs on line during eye fixations (Just and Carpenter, 1987), this suggests a connection between the efficiency of SLWR and SLR proficiency. Thus, there is some preliminary evidence that the efficiency of SLWR processes is a significant determinant of SLR proficiency.

In summary, WR may be fundamentally crucial to the success of SLR as has been argued in FLR. Moreover, skill in SLWR cannot be presumed to result from FLWR experience. In fact the problem of developing skillful WR in a SL, may pose some unique challenges. Thus, the study of SLWR is requisite to understanding the development and success of SLR.

PHONOLOGICAL CODES IN SECOND LANGUAGE READING

It has been argued that in FLR phonological codes contribute significantly to higher level reading processes in which information must be temporarily held and manipulated in short term memory because of the relative stability of phonological codes. In addition, phonological codes may contribute to the activation of semantic codes in WR for at least some if not all words because of their relative coherence in comparison to other codes. In the study of FLR, reading deficiency is highly associated with deficiencies in phonological coding processes. These deficiencies have been associated with deficits in segmental language skills. Parallel questions may be asked about SLR. Do phonological codes also contribute significantly to SLR? If so, are there specific challenges to developing skillful phonological coding in a SL which will crucially constrain SLR?

It has been noted that SL readers often begin learning to recognize words in print before having had much if any experience in aural word recognition. It has therefore been suggested that phonological coding may be impossible and therefore unnecessary in SLR.

> Most foreign/second language readers do not have a fully developed phonological system when they begin to read. Therefore, the bottom-up models that depend on the reader's encoding of the text into phonological symbols or internal speech cannot apply directly to the second language reading process (Barnett, 1989, p. 34).

However, in fact, normal hearing SL readers have a great deal of phonological knowledge that could be applied to SLR regardless of how this knowledge may deviate from native speaker phonological knowledge. There is evidence that even profoundly, prelingually deaf readers have access to phonological codes from very limited speech instruction and lip reading experience which they can apply to FLR (e.g. Hanson & Fowler, 1987). Most non-hearing impaired SL readers have some knowledge of the SL phonology as well as the potential to make hypotheses based on their FL knowledge of how sounds relate to print. Thus phonological coding can never be ruled out in SLR. However, it remains possible that the extent of reliance on phonological codes or the quality of those phonological codes may be different in SLR because of such problems as the learner's incomplete knowledge of SL phonology. If phonological codes are crucial to SLWR, these differences in phonological coding could be a key problem for SLR just as phonological coding problems have been linked to poor WR and reading in research on FLR.

In fact, some researchers in SLR have reported that phonological codes are used less or are deficient in SLR. In a letter cancellation task in English, Hatch et. al. (1970) found that SL readers crossed out e's regardless of stress, whereas, FL readers crossed out more e's in stressed than unstressed syllables. They interpreted this as evidence that SL readers either make less use of phonology during reading or have less proficient knowledge of SL phonology. In analysis of oral reading miscues, Cziko (1980) noted that intermediate SL readers of French made more graphically similar oral miscues than did advanced SL and native readers. He interpreted this as evidence of greater dependence on orthographic coding over phonological coding in SLR. However, the general nature of these tasks leaves room for many possible interpretations. Chu-Chang and Loritz (1977) looked at low level SL readers of English whose FLs were Chinese (a deep logograph) and Spanish (a shallow alphabet). In a forced choice word list task, subjects viewed lists of four English words and then chose from a second list words that matched those in the first. The second list contained foils which were orthographically and phonologically similar to the target words in the first list. Both groups made more errors on orthographic than on phonological foils. They concluded that poor SLR may be related to decreased use of phonological codes regardless of FL background. However, these effects may be artifacts of the task. Word memory tasks have been noted to focus attention on formal orthographic and phonological characteristics of words depending on the similarity between distractors and targets (Hummel, 1993).

Segalowitz and Herbert (1990) looked for evidence of phonological coding in the reading of highly skilled bilingual users of French (a very shallow language) and English (a less shallow language). Subjects were divided into four groups according to FL and SL reading speed. Experiment I was a lexical decision task containing homophone foils. There were no significant differences in error rates or reaction times for homophone foils in French FLR, but a significantly higher error rate on homophone foils in English FLR suggesting (contrary to the orthographic depth hypothesis) that phonological codes may be implicated in lexical access in English, but not in French. There was no significant difference on phonological foils for any of the SL groups indicating little use of phonological codes in SLR. Because there was no difference, they could not relate SLR speed to phonological coding. Given the mixed results found in lexical decision tasks in general, these conclusions must be tentative. In sum, there is minimal support for the belief that SLR differs significantly from FLR in that there is less use of phonological codes.

In contrast, Chitiri, Sun, Willows and Taylor (1992) found similarities between SL and native readers of Chinese. In experiment 1, intermediate and advanced level SL and native readers of Chinese viewed two consecutive Chinese words separated by a brief pause and indicated whether they were the same or different. In half of the trials, targets were phonologically, orthographically or semantically similar foils. Error rates on phonological and semantic foils were low, but all three groups made a higher proportion of errors on orthographic foils suggesting they all made predominant use of orthographic codes in this logographic orthography. However, this type of task may have encouraged subjects to attend to surface orthographic details of the stimuli in order to compare the two stimuli. Error rates were highest for intermediate readers and lowest for natives. Decision latencies for the SL readers were also slower than for natives. This suggests that coding skills of SL readers may be similar in kind to FL readers, but perhaps slower and less accurate. Verhoeven (1990) drew similar conclusions from a longitudinal study of SLR acquisition by young children. In comparison to FL readers, He found that the SL readers were less efficient in various measures of reading, but relied on similar strategies as the native readers. Moreover, reading comprehension and word recognition were highly related to oral proficiency.

There is a growing body of concurring evidence that phonological codes contribute to sentence comprehension in SLR from sentence judgment tasks in which subjects judge the acceptability of sentences, some of which contain phonological, orthographic or semantic foils. In Chitiri et. al.'s (1992), experiment 2, sentence judgment response times were slower for SL readers than natives. Intermediate SL readers made more phonological errors than did advanced SL readers who made more than did native readers. This offers evidence that phonological codes are used in sentence comprehension in both FLR and SLR of Chinese. SLR may actually be associated with increased reliance on phonological codes or these readers may be less skilled at using orthographic codes to correct phonological errors. Similarly, in Segalowitz and Herbert's (1990), experiment 2, the four subject groups judged the acceptability of English and French sentences. In the English sentences, English FL readers and both groups of SL readers made significantly more errors on homophone foils suggesting that phonological codes are utilized in this task by both FL and SL readers of English. There was no difference in the French task except for slow SL readers. These differences between French and English are difficult to reconcile with the orthographic depth hypothesis described below. Oddly enough, Segalowitz and Herbert suggested that this latter outcome may result from the slow SL French readers' greater difficulty with using phonological codes in memory either because phonological codes are deficient or they are inefficiently generated resulting in working memory problems. Khaldieh (1991) also reported evidence of the use of phonological codes in a sentence judgment task in SLR of Arabic. Thus, although earlier studies suggested phonological codes play a smaller role in SLR, there is some scant evidence that they are similarly important to SLR as has been demonstrated in FLR.

PHONOLOGICAL CODES IN SECOND LANGUAGE WORD RECOGNITION

These studies are not able to determine whether phonological codes are activated early enough to contribute to WR. There is very little published research on SLWR with which to answer this question. One type of study which offers evidence that phonological codes are employed in SLWR comes from studies of cross-linguistic influence in bilingual reading. This line of research stems from investigations of the extent to which bilingual lexical representation and processing is language specific. Several researchers have argued that to the extent that orthography does not specify one of the two languages, low level processes in bilingual WR may overlap (Beauvillain & Grainger, 1987; Beauvillain, 1992). Doctor and Klein (1992) incorporated this view in a bilingual WR model. In this model, the visual codes for words in either of a bilingual's two languages are transcoded into one or more phonological codes via one shared non-language-specific set of all the GPC rules applicable to both languages. The resulting codes are then mapped to possible matches in the bilingual's two separate phonological input lexicons. Resulting matches are later converted to graphemic codes and compared with orthographic inputs in order to select the correct candidate meaning. Thus, words that are homophones in both languages but only orthographically correct in one of the languages would result in a match in both the correct and incorrect lexicon. This identification error could only be corrected by time consuming correction processes. They found positive support for this model from a lexical decision task in which Afrikaans/English balanced bilinguals had to determine whether stimuli were words in either Afrikaans, English or neither language. The subjects made a significant number of errors and had significantly higher latencies for interlingual homophones in comparison to nonhomophones and pseudohomophones of only one language. Further support for non-language specific activation of phonological codes has come from bidialectal interference in reading in Chinese (Lam et. al., 1991) and knowledge of phonotactic constraints in bilingual judgment and lexical decision tasks (Altenberg & Cairns, 1983). The issue of language contact or overlap in bilingual/bidialectal processing is controversial. Task demands influence the extent to which overlap effects are observed

(Durgunoglu & Roediger, 1987; Hummel, 1993). Nevertheless, these findings suggest that under certain conditions, phonological codes are implicated in SLWR. Moreover, these codes may lead to the activation of additional false candidates in the other language. This could increase the burden on orthographic verification processes and increase the likelihood of errors which could decrease WR efficiency in bilinguals. In this way, the use of phonological codes would seem to be a lot noisier in bilingual reading.

Transfer of first language coding preferences

Some researchers have suggested that the extent to which phonological codes are employed in one's FL reading experience may influence the extent to which phonological codes are employed in a SL. Orthographic depth (cf., Liberman, Liberman, Mattingly & Shankweiler, 1980) is a measure of the distance in the relationship between symbols and speech sounds in languages. The Chinese logographic orthography is deep whereas the Spanish alphabetic orthography is very shallow. The *orthographic depth hypothesis* predicts that the more shallow the orthography, the more reliance on phonological codes in WR. Phonological codes have been more frequently implicated in WR in shallow orthographies than in deeper ones, although there is considerable controversy (for an early review see Tzeng, 1980). For example, FL readers of Serbo-Croation, a very shallow orthography, have been reported to rely heavily or even necessarily on phonological codes

(Carello, Lukatela & Turvey, 1988; Feldman, Lukatela, & Turvey, 1985). In contrast readers of deep orthographies such as Hebrew in the unvowelized form have been said to evidence little use of phonological coding (Frost & Katz, 1989; Frost, Katz & Bentin, 1987; Shimron & Sivan, 1994). The possibility that WR processing varies across orthographies opens up the possibility that the type of FLWR processes fostered in one orthography could be transferred to SLWR exerting an additional influence on SLWR processing. When the orthographic depth of the FL and SL diverge, transfer effects could predispose the SL reader to rely on phonological codes to a different extent than most normal FL readers of that language (e.g., Brown and Haynes, 1985; Haynes and Carr, 1990). There could be implications on the efficiency and success of SLR as a result.

Some evidence of this has been reported (see Koda, 1996 for a review). In the Chu-Chang and Loritz (1977) study, Chinese FL subjects made more errors on orthographic foils than did the Spanish FL subjects, indicating that experience reading a deep FL orthography may lead to even greater reliance on visual processing over phonological processing in a SL. Brown and Haynes (1985) found that SL readers of English who were FL readers of Japanese were better in both linguistic and nonlinguistic visual processing tasks but worse at a word naming task than ESL readers who were FL readers of Arabic (a shallow orthography). In addition, they found that the Japanese subjects' SL listening proficiency was unrelated to their SL reading proficiency. Conversely, there was a strong correlation between these two for FL readers of more shallow orthographies (Arabic and Spanish).

Koda (1990) studied SL readers of English whose FL orthographies were likely to lead them to be heavily dependent on either orthographic or phonological processing strategies according to the orthographic depth hypothesis. She compared the subjects' reading speeds in two matched English texts: a normal control text and one containing several key words encoded in a novel script for which phonological information could not be assembled. In the second text, there was a significant decrease in reading speed for readers of a relatively shallow FL, but no change for readers of a deeper FL orthography. She concluded that these readers did transfer coding strategies from their FLR experience. As a result, the readers predisposed to phonological coding were handicapped by the inaccessibility of phonological information in the test passage whereas those predisposed to orthographic coding were not. However, a problem with this conclusion is that the Japanese readers who have FL logographic reading experience may simply be better at retaining a novel visual pattern in memory without the aid of phonological information or language specific orthographic information better than readers from nonlogographic FL orthographies. It is not clear whether they actually make less use of phonological coding during SLR of real words. Overall, Koda (1996) concludes that similarity between the FL and SL orthographies facilitates SLWR.

Deficient phonological codes

Finally, several researchers have suggested that deficiencies in the phonological codes generated by SL readers may impact their use in SLR. Muchisky (1983) compared college level FL readers to SL readers of English from various FL backgrounds including both alphabetic and non-alphabetic scripts. He used a short-term memory, reaction time study consisting of four same-different decision tasks. The tasks required subjects to decide whether word pairs rhymed (a phonological decision), were spelled similarly (an orthographic decision) or were synonymous in meaning (a semantic decision) and whether geometric shapes were alike (a control visual pattern recognition decision). Each task was done twice with different stimuli. In one condition subjects had to orally shadow an aural recording of random numbers in English. The reaction times of the second language subjects were longer for all tasks compared to those of the FL subjects. The error rates for the rhyming tasks were higher than for the other tasks suggesting difficulty using phonological knowledge (at least the kind of phonological knowledge needed to make such judgments). Most interestingly, opposite to FL readers, the reaction times of SL readers decreased in the shadowing condition for all three word choice tasks. Reaction times in the rhyming task decreased the most. Assuming that shadowing disrupts phonological processing, he concluded that phonological processing must handicap rather than facilitate SLWR. He suggested this may be because these SL readers apply their FL phonological system inappropriately to phonological processing in SLR. His conclusion is interesting but doesn't necessarily follow from these results. It has been argued that shadowing also requires attentional and short term memory resources. If so, his study may instead demonstrate that when SL readers have sufficient resources, they engage in more time consuming processes perhaps additional verification processes. When they cannot do this, more automatic, perhaps phonological codes, quickly determine WR.

In an early study, Hatch (1971) found that when fourth grade ESL students whose native language was Spanish were asked to choose exemplars of categories from a list, they incorrectly chose words like *fit* for a *body part*. These errors could be explained by the application of Spanish FL phonological rules in SLR of English. Hatch reports similar findings by Serpell (1968) of reading errors on /r/-/l/ distinctions in FL Bantu readers of English. Khaldieh (1991) studied beginning, intermediate and advanced SL readers of Arabic (a shallow alphabet) whose FL was English (a somewhat less shallow alphabet of a different script). Experiment I was a forced choice word list memory task containing visually and phonologically similar foils. In experiment II the subjects judged the semantic acceptability of sentences. Unacceptable sentences contained orthographic or phonological foils that resembled a word that would make the sentence acceptable. The phonological foils in both experiments differed from the target by a single phonological distinction not found in spoken English and according to Khaldieh one that is difficult for native English learners of Arabic as a SL. He found that the error rates on both types of distractors in both tasks were highest for beginning readers and decreased with increasing proficiency. Advanced readers still made significantly more errors than natives who made only some visual, but no phonological errors (of course these would not be similar sounding phonological foils for the natives). In the word task, he found that the beginning and intermediate subjects made relatively more visual errors, but the advanced subjects made relatively more phonological errors. He concluded that with increasing proficiency, SL readers gradually use more phonological codes in such tasks. However, it could also be true that the low level readers make more orthographic errors, not because of more reliance on orthographic processing, but because of less spelling knowledge. In the sentence task, nonnatives of all levels made more phonological errors than visual errors. Khaldieh concludes that nonnative readers use both types of codes and that both pose difficulties for them through all levels of language proficiency. In particular, their use of phonological codes at low language proficiency levels demonstrate that nonnative knowledge of phonemic distinctions can result in deficient phonological codes in SLR leading to the acceptance of incorrect foils. Furthermore, because the orthographies of Arabic and English are distinct, these codes cannot be attributed to the misapplication of FL GPC rules.

In summary, despite claims that phonological codes do not play a significant role in SLR, there is some evidence they do influence processing in SLR. The best evidence of this comes from errors to phonological foils in sentence judgment tasks. However, none of these studies indicate whether phonological codes are activated early enough in SLR to influence the activation of semantic codes in WR. There is some indication phonological codes may be employed less in SLR compared to FLR in word reading tasks especially at lower levels of reading proficiency. Moreover, the extent of facilitation offered by phonological codes may be smaller than in FLR. Possible problems in developing and using efficient phonological coding in SLR could arise from transfer effects from FLR experience, cross-linguistic interference from phonological similarity between the two languages, and deficient SL phonemic knowledge.

CHAPTER II

RESEARCH PROBLEM & METHODS

Phonological codes in second language word recognition

The importance of lower level processes in SLR has often been minimized resulting in a paucity of research. In contrast, a great deal of research in FLR demonstrates that skillful text-driven WR is the crucial foundation to skillful reading. Poor FLR is strongly associated with deficient WR and this in turn is highly associated with deficiencies in phonological sensitivity or knowledge. Phonology plays a significant role in FLWR of English although there is debate over the extent of that role. Phonological codes contribute significantly to the activation of semantic codes and may facilitate the retention of these words in short term memory during higher level processing.

Some preliminary research has indicated that WR is also fundamental to the development of skillful SLR (e.g., Eskey, 1988; Favreau and Segalowitz, 1983; Haynes & Carr, 1990). However, very little research has been conducted on the subcomponent processes which underlie WR and reading. In particular, little is known about the use of phonological codes in accessing semantic codes for words and in facilitating subsequent higher level processing. It has been suggested that SL readers of English may make little use of phonological codes and may instead rely heavily on orthographic codes. Some reasons for this include the primacy of printed language in foreign language acquisition, the transfer of predominantly visual coding strategies from FLR experience in a deeper orthography, insufficient knowledge of SL orthographic-phonologic correspondence or insufficient knowledge of SL phonology. There is some indication that phonological codes may not facilitate SLR as much as in FLR. In SLR, phonological codes may not relate to semantic codes with as much specificity. Phonological codes may lead to the increased activation of a large number of false candidates because the codes are constructed on the basis of faulty phonological knowledge or because they may activate similar sounding words in the FL lexicon.

Very few studies have been conducted to investigate whether phonological codes are employed by SL readers early enough in SLWR to influence semantic access. Segalowitz and Herbert's (1990) finding of little involvement of phonology in SLR of English and French, and Doctor and Klein's (1992) conclusion that non-optional phonological codes mediate access to the lexicons of both languages of bilingualsis are both suspect because they utilized lexical decision tasks. Lexical decision tasks in monolingual readers have also offered mixed evidence about the role of phonological codes in WR. Performance on these tasks may vary as a function of the types and proportions of stimuli. In Doctor and Kleins' (1992) study, one eighth of the stimuli were homophones and there were no pseudohomophones. In Segalowitz and Herbert's (1990) study, half of the stimuli were homophones and half of these were pseudohomophones. This difference in stimuli may have affected the extent of reliance on phonological codes. In addition, neither of these studies reported the word frequencies of the stimuli nor tested the subjects for spelling knowledge. Above all, these tasks have limited application to the question of what codes are used to activate meaning, since they may be performed without reference to semantic information (Coltheart, Davelaar, Jonasson & Besner, 1977; Hummel, 1993). Finally, in both of these studies of SLWR, subjects read in the same script in the FL and SL, opening up the possibility of confounding influences between the FL and SL. Although Doctor and Klein (1992) demonstrated that phonological codes were utilized by the subjects in their task, this may be a result of FLWR processes. It is not clear whether phonological codes are similarly employed in SLWR of English when the FL does not share the same orthography.

Thus, it remains to be shown whether phonological codes mediate the activation of semantic codes for less familiar words in SLR of English among advanced readers as has been demonstrated in skillful FLR in English. To address this question, the research task must require semantic access. The semantic categorization task is one task which has been used in FLR research, but not in SLWR research. The SL script should be distinct from that of the reader's FL in order to avoid the confounding potential effects of a shared script and a potentially shared set of GPC rules. The FL orthography should not be a deep orthography which might predispose the SL reader to adopt predominantly orthographic coding strategies. Thus, the first aim of this research is to look for evidence that phonological codes play a role in the activation of semantic codes in word comprehension in SLR as has been demonstrated in FLR. A semantic categorization task will be used and subjects will be advanced SL readers whose FL orthographic system is shallow and distinct from English orthography.

Phonological codes in sentence reading

Phonological codes are also thought to be involved in higher level reading processes in which information must be temporarily held and manipulated in short term memory because of their stability relative to other codes (Baddeley & Lewis, 1981; Conrad, 1972; Perfetti, 1985; 1988; Van Dijk & Kintsch, 1983). In sentence judgment tasks, Coltheart et. al. (1988) and Coltheart et. al. (1991) reported significant error rates to sentences containing homophone and pseudohomophone foils suggesting that both addressed and assembled phonology contributes to sentence comprehension.

A handful of studies using sentence judgment tasks in SLR have found that subjects make more errors on sentences containing homophone foils than on control sentences in SLR of Chinese (Chitiri et. al., 1991), Arabic (Khaldieh, 1991), English and French among slower readers only (Segalowitz & Herbert, 1990). Word list memory tasks have also offered evidence of reliance on phonological codes among SL readers of Chinese (Chu-Chang & Loritz, 1977), Arabic (Khaldieh, 1991) and English (Muchisky, 1983) although these tasks are less informative because results are highly influenced by the stimulus set. Thus, the second aim of this research is to look for further evidence that phonological codes are employed in sentence comprehension in SLR of English as has been demonstrated in FLR. A sentence judgment task will be used and subjects will meet the same requirements as noted above.

Interlanguage phonology in second language reading

The SL learner's linguistic competence at any point up until native-like competence is attained may be termed inter-language (IL) competence (Selinker, 1972). If phonological codes are utilized in SLR, the nature of the SL learner's IL phonological competence becomes relevant to SLR as well. IL phonology may result in deviations and possibly even impairment in SLR performance.

A number of different aspects of the IL phonological system may have implications on phonological coding and dependent processes in SLR. Segmental phonology is the attribute selected for consideration in this research. A number of different factors in SLA may influence the development of segmental phonology resulting in deviations from native norms including phonemic underdifferentiation, overdifferentiation, reinterpretation and phone substitution (Ioup & Weinberger, 1987;

Weinreich, 1953). Developmental factors may also result in phonemic mergers and approximations (Major, 1987). Phonemic mergers or underdifferentiation occur when a phonemic distinction in the FL is neutralized by SL learners. As a result, two or more phonemes in the target language are incorrectly considered allophones of a single phoneme by the SL learner. Minimal pairs crucially differentiated by these two phonemes could in effect become homophones for the SL learner. Such potential homophones are hereafter referred to as IL homophones in contrast to homophones which are word pairs that are phonemically undifferentiated by a particular group of native readers.

Because IL phonological competence emerges through the influence of a number of complex factors which vary across individuals, it is difficult to predict the behavior of a particular individual SL learner. What constitutes an IL homophone may vary from one person to the next and from one point in a learner's SLA to the next. However, some specific IL features like phonemic neutralizations are often observed in significant proportions among adult SL learners who share commonalities like FL background and length and type of SL learning experience. They also appear to be fairly resilient features as well. The development of new second language phonological representations may be severely impeded by the existence of phonetically similar FL representations (Flege, 1995). The difficulty is so widespread that some researchers have proposed a sensitive period for phonological acquisition: a limited period of time during the development of an individual during which he or she is capable of successfully acquiring the sound system of a language (Long, 1988; Singleton, 1989; Scovel, 1988). After this period, the acquisition of the SL phonological system is likely never to reach native speaker norms. The offset proposed for this period may be as early as age 5 or 6 (Long, 1988). Sensitive periods are highly controversial (e.g., Flege, 1987; Snow, 1986). Nevertheless, the notion of a sensitive period for the acquisition of phonology has attracted substantial interest because of the resilience of IL phonology.

In any case, given the observation that deviations from native norms are widespread and resilient in SL speech production and perception, there may be similarly widespread and resilient implications for reading processes which are dependent on phonological codes. Thus, an important research question is whether underdifferentiated phonemic contrasts cause SLR to deviate from FLR. Thus, the third aim of this research is to look for evidence that SLR deviates from FLR as a result of deviations in the phonological system of SL readers. IL homophones will be used as the test case in both the semantic categorization task and the sentence judgment task. Subjects will be SL users who began SLA after early childhood in addition to meeting the requirements noted above.

Implications of interlanguage phonology in second language reading

The efficiency of reading processes which utilize phonological codes depends on the efficiency of generating those codes and relating them to other codes. In FLR research, developing skill in phonological coding has often been considered crucial to developing WR skills and these in turn are crucial to reading comprehension (e.g., Chard, 1995; Perfetti, 1988; Perfetti and Marron, 1995; Stanovich, 1992). Deficits in phonological coding abilities have been strongly associated with poor FLR (e.g., Elbro, 1994; Shankweiler et. al., 1995; Torgesen, 1994). Specifically, deficits in segmental language skills may be the underlying cause (Shankweiler & Crain, 1986; Shankweiler et. al., 1992). There are some suggestions that phonological representations of poor readers may be less differentiated than those of better readers and this impairs the development of letter-sound relationships which underlie skillful reading (Fowler, 1991). As noted above, many SL users have difficulties developing native-like differentiations in segmental knowledge often resulting in non-native speech perception and production. Although these phonological problems are different from those observed among poor FL readers, there may be possible parallels as to their impact on reading.

To the extent that SLR also relies on phonological coding, deficiencies in segmental phonology could have a parallel negative impact on the success of SLR. SL readers with deficient segmental knowledge might generate phonological codes less efficiently and less accurately. For example, the neutralization of phonemic distinctions could result in phonological codes that relate to semantic representations with less specificity. These codes might increase the activation levels of a greater number of inappropriate candidates which would take a longer time to resolve (Van Orden et. al., 1990). Increased processing time and greater reliance on orthographic codes or additional orthographic verification processes might be necessary in order to secure the correct candidate. If the correct candidate is not secured, or an inappropriate candidate is, higher level knowledge and context based expectancies must be employed to assist in choosing or in regressing and correcting the error once it becomes evident. Thus, enabling reading comprehension but at a cost in time and resources (Favreau and Segalowitz, 1983).

Several researchers have suggested negative implications are associated with phonological coding in SLR due to deficiencies in the SL phonological system (e.g., Hatch et. al., 1970; Muchisky, 1983). Segalowitz and Herbert (1990) suggested that slower advanced SL readers may have more difficulty with phonological codes either because the codes are deficient or the cost of generating them curtails retention of other nonphonological supporting information in working memory. Khaldieh (1991) has suggested that SL readers may store incorrect phonological representations of words in memory leading to confusions with other words in sentence reading. However, as was discussed in chapter one, these conclusions are limited because of problems with experimental design. Moreover, none of them can address the issue of phonological coding in the activation of semantic codes for words. Thus, the fourth and final aim of this research is to investigate whether a prescribed set of IL phonemic deviations from native norms are associated with decreased comprehension or speed in the activation of semantic codes for words and in utilizing phonological codes in sentence and passage comprehension.

In summary, there are four general questions posed in this research on SLR in English:

1. Is SLR similar to FLR in that phonological codes contribute to semantic activation for less familiar words?
2. Is SLR similar to FLR in that phonological codes are employed in sentence reading?
3. Is the SL reader's IL phonological system operative in SLR processes utilizing phonological codes resulting in deviations from native readers' performance?
4. Are phonemic deviations from native norms associated with decreased comprehension or speed in SLR processes utilizing phonological codes?

A set of experimental tasks were designed to attempt to address these questions. The general parameters relevant to all of the tasks are described first, followed by each of the specific experimental tasks and their relevant hypotheses.

RESEARCH DESIGN

Second language reading in English

This study investigates reading in English as a second language. English orthography is moderately shallow. Spelling to sound correspondences are highly regular for the majority of words, but there are a substantial number of exceptions. There is a substantial body of research on phonological coding among first language readers of English as discussed in chapter 1. This provides a foundation for SLR research and a basis for comparing FLR to SLR. The study of SLR in English is of widespread interest because of the large number of SL learners of English.

Thai first language

To avoid the additional complication of different FLs and FL scripts, this study investigates SLR by subjects of a single FL. Thai FL is selected for several reasons. First, the Thai script is a Sanskrit based alphabet which has no resemblance to the script used in English. Consequently, when the Thai English bilingual reader is reading in either of his or her languages, distinct graphic features of the text clearly specify which language the word belongs to, enabling language specific phonological codes to be generated. Without this specification, processing may be complicated because there is a greater potential for printed words to activate codes in the inappropriate language

(Beauvillain, 1992; Doctor and Klein, 1992).

Secondly, the relationship between Thai orthography and phonology is very shallow. Spelling to sound correspondences are highly regular with very few exceptions. There are very few homographs or words with the same spelling which have more than one pronunciation. There are a small number of homophones or different words that sound the same but are spelled differently. One symbol generally represents only one sound in a given linguistic context, but the same sound in a particular context may be represented by a number of different symbols. Thus, phonological codes may be employed in reading Thai and Thai FL readers would not likely be predisposed against using phonological coding strategies in SLR in English as has been suggested for FL readers of deeper orthographies such as Chinese. Meara et. al. (1985) have suggested that for readers of a very shallow orthography, experience with the close mapping between print and speech may predispose SL learners of English to seek similarly close ties between the two modalities in English.

Thirdly, Thai is chosen because Thai phonology varies quite extensively from English phonology. Certain phonemic neutralizations are predicted to occur among these subjects on the basis of processes operative in the development of SL phonological competence such as transfer and developmental processes (Corder, 1971; Eckman, 1987; Selinker, 1972; Tarone, 1987).[1] Observations of Thai learners of English,

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[1]Tarone (1987, p. 79) notes at least nine potential processes that are operative in

concur that they do occur in significant proportions in the speech production and perception among Thai SL users of English (Richards, 1969; Defense Language Institute, 1974). Ideally, subjects would be chosen for this set of experiments who have been tested and found to neutralize these phonemic contrasts. However, any such test of the subjects in this experiment would risk revealing the focus of the research which might lead the subjects to adjust their strategies accordingly. In addition, performance on phonological tests by SL learners have been shown to vary extensively according to the test features, the context in which the test occurs and the learner's own perceptions of the test (for a review see Majors, 1987). For instance, pronunciation is often closer to native norms when reading word lists than when reading texts, and when speaking to a native speaker of the SL than when speaking to a SL speaker . It is unclear what test would best reveal the SL user's phonological competence underlying phonological coding processes in SLR. The experimental reading tasks themselves may offer the best evidence.

Five types of phonemic neutralizations are selected for study. They

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the development of IL phonology: negative transfer from the FL, first language acquisition processes such as markedness, overgeneralization, approximation, avoidance, the inherent difficulty of target phonemes, the natural preferences of articulators and social and emotional constraints. Tarone concludes that because of these multiple interacting factors, the IL system may not be predictable, but may be variable. However, despite the fact that performance may vary, Eckman (1987) has argued that underlying IL phonological competence is not entirely variable, but can be described by the operation of linguistic rules.

are presented in table 2.1. Some potential SLA processes that might induce them are listed as well. All of them are frequently observed in general observations of Thai SL users of English like the subjects in this study and have been formally reported in error data (Richards, 1969; Defense Language Institute, 1974). IL homophones containing the first three consonant contrasts also attracted a significant number of errors on a semantic categorization task in a pilot study. Consonants are

Table 2.1 Selected Phonemic Contrasts

Neutralization in IL English	Thai FL influence	Other relevant factors
Final voiced obstruents are devoiced to become unreleased plosives. /b/ & /p/ are merged, /d/ & /t/ are merged	Terminal devoicing of obstruents, Thai orthography retains distinction	Markedness: final voiced contrasts acquired last (Eckman, 1987)
Fricative /sh/ & affricate /ch/ are both substituted for by a less aspirated form of /ch/	Thai /ch/' has less aspiration than English and includes phones ranging between English /ch/ to /sh/	
/r/ initially or in initial consonant clusters is flapped to merge with /l/	Flapped [r] & trilled [r] allophones of /r/ contrast with flapped /l/ only in formal speech styles; /r/ is substituted for by flap [l] in 95% of everyday speech in Bangkok variety, (Beebe, 1974), Thai orthography retains the distinction.	English /r/ and /l/ often merged in IL (Borden, Gerber & Milsark, 1983; Dickerson, 1976) Thai ESL learners produced the contrast correctly on 9% of the time in a listing task (Beebe, 1974)
Initial /v/ is substituted for by /w/	/w/, no initial /v/	
/e/ is substituted for by /e/	Thai has phonemic long and short /e/ , the latter is similar to English /e/	

emphasized because they may be particularly important in WR since in English they map onto phonological codes more regularly than do vowels, which often have a many to many relationship to sound. In addition, these neutralizations are not common to the regional dialect of American English of the native English speaking subjects in this study.

Native Thai subjects

Subjects were twenty-four native speakers of Thai[2] who were highly proficient in English as a SL and were studying full time at Michigan State University. Subjects participated voluntarily and did not receive any compensation for participation. Subjects all met the following criteria:

1. They have normal or corrected to normal vision.
2. They consider standard Thai[3] to be their native language.
3. Thai was the predominant language used in childhood.
4. Thai was the predominant language used in primary and secondary education.
5. They feel they are proficient readers in their FL.
6. They are not proficient readers in any other language besides

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[2]Because some of these Thai speakers were also exposed to a Chinese language in the home, the notion of native speaker may be difficult to define. All of the participants felt that Thai was their native language and met the other requirements as noted.

[3]

he variation of Thai spoken in central Thailand is generally considered standard. The research here is based on the sub-class of this variation which is spoken in Bangkok, the capital and single largest city in Thailand.

Thai and English.

7. They have advanced level competence in English and English reading as demonstrated by at least 3 years of formal instruction and/or exposure to English as a foreign or second language and have previously scored at least 550 on the Test of English as a Foreign Language or at least 80 on the Michigan State University English Language Center Placement Test or the Michigan English Language Assessment Battery.

10. Intensive English acquisition was not begun before age 10.

11. They are no older than age 40.

The subjects included 14 females and 10 males. The average age was 24.9 years (standard deviation = 3.8). Additional information on the subjects is provided in Appendix 1.

Native English subjects

Twenty-four native speakers of English also participated in the study as a native comparison group. All subjects participated voluntarily and were either undergraduate students at Michigan State University who received credit for a course requirement for participation or graduate students or members of the local community with at least some post secondary education who received no compensation for participation. All of these subjects met the following criteria:

1. They have normal or corrected to normal vision.
2. They consider English to be their native language.
3. They do not have advanced proficiency in any other language.
4. They have completed secondary education and some tertiary education in English.
5. They are no older than age 40.

The subjects included 10 females and 14 males. The average age was 25.2 years (standard deviation = 6.14). Additional information on the subjects is located in Appendix 1.

General procedures

All subjects were naive about the specific types of stimuli and predictions of this experiment. Before beginning, they were informed of the general purpose, and requirements of the experimental tasks and were asked to give their written consent. Subjects were assigned a number and completed a brief language and reading information survey. At the end of the experiment, the native subjects were offered an optional brief explanation of the specific aims of the research. All subjects were the same for all three experimental tasks and all subjects participated in all three tasks in one session with breaks in between tasks. The subjects were randomly assigned to one of three different orderings of the three tasks. A fourth task, a spelling knowledge task, was completed at the end by the native Thai subjects only. The entire experimental session took around one hour for the native English subjects and around one and 1/2 hours for the native Thai subjects. Subjects were tested individually in a quiet, well lit testing room or office. The experimenter was usually present in the room during the experiment seated at a separate desk across the room so that neither subject or experimenter were within direct sight of each other while subjects were performing the experimental tasks.

Experiment I: Phonological codes in word comprehension--Lexical semantic categorization task

Experiment I is a brief exposure, masked semantic categorization task. In this task, subjects view a semantic category (e.g., *an animal*) followed by a single word stimulus (e.g., *cow)* which is briefly exposed before being replaced by a graphic mask (*XXXXXXX*). Subjects must decide whether the word is an exemplar of the semantic category or not. Some of the non-exemplars are the crucial targets. They are homophone foils (e.g., *bare)* which are themselves non-exemplars, but which sound like a true exemplar (*bear*). Because the task requires subjects to evaluate the meaning of the stimulus words, false positive responses to these phonological foils would be expected if they have activated the meaning of the sound-alike true exemplar via phonological codes. Alternatively, longer response times to correct no responses would be expected if the inappropriate meaning is activated but the subject uses additional processing to rule out the foil on the basis of some additional orthographic verification procedure. These phonological foils not only sound like the true exemplars, but also look like them to some extent. Thus, it is possible that their similar orthographic features are in fact responsible for the semantic activation of the sound-alike true exemplars. In order to control for the potential effect of their orthographic similarity, a yoked orthographic foil (e.g., *belt*), which is closely matched to the actual exemplars orthographically but not phonologically, is included for each phonological foil. These foils look similar but sound different from the actual exemplar. False positive decisions and correct positive decision latency times to the phonological foils in comparison to the orthographic foils are the crucial results for this experiment.

The stimulus set includes 10 homophone foil words and 10 yoked orthographic control foil words. If phonological codes lead to the activation of semantic codes for words in SLWR as has been previously demonstrated in FLWR of less familiar English words, the following results are expected:

Hypothesis 1: In comparison to their yoked orthographic control foils, for these homophone foils, the native English subjects will:

a. make more false positive errors.

b. have longer correct no response times.

Hypothesis 2: In comparison to their yoked orthographic control foils, for these homophone foils, the native Thai subjects will:

a. make more false positive errors.

b. have longer correct no response times.

It may be argued that false positive errors to phonological foils in the first set of words could arise from phonological codes that are activated after semantic activation, on the basis of addressed phonological codes stored in the lexicon. Thus the stimulus set also includes 10 pseudohomophone foils and 10 yoked orthographic control foils. Pseudohomophones (e.g., *focks*) are non-words that sound similar to actual exemplars (*fox)* of the category (e.g., *an animal*) and are legal according to English rules of orthography and phonology. They are included to simulate highly unfamiliar or novel words for which no lexical representation should be available. Phonological codes must be computed in order for pseudoword foils to result in the semantic activation of their corresponding homophone real word exemplars. Again, if phonological codes lead to the activation of semantic codes in SLWR as has been previously demonstrated in FLWR of pseudowords, the following results are predicted:

Hypothesis 3: In comparison to their yoked orthographic control foils, for these pseudohomophone foils native English subjects would:

a. make more false positive errors.

b. have longer correct no response times.

Hypothesis 4: In comparison to their yoked orthographic control foils, for these pseudohomophone foils, native Thai subjects would:

a. make more false positive errors.

b. have longer correct no response times.

In order to look for evidence that IL phonology may result in deviations from native norms in the activation of semantic codes via phonological codes in SLWR, an additional set of 16 IL homophone foils and 16 IL pseudohomophone foils are included along with their corresponding yoked orthographic control foils. IL homophones and IL pseudohomophones are words and pseudowords containing one of the selected phonemes listed in table 2.1 which are likely to be neutralized. These words should sound the same as the correct category exemplar for many of the Thai subjects, but not for the native English speaking subjects. The following results are predicted:

Hypothesis 5: In comparison to their yoked orthographic control foils, for these IL homophone foils native English subjects will:

a. NOT make more false positive errors

b. NOT have longer correct no response times

Hypothesis 6: In comparison to their yoked orthographic control foils, for these IL homophone foils, native Thai subjects will:

a. make more false positive errors

b. have longer correct no response times

Hypothesis 7: In comparison to their yoked orthographic control foils, for these IL pseudohomophone foils native English subjects will:

a. NOT make more false positive errors

b. NOT have longer correct no response times

Hypothesis 8: In comparison to their yoked orthographic control foils, for these IL pseudohomophone foils, native Thai subjects will:

a. make more false positive errors

b. have longer correct no response times

STIMULI: The experiment consists of 250 trials. Each trial contains a category and a stimulus word or pseudoword. There are 120 exemplars and 130 non-exemplars. The non-exemplars are listed as follows along with a hypothetical example not actually used in this experiment for the same correct category exemplar: *blue* for the category: *a color*: 10 homophone foils (*blew*), 10 pseudohomophone foils (*bloo*), 16 IL homophone foils (*brew*), 16 IL pseudohomophone foils (*broo*), 52 yoked orthographic control foils (*blow*) and 13 word *(fish*) and 13 pseudoword foils (*bamp*) not chosen according to any systematic criteria outside the general requirements for all trials. The entire stimulus set is listed in Appendix 2. Each stimulus word or pseudoword appears only once in the experiment. Phonological foils of different types are not related to each other as are the examples above used here only to demonstrate the types of foils. Trials are presented in random order with the exception that the first three words at the beginning and after a break in the middle are not crucial test words, no two phonological foils appear consecutively and a phonological foil and its orthographic control are separated by at least 3 other stimuli. Subjects view one of three different random orderings of trial presentations.

Yoked orthographic control foils are closely matched to their corresponding phonological foils. In most cases, they differ from their correct category exemplar words in the same position as their yoked phonological foils differ from them. Orthographic similarity between foils and correct category exemplars is computed according to Van Orden's (1987) estimate of orthographic similarity which is a modification of Weber's (1970) graphic similarity index. Van Orden's index assumes that the same word is identical to itself and would receive a maximum rating of 1. The index decreases towards 0 with increasing differences between two words. The computed orthographic similarity index for the phonological and yoked orthographic foils to their correct category exemplars are listed in Appendix 2.

The real word exemplars and nonexemplar foils in this study are all medium frequency words in the index of Francis and Kucera (1982). They average around 50 tokens with a range of 2-451. Frequencies represent the number of tokens of a particular word that are found in the data base used to construct this index. This index serves as a rough estimate of word familiarity for the subjects. Medium frequency words are chosen because they are more likely to be known by most of the Thai subjects, but not be highly familiar to them, a necessary condition if phonological codes are only able to activate semantic meanings for less familiar words. The actual homophone exemplars corresponding to the real word phonological foils are also medium frequency words so that large differences in familiarity may not influence responses to the foils. Word frequencies for the crucial target words and yoked orthographic controls and the real word exemplars are given in Appendix 2.

Although the test words were all fairly common words in English and the subjects were all advanced users of English, it is likely that some words in the stimulus set were not known to some of the subjects. Subjects were instructed to answer no to any stimulus words that they did not know. Although it would have been very informative to know which words were rejected because of unfamiliarity, adding a third choice to the decision task may have increased decision latencies making it harder to capture the effects of phonological codes activated very early on in the activation of semantic codes. This design feature, however, does not work to the advantage of the experimental hypotheses which are based on false positive acceptances of phonological foils in comparison to orthographic foils.

It may be argued that false positive errors to the target foils may not be due to phonological codes, but incorrect orthographic codes which the Thai readers have associated with the semantic representations for these words. In other words, *blew* may be the spelling they have associated with the semantic representation for *blue* and on the basis of orthographic codes alone, they will incorrectly judge *blew* to be an exemplar of the category, *a color*. Thus, the subjects' inadequate knowledge of spelling might result in errors to foils. To check for this potential factor, at the end of all three experimental tasks, the Thai subjects completed an additional word knowledge task which included the real word exemplars for the 16 IL homophone foils in this study. Unfortunately, time did not allow for all of the foils in this and the following experiment to be included. But it is hoped that this representative sample will give insight into the Thai subjects' general knowledge of English spelling. Subjects listened on headphones to a recording of each of the words followed by a simple definition using the word in it. Subjects could pause or replay the tape at any time. Subjects were instructed to write down the words on an answer form and to be careful to spell the words correctly. They were instructed to leave the item blank if they did not know the word.

The Thai language includes a growing number of borrowed words from English. To ensure that none of the test items sound similar to a Thai word with the same meaning, a native Thai speaker who is similar to the subjects, but not herself a participant, read the list of potential target words out loud. For each word she listed any possible Thai words with a similar meaning. Any words that sounded similar in Thai and English were eliminated to avoid confusions and potential cross linguistic effects due to cognates.

Each category appeared in the test from between four to eleven times, each time with a different exemplar or non-exemplar foil. Narrow class categories (e.g., *a narrow stream* or *a male relative*) which have been used in some similar experiments are avoided. Jared and Seidenberg (1991) have pointed out that such categories may result in expectancies or priming of phonological codes for higher frequency correct candidate exemplars (e.g., *creek* and *son*). This effect could lead to higher numbers of errors on high frequency homophone foils although they did not find that category breadth altered the error rates on low frequency words. The typicality of exemplars to categories my also affect response times. It was not possible to select items only from a published index of typicality which may have limited application to SL subjects. To provide a rough check of this, four Thai speakers similar to the subjects, but not participating in the study were given a list of exemplar-category pairs including the target items in this test. They were asked to rate on a scale of 0-4 how typical they felt the exemplars were of the categories. These results are listed in Appendix 2. This provides a rough estimate for how well the exemplars related to the categories for the Thai subjects, a factor which influences decision times.

APPARATUS AND PROCEDURE: Before beginning, subjects are asked to read the instructions reproduced in Appendix 3. Subjects are seated before a Macintosh SE computer loaded with a psychological experiment program. One key on the left of the keyboard is marked N and one on the right is marked Y. Each trial begins with a 2000 msec presentation of a category name (e.g., *an animal*) in a white box in the center of a grey screen. This is immediately followed by a + fixation point in the middle of the screen. After 500 msec, this is replaced by a word or pseudoword exemplar or nonexemplar (e.g., *cow* or *focks*). This remains visible for 200 msec after which it is replaced by a graphic mask composed of ten capital X's which extend beyond either end of the location of the preceding stimuli. The graphic mask remains on the screen until the subject responds by pressing either of the two keys marked: Y to signify the stimulus is an exemplar of the category or N to signify that it is not an exemplar. There is a 2000 msec inter-trial interval. All stimuli are presented in all lower case except for the capitalization of first letters in proper nouns (e.g., *Spanish*), Geneva bold 24 point font. Half way through the set of trials, subjects are offered a break and then may resume the trials when they are ready.

Jared & Seidenberg (1991) found no evidence that the proportion and types of phonological foils in semantic categorization tasks affect phonological coding. In other words, their subjects did not exhibit strategic control over this process. However, they found that subjects may use a strategic spelling check when stimuli include homophone and pseudohomophone foils. In order to discourage such a strategic check or any other post semantic access processing effects, this study employs a brief exposure masking condition in which targets are only visible for 200 msec before being replaced by a graphic mask: XXXXXXXXXX. Graphic masks may interrupt processes dependent orthographic codes but not phonological codes (Lesch and Pollatsek, 1993; Van Orden, 1987). Lesch and Pollatsek (1993) found that homophone primes facilitated naming times of semantic associates only when the prime was exposed for 50 ms and not for 200 ms before a pattern mask. This suggests that phonological codes may be activated very early in WR and effects may not be observable for long due to the effects of orthographic codes perhaps employed in a verification process. For college level FL readers of English, phonological mediation effects have been observed in semantic categorizations tasks with stimulus onset asynchronies between target word and graphic mask at well under 150 msec (Van Orden, 1987, experiment 2). Because SL readers have been shown to complete other types of WR tasks more slowly than native readers, a 200 msec stimulus onset asynchrony is chosen for all subjects in this study in order to allow adequate time for processing but to place a very generous limitation on the time available for orthographic verification. It is hoped that this will improve chances of observing any effects of phonological codes activated prior to semantic access among the Thai subjects in particular.

Subjects first view 16 practice trials. They are composed of equal numbers of exemplars and word and pseudoword foils not chosen in any systematic way. None of the categories in the practice trials are common to any in the experiment trials. After completing the practice trials, subjects are asked if they have any questions and may proceed with the experimental trials when they are ready.

Experiment II: Phonological codes in sentence comprehension--Sentence judgment task

Experiment two is a sentence judgment task in which subjects read a series of unrelated sentences and judge whether they are sensible or not. The crucial test sentences are anomalous sentences containing foil words that sound like words that would make the sentences sensible. False positive evaluations of these sentences are expected if phonological codes for the false foils are activated and utilized in sentence comprehension making these anomalous sentences sound sensible. As in the first experiment, the orthographic similarity of these homophone foils to their sound-alike meaningful pairs is controlled for by including an additional set of anomalous sentences each containing a yoked orthographic foil. These foils look similar but do not sound similar to the word that would make the sentence sensible.

The stimulus set includes ten anomalous sentences each containing a homophone foil word[4] and ten anomalous sentences each containing a yoked orthographic control. If phonological codes are employed in

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[4] Pseudowords are not used in this experiment because the question of whether addressed or assembled codes are utilized in the activation of semantic codes for words is already addressed in experiment 1. Additionally, Coltheart et. al. (1991) found low error rates on sentences containing pseudohomophones which they believed were due to a lexical checking strategy.

sentence comprehension in SLR as has been previously demonstrated in FLR, the following results are predicted:

Hypothesis 1: In comparison to the sentences containing orthographic control foils, for the sentences containing homophone foils, the native English subjects will:

a. make a higher number of false positive errors.

b. have longer correct no response times.

Hypothesis 2: In comparison to the sentences containing orthographic control foils, for the sentences containing homophone foils, the native Thai subjects will:

a. make a higher number of false positive errors.

b. have longer correct no response times.

In order to look for evidence that IL phonology may result in deviations from native norms in sentence comprehension in SLR, the stimulus set also includes 20 anomalous sentences each containing an IL homophone foil word. IL homophones are words containing one of the selected phonemes listed in table 2.1 which are likely to be neutralized. These words should sound the same as the corresponding word that would make the sentence sensible for many of the Thai subjects, but not for the native English speaking subjects. There is an additional set of 20 anomalous sentences each containing a yoked orthographic control foil. The following results are predicted:

Hypothesis 3: In comparison to the sentences containing orthographic control foils, for the sentences containing IL homophone foils, the native English subjects will:

a. NOT make a higher number of false positive errors.

b. NOT have longer correct no response times.

Hypothesis 4: In comparison to the sentences containing orthographic control foils, for the sentences containing IL homophone foils, the native Thai subjects will:

a. make a higher number of false positive errors.

b. have longer correct no response times.

STIMULI: Subjects view a total of 135 experimental trials: 65 sensible sentences and 70 anomalous sentences. The latter are made up of 10 anomalous sentences each embedded with one homophone foil word, 20 anomalous sentences each embedded with one IL homophone foil, 30 anomalous sentences each containing a yoked orthographic control for each of the target phonological foils, and 10 anomalous sentences embedded with words not chosen according to any systematic principle. Examples of anomalous sentences are as follows:

1. homophone foil: *She guest my age correctly.*
2. yoked orthographic control foil: *He gushed who she was.*
3. IL homophone foil: *They crime up the mountain.*
4. yoked orthographic control foil: *Monkeys can chime trees.*
5. random anomalous sentence: *The yellow was angry.*

In order to control for differences in the sentence frames for the phonological foils and their orthographic controls foils, two sets of anomalous target sentences were devised The sentence frames containing the homophone foils and those containing the orthographic control foils in the first set are reversed in the second set. For example, the example foils from above are placed in the alternate sentence frame in the second set: *He guest who she was. She gushed my age correctly. They chime up the mountain. Monkeys can crime trees.* Half the subjects view one set and half view the other set. For each set of sentences, two different orderings are devised. Trials in each of these are presented in random order with the exception that the first two trials are not target sentences, test sentences containing phonological foils must be separated by at least one filler trial and sentences containing phonological foils must be separated by at least three other sentences from their corresponding control sentences containing the yoked orthographic foils. Subjects views one of two different orderings of one of the two sets of sentences.

Yoked orthographic control foils are closely matched to their corresponding phonological foils. In most cases, they differ from the corresponding appropriate words for the sentence frames in the same position as their yoked phonological foils differ from them. Orthographic similarity between foils and correct category exemplars is computed according to Van Orden's (1987) estimate of orthographic similarity which is a modification of Weber's (1970) graphic similarity index.

As in experiment 1, it may again be argued that false positive judgments of target sentences containing foils may not be due to phonological codes, but incorrect orthographic codes which the Thai readers have associated with the semantic representations for these words. For example, *crime* could be the spelling some of the Thai subjects have associated with the semantic representation for *climb* and on the basis of orthographic codes alone, they will incorrectly judge the anomalous sentences containing *crime* as sensible. Thus, inadequate knowledge of spelling might result in errors to foils. To check for this potential factor, at the end of all three experimental tasks, the Thai subjects completed an additional word knowledge task which included the appropriate words corresponding to each of the 20 IL homophone foils in this study. Although time did not allow for the inclusion of the appropriate words corresponding to the 10 homophone foils as well, it is hoped that this representative sample will give insight into the Thai subjects' general knowledge of English spelling. The test procedures are as previously explained in the section on stimuli in experiment 1 above.

All sentences are 4-6 words long and are grammatically simple sentences. The average sentence length for each type of sentence is very similar. The test words are embedded in roughly similar proportions in the beginning, middle and end of the sentences. The list of target anomalous sentences containing phonological foils and the corresponding sentences containing yoked orthographic control foil words along with word frequencies and orthographic similarity indexes are found in Appendix 4.

APPARATUS AND PROCEDURE: Before beginning, subjects are asked to read the instructions in Appendix 5. Subjects are seated before a Macintosh SE computer loaded with a psychological experiment program. One key on the left of the keyboard is marked N and one on the right is marked Y. The space bar is marked *start*. Each trial begins with a + sign in the center of the screen until subjects initiate the trial when they are ready by pressing the space bar. After a pause of 100 msec, a sentence appears in the center of the screen in a white box set against a grey background. The sentences are printed in Geneva plain 18 point font in lower case letters except where upper case letters are required according to the general conventions of printed English sentences. The subjects indicate whether the sentence is sensible (meaningful) by pressing the Y key or not by pressing the N key. The sentence remains on the screen until the subjects respond by pressing one of these keys. There is a 1017 msec inter trial interval before the + appears again. Subjects view 10 practice trials first. They are composed of equal numbers of sensible and anomalous sentences not chosen in any systematic way. None of the sentences in the practice trials are the same as any in the experiment trials. After completing the practice trials, subjects are asked if they have any questions and may proceed with the experimental trials when they are ready.

Experiment III: Implications of phonological codes based on IL phonology--passage, sentence and word comprehension tasks

The fourth and final aim of this research is to investigate whether the selected aspects of IL phonemic competence which deviate from native norms are associated with decreases in comprehension or speed in reading processes utilizing phonological codes. To address this question, a passage reading task is devised and a set of target stimuli are included in the sentence judgment and semantic categorization tasks described in experiments 1 and 2.

Passage reading task: In this task, two passages matched for various measures of reading difficulty are constructed. The test passage is loaded with potential IL homophones used appropriately in context. Their sound-alike IL homophone pairs would not be appropriate for the context. The control passage does not contain any potential IL homophones of those listed above. Subjects read the passages silently as quickly as possible and then answer four comprehension questions. If the IL homophones activate multiple semantic codes and extra time is needed to select the correct meaning or a higher proportion of incorrect meanings are selected, it is expected that reading times and performance on the comprehension questions will be lower for the test passage. Thus the following hypotheses are proposed:

Hypothesis 1: In comparison to the control passage, for the passage loaded with potential IL homophones Native English subjects will:

a. NOT have longer reading times

b. NOT make more errors on comprehension questions

Hypothesis 2: In comparison to the control passage, for the passage loaded with potential IL homophones Native Thai subjects will:

a. have longer reading times.

b. make more errors on comprehension questions.

STIMULI: The two passages are each 509 words long. They are both written by this investigator and are similar in style and subject. Both are narratives featuring two main characters involved in a series of connected events. The test passage contains a high proportion of IL homophones (11.2%) which for at least some of the Thai subjects may sound similar to words that would be inappropriate for the context. The control passage contains no words with possible IL homophones as defined in this study. The passages are matched for a number of features including word and sentence count, average sentence length and the Flesch index of readability. This information along with the passages and comprehension questions is presented in Appendix 6.

PROCEDURE: Before beginning, subjects read the instructions and a complete an example task including a short example passage followed by one comprehension question. This is reproduced in Appendix 7. Subjects read each of the 2 passages printed on paper one time as quickly as possible. Reading time is measured by subjects pressing the space bar before beginning and immediately after finishing reading. After reading each passage, subjects turn over the paper and answer 4 multiple choice comprehension questions on a separate answer sheet. Half the subjects read the control passage first and half read the test passage first.

Sentence reading task: Included in the sentence judgment task in experiment 2 above, is a set of 10 sensible sentences each containing an IL homophone. The IL homophone is appropriate for the sentence, but its sound-alike pair would not be appropriate for the sentence frame. For comparison with each test sentence, two control sentences are selected from the set sensible sentences on the basis that they are similar in syntactic complexity. They do not contain any IL homophones as defined in this study. These stimuli are listed in Appendix 8. If the IL homophones activate multiple semantic codes and extra time is needed to select the correct meaning or a higher proportion of incorrect meanings are selected, it is expected that decision latencies for these sentences will be higher and there will be more false negatives in comparison to control sentences. The following hypotheses are proposed:

Hypothesis 3: In comparison to control sentences, for the sentences containing IL homophones, native English speakers will:

a. NOT have longer correct yes response times.

b. NOT make more false negative errors.

Hypothesis 4: In comparison to control sentences, for the sentences containing IL homophones, native Thai speakers will:

a. have longer correct yes response times.

b. make more false negative errors.

Word reading task: Included in the semantic word categorization task in experiment 1 above, is a set of 12 IL homophones. They are correct exemplars of the semantic category, but their sound-alike pairs would not be. For comparison with each of these IL homophones, two correct exemplars of the same categories which are not homophones or IL homophones are selected from the set of correct exemplar filler trials. These stimuli are listed in Appendix 9. If the IL homophones activate multiple semantic codes and extra time is needed to select the correct meaning or a higher proportion of incorrect meanings are selected, it is expected that decision latencies for these words will be higher and there will be more false negatives in comparison to controls. The following hypotheses are proposed:

Hypothesis 5: In comparison to the control exemplars, for the IL homophone exemplars the native English speakers will:

a. NOT have longer correct yes response times.

b. NOT make more false negative errors.

Hypothesis 6: In comparison to the control exemplars, for the IL homophone exemplars the native Thai speakers will:

a. have longer correct yes response times.

b. make more false negative errors.

CHAPTER III

ANALYSIS & INTEPRETATION OF THE DATA

EXPERIMENT I: PHONOLOGICAL CODES IN WORD COMPREHENSION--LEXICAL SEMANTIC CATEGORIZATION TASK

The first experiment was a brief exposure, masked semantic categorization task. The key target trials were words or pseudowords which were not exemplars of the category, but which sounded or looked like actual exemplars. Due to missing data only 23 native English subjects were included in this analysis. All false positive error response data and correct no response time data were subjected to one-tailed paired Student's t-tests of significance. The comparisons between phonological and yoked orthographic foils were computed by items and by subjects. The comparisons between orthographic foils and unrelated foils were computed by subjects only because these items were not yoked. All proportion scores were first subjected to the arcsin transformation (Winer, 1971) before statistical analysis. All response times over three standard deviations above the grand mean correct response time for all trials for all subjects of the same first language were removed before analysis. In addition, one response time of 19 ms by a native English subject was removed from the analysis because it presumably arose from a false key stroke or anticipation.

Homophone Foils

The first set of key trials contained homophone foils which sounded like correct exemplars and yoked orthographic control foils which looked like these same exemplars. The following hypotheses were proposed:

Hypothesis 1: In comparison to their yoked orthographic control foils, for these homophone foils, the native English subjects would:

a. make more false positive errors.

b. have longer correct no response times.

Hypothesis 2: In comparison to their yoked orthographic control foils, for these homophone foils, the native Thai subjects would:

a. make more false positive errors.

b. have longer correct no response times.

Mean percentage of false positive errors and mean correct no response times for target trials containing homophone foils, yoked orthographic control foils and non-exemplar words that did not look or sound like actual exemplars are presented in table 3.1.

Error rate data: The error rate data is depicted in figure 3.1. For the native English subjects the mean percentage of false positive errors to homophone foils was higher than to orthographic control foils. However, the difference was not significant by items: $t(9) = 0.72$, $p > .2$ and only approached significance by subjects: $t(22)=1.66$, $p = .055$. Thus, hypothesis 1a was not supported. However, for the Thai subjects the

Table 3.1 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for Homophone Foils and their Yoked Orthographic Control Foils

	Native English Subjects		Native Thai Subjects	
Foil Type	% Errors	Correct No RTs[1]	% Errors	Correct No RTs[1]
Homophones	5.7	821	21.7	1127
Orthographic Controls	3.0	826	7.9	1155
Nonexemplar Words	3.3	797	5.1	1028

[1]in milliseconds

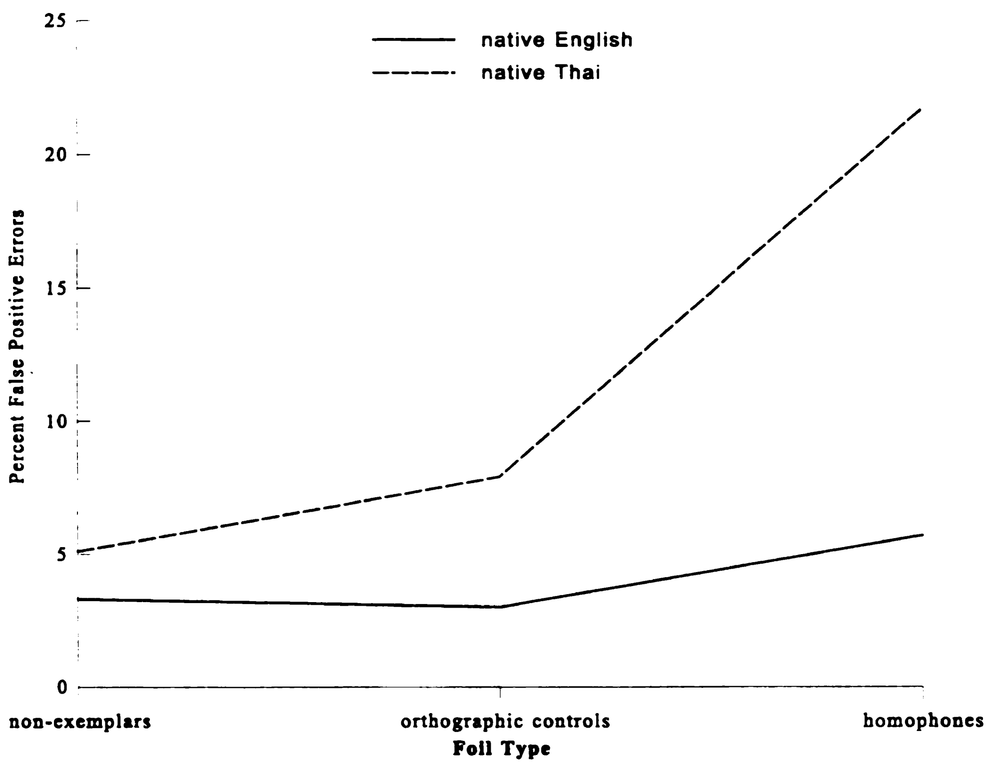

Figure 3.1 Mean Percentage of False Positive Errors for Homophone, Yoked Orthographic Control and Nonexemplar Foils

mean percentage of false positive errors to homophone foils was significantly higher than to orthographic control foils by items: t(9) = 2.12, $p < .05$ and by subjects t(23) = 3.11, $p < .05$. This supports hypothesis 2a.

Closer inspection of the data shows that the native Thai subjects made false positive errors on 8 of the 10 targets containing homophone foils. However, the native English subjects made errors on only three of them and the majority of these were made on only two stimuli: *an animal: dear* and *a metal: steal.* The average error rate for these two items was 24% for the native English subjects. The native Thai subjects also had a high error rate to these two items: 46%. These two stimuli along with a third: *a part of a car: break* had the highest error rates for the native Thai subjects.

There was no significant difference between the mean error rates to these orthographic control foils and to the unrelated nonexemplar word foils for the native English subjects by subjects: t(22) = -0.19, $p > .40$, as well as for the native Thai subjects by subjects: t(23) = 1.14, $p > .13$.

Response time data: For both the native English and native Thai subjects the mean correct no response time to phonological foils was not significantly different than to orthographic control foils. For the native English subjects: t(9) = -.01, $p > .49$ by items and t(22) = -.03, $p > .48$ by subjects. For the native Thai subjects: t(9) = -.025 , $p > .49$ by items and

$t(23) = -.61$, $p > .27$ by subjects. Thus, no support was found for hypotheses 1b and 2b.

Pseudohomophone Foils

The second set of key trials in experiment 1 contained pseudohomophone foils which sounded like correct exemplars and yoked orthographic control foils which looked like these same exemplars. The following hypotheses were proposed:

Hypothesis 3: In comparison to their yoked orthographic control foils, for these pseudohomophone foils native English subjects would:

a. make more false positive errors.

b. have longer correct no response times.

Hypothesis 4: In comparison to their yoked orthographic control foils, for these pseudohomophone foils, native Thai subjects would:

a. make more false positive errors.

b. have longer correct no response times.

Mean percentage of false positive errors and mean correct no response times for target trials containing pseudohomophone foils, yoked orthographic control foils and non-exemplar pseudowords that did not look or sound like actual exemplars are presented in table 3.2.

Error rate data: The error rate data is depicted in figure 3.2. For the native English subjects, the mean percentage of false positive errors to pseudohomophone foils was higher than to orthographic control foils.

Table 3.2 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for Pseudohomophone, Yoked Orthographic Control and Nonexemplar Pseudoword Foils

	Native English Subjects		Native Thai Subjects	
Foil Type	% Errors	Correct No RTs[1]	% Errors	Correct No RTs[1]
Pseudohomophones	9.1	824	18.3	1111
Orthographic Controls	2.6	747	15.4	1056
Nonexemplar Pseudowords	1.3	707	3.8	1052

[1]in milliseconds

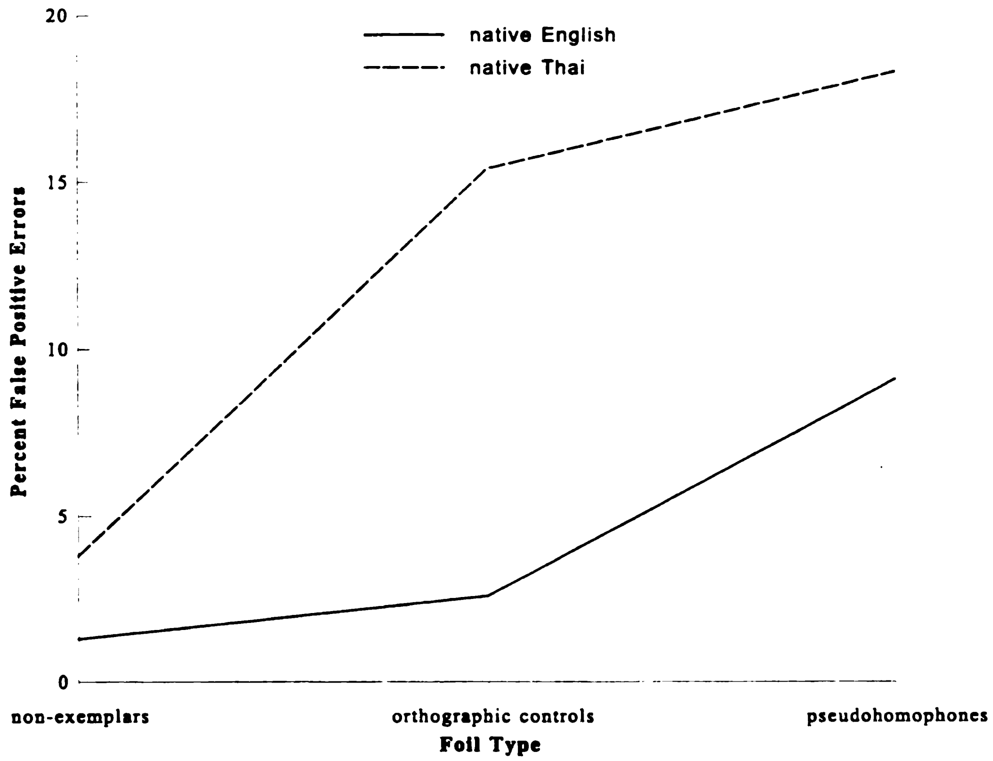

Figure 3.2 Mean Percentage of False Positive Errors for Pseudohomophone, Yoked Orthographic Control and Nonexemplar Pseudoword Foils

The difference only approached significance by items t(9) = 1.63, $p = .07$, but was significant by subjects t (22) = 3.54, $p < .05$. Thus, there is some support for hypothesis 3a. For the native Thai subjects, the mean percentage of false positive errors to orthographic control foils was almost as high as to pseudohomophone foils. There was no significant difference between them by items: t(9) = 0.48, $p > .32$ or by subjects: t(23) = 1, $p > .16$. Thus, despite a high error rate to pseudohomophone foils, the parallel high error rate to the yoked orthographic foils results in no support for hypothesis 4a.

A closer inspection of the data reveals that there was a disproportionately high error rate (46%) to the orthographic foil *biran (a part of the human body).* This stimulus also had the highest error rate among the orthographic control foils for the native English subjects, although it was not so remarkably high (13%). One strategy for pronouncing consonant clusters in English among native Thai SL speakers of ESL is to insert a short vowel such as /I/ between the two consonants. Thus, it may be that this foil was phonologically similar to the correct exemplar, *brain*, for many of the Thai subjects. When this stimulus and its yoked phonological foil, *brane*, is removed from analysis, the mean percentage of false positive errors to pseudohomophone foils is: 18.06, and to yoked orthographic control foils is: 12.04. The difference is not significant by items t(8) = 1.04, $p > .16$ but is significant by subjects t(23) = 1.84, $p < .05$. This, offers some support for hypothesis 4a.

There was no significant difference between the error rates to these orthographic control foils and to the unrelated nonexemplar pseudowords for the native English subjects by subjects: $t(22) = 0.83$, $p > .2$. In contrast, for the native Thai subjects, there was a significant difference by subjects both before the yoked stimulus pair: *biran* and *brane* was removed from analysis: $t(23) = 4.43$, $p < .05$ and after its removal: $t(23) = 3.15$, $p < .05$.

Response time data: For the native English subjects, the mean correct no response time to pseudohomophone foils was significantly higher than to orthographic control foils by items: $t\ (9) = 1.94$, $p < .05$ and by subjects: $t\ (22) = 2.38$, $p < .05$. This supports hypothesis 3b. For the native Thai subjects there was no significant difference between the mean correct no response time to pseudohomophone foils and to orthographic control foils by items: $t(9) = 0.66$, $p > .6$ or by subjects: $t\ (23) = 0.18$, $p > .4$. However, when the stimulus pair: *biran* and *brane* was removed from analysis, the difference between the mean correct no response time to pseudohomophone foils (1132) and to the orthographic control foils (1036) was significant by items: $t\ (8) = 2.31$, $p < .05$ but not by subjects: $t\ (23) = 1.07$ $p > .15$. This offers some support for hypothesis 4b.

Homophone Foils vs. Pseudohomophone Foils

A two-tailed t-test by subjects indicated no significant difference between error rates to homophone foils and to pseudohomophone foils for neither the native English subjects: t(22) = -2.01, $p > .05$, nor the native Thai subjects: t(23) = 0.95, $p > .34$. Likewise, there was no significant difference between the reaction times for both groups.

IL Homophone Foils

The third set of key trials in experiment 1 contained IL homophone foils which in the IL phonological system of native Thai speakers of ESL might sound like correct exemplars and yoked orthographic control foils which looked like these same exemplars. The following hypotheses were proposed:

Hypothesis 5: In comparison to their yoked orthographic control foils, for these IL homophone foils native English subjects would:

a. NOT make more false positive errors

b. NOT have longer correct no response times

Hypothesis 6: In comparison to their yoked orthographic control foils, for these IL homophone foils, native Thai subjects would:

a. make more false positive errors

b. have longer correct no response times

Mean percentage of false positive errors and mean correct no response times for target trials containing IL homophone foils, yoked orthographic control foils and non-exemplar words that did not look or sound like actual exemplars are presented in table 3.3.

Error rate data: The error rate data is depicted in figure 3.3. For the native English subjects there was no significant difference between the mean percentage of false positive errors to IL homophone foils compared to orthographic control foils by items: t(15) = 0.42, $p > .34$ and by

Table 3.3 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for IL Homophone, Yoked Orthographic Control and Nonexemplar Foils

Foil Type	Native English Subjects		Native Thai Subjects			
			% Errors		Correct No RTs[1]	
	% Errors	Correct No RTs[1]	Not Adj.	Spelling Test Adj[2]	Not Adj	Spelling Test Adj[2]
IL Homophones	3.2	875	18.2	17.12	1265	1260
Orthographic Controls	2.5	825	8.3	8.92	1207	1219
Non-exemplar Words	3.3	797	5.1		1028	

[1]in milliseconds [2]after removing trials according to the spelling test results

subjects: t(22)= .72, $p > .23$ This supports hypothesis 5a. For the native Thai subjects, the results are presented in two forms. The unadjusted figures reflect the mean error rate for all the subjects for all the stimuli. The spelling test adjusted figures reflect the mean error rate for only those stimuli for each subject remaining after the results of the spelling task were used to eliminate trials that may have been affected by inaccurate spelling or word knowledge. The results of the spelling task for the actual correct exemplars corresponding to the 16 IL homophone foils used in this semantic categorization task are presented in table 3.4.

A large number of errors were made on this productive form of spelling test. As indicated in the first row in the table, in many cases, subjects apparently did not know or understand the spoken definition and word. It seems that this instrument inflated error rates and may not be a valid

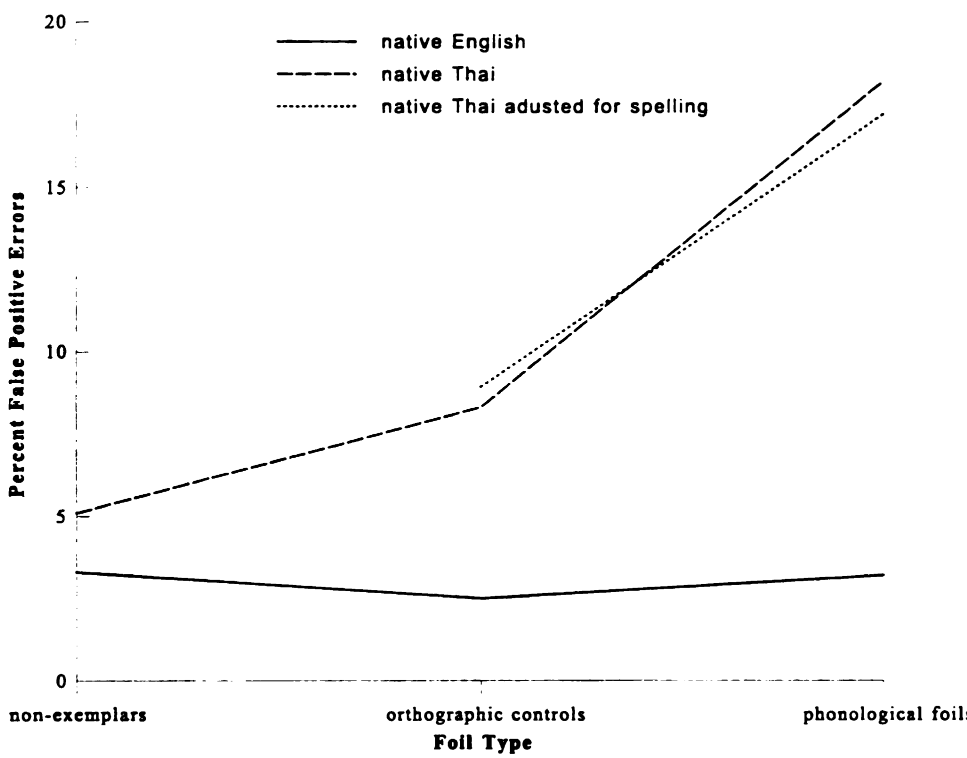

Figure 3.3 Mean Percentage of False Positive Errors for IL Homophone, Yoked Orthographic Control and Nonexemplar Foils

measure of spelling knowledge needed for word comprehension in this task. Four additional Thai readers, similar to these subjects, were later asked informally under no time pressure to choose the correct spelling from a list of the phonological foil, orthographic foil and the correct category exemplar. Only one subject made one error on the entire list of target trial stimuli for experiment one. Nevertheless, if in the spelling test a subject indicated she did not know the word or misspelled it in any way other than those errors resulting in a true homophone, the corresponding phonological and orthographic foil trials were eliminated from the data analysis. For the native Thai subjects' adjusted scores there was a significant difference between the mean percentage of false positive errors to IL homophone foils and to orthographic foils by items: t(15) = 2.50, $p < .05$ and by subjects t(23) = 6.48, $p < .05$. A similar significant result was obtained for the unadjusted scores. These findings support hypothesis 6a.

Table 3.4 Spelling Task Errors to the Correct Exemplars Corresponding to the 16 IL Homophone Foils

Subjects' Incorrect Response Types	An Example Response *(exemplar)*: error	% Errors to Words Tested[1]	% of Corresponding False Positives eliminated [2]
Word unknown, misunderstood or misspelled changing meaning or sound	*(coat)*: cloth	7.8	8.6
Word misspelled resulting in the IL homophone foil	*(clam)*: cram	3.6	10.3
Word misspelled resulting in a true homophone (not eliminated)	*(clam)*: clamb	1.0	

[1]total percentage of errors made on the 16 words tested
[2]total percentage of false positive errors to IL homophone foils in experiment 1 which are eliminated because of errors made to the corresponding true exemplars in the spelling task

There was no significant difference between the error rates to the orthographic control foils and the nonexemplar words for the native

English subjects by subjects: $t(22) = -0.80$, $p > .21$. However, for the native Thai subjects there was a significant difference between the error rates to orthographic control foils adjusted for spelling knowledge in comparison to the nonexemplar words: $t(23) = 2.17$, $p < .05$.

Response time data: For the native English subjects the mean correct no response time to IL homophone foils was higher than to orthographic control foils. The difference was not significant by items: $t(15) = 1.44$, $p < .08$ but was just significant by subjects: $t(22) = 1.72$, $p = .049$. This result is contrary to the prediction made in hypothesis 5b. A closer examination of the data reveals that the average response time to the IL homophone foil: *rock* for the category: *a security device* is greater than 2 standard deviations above the mean response time to IL homophone foils. It is likely that this foil took longer to respond to because it is questionable whether a rock could be a security device. When this item is eliminated from the analysis, there was no significant difference between the mean response times for the IL homophone foils and the orthographic control foils, a result supporting hypothesis 5b. For the native Thai subjects the difference between the mean correct no response times to IL homophone foils and to orthographic control foils was not significant by items: $t\ (15) = 1.35$, $p > 0.09$ or by subjects: $t\ (23) = 1.08$, $p > 0.14$. Thus, there is no support for hypothesis 4b.

IL Pseudohomophones

The fourth set of key trials in experiment 1 contained IL pseudohomophone foils which in the IL phonological system of native Thai speakers of ESL might sound like correct exemplars of the category and yoked orthographic control foils which looked like these exemplars. The following hypotheses were proposed:

Hypothesis 7: In comparison to their yoked orthographic control foils, for these IL pseudohomophone foils native English subjects would:

a. NOT make more false positive errors

b. NOT have longer correct no response times

Hypothesis 8: In comparison to their yoked orthographic control foils, for these IL pseudohomophone foils, native Thai subjects would:

a. make more false positive errors

b. have longer correct no response times

Mean percentage of false positive errors and mean correct no response times for target trials containing IL pseudohomophone foils, yoked orthographic control foils and non-exemplar pseudowords that did not look or sound like actual exemplars are presented in table 3.5.

Error rate data: The error rate data is depicted in figure 3.4. For the native English subjects, the mean percentage of false positive errors to orthographic control foils was higher than to IL pseudohomophone foils. This difference was not significant by items: $t(15) = -1.10$, $p > .10$ but was significant by subjects: $t(22) = -1.85$, $p < .05$. Although this result

Table 3.5 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for IL Pseudohomophone, Yoked Orthographic Control and Nonexemplar Pseudoword Foils

	Native English Subjects		Native Thai Subjects	
Foil Type	% Errors	Correct No RTs[1]	% Errors	Correct No RTs[1]
IL Pseudohomophones	3.8	712	19.0	1056
Orthographic Controls	6.8	754	19.3	1047
Nonexemplar Pseudowords	1.3	707	3.8	1052

[1]in milliseconds

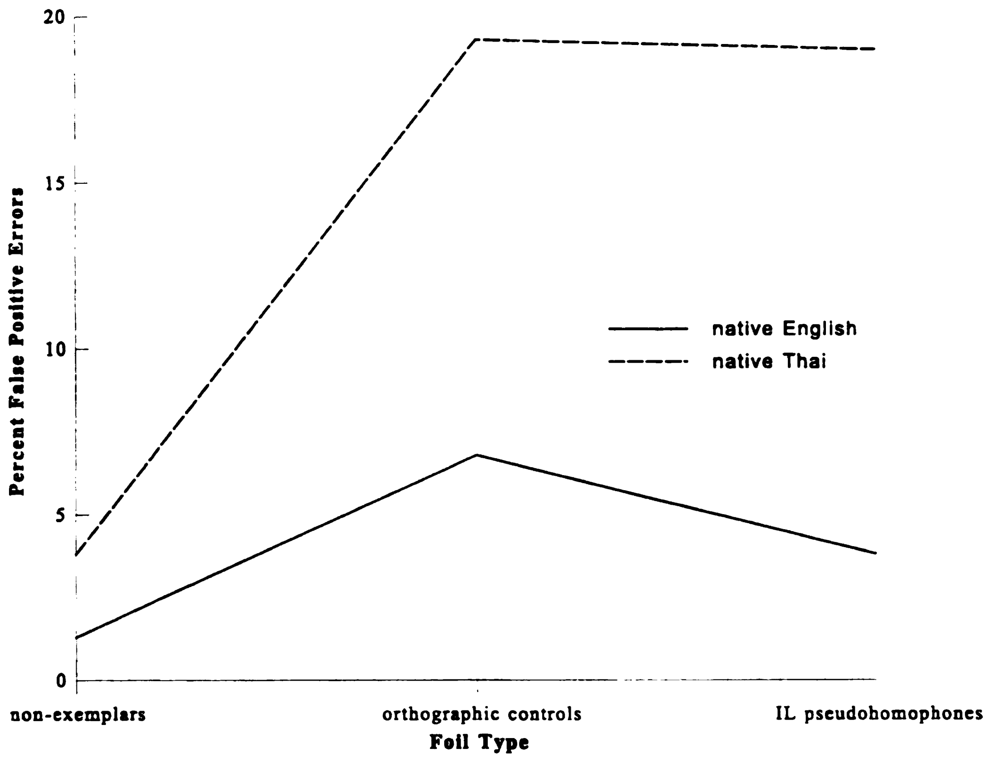

Figure 3.4 Mean Percentage of False Positive Errors for IL Pseudohomophone, Yoked Orthographic Control and Nonexemplar Pseudoword Foils

does not contradict the prediction in hypothesis 8a, it is an unexpected result. A closer look at the data shows that for one of the orthographic control foils: *a human body part: thorat*, there was an unusually high rate of false positive errors: 30.4%, which was 2.6 standard deviations above the mean error rate for this set of orthographic controls. A possible factor contributing to this high rate is the similarity in sound and appearance between the foil: *thorat* and a low frequency true exemplar: *thorax*. If this stimulus pair is eliminated from analysis, the mean percent error is 4.1% for IL pseudohomophones and 5.2% for orthographic controls. The difference is not significant by items $t(14) = -0.54$, $p > .29$ or by subjects $t(23) = -1.68$, $p > .53$. In either case, hypothesis 8a is supported by the data.

For the native Thai subjects, the mean percentage of false positive errors to orthographic foils was slightly higher than to IL pseudohomophone foils. The difference was not significant by items $t(15) = -0.05$, $p > .47$ or by subjects $t(23) = -.11$, $p > .45$. Parallel to the native English subjects' error rates, there was an unusually high error rate to the stimulus containing the orthographic control foil: *a part of the human body: thorat*. The error rate was 75%, which was 2.8 standard deviations above the mean for these orthographic controls. This rate was much higher than that of the yoked phonological foil. Furthermore, a post hoc review of the stimulus set given a better understanding of Thai language and the IL of Thai second language speakers of English suggests that three of the orthographic controls should be removed from the stimulus set. They not only look similar to the correct exemplar but may also sound similar in the IL phonological system of some native Thai speakers of ESL. They, therefore cannot serve as orthographic controls. Thai language has only 6 possible final consonants: 3 nasals and 3 voiceless stops: /p/ /t/ and /k/. A number of Thai words are spelled with other consonant endings, but they are always pronounced as one of the above permitted endings. Many native Thai speakers of English as a second language continue to apply this rule in their IL phonological system. The final consonants blends: /st/ and /th/ as well as /ch/ and /sh/ may all be replaced by the final stop /t/. Consequently, the orthographic control foils in the targets: *a language: Spanist* and *a religious place: churth* might actually sound the like their corresponding correct exemplars: *Spanish* and *church*. They therefore act as phonological foils just as their corresponding phonological foils (*Spanish* and *chursh*) were intended to do. In fact, in this experimental task, the Thai subjects had virtually the same mean error rate to these two problematic orthographic foils as to their corresponding phonological foils as is shown in table 3.6. In addition, in the IL phonological system of many native Thai speakers of ESL, in initial consonant clusters containing /r/ or /l/, these sounds are often omitted. Thus, the orthographic control: *clothing: boulse* and the phonological foil: *brouse* may actually both sound very similar to the correct exemplar *blouse*. The error rates are shown in table 3.6 as well.

When these four orthographic control foils are removed from the analysis, the mean error rate for orthographic control foils drops from 19.3 % to 9.0 %. This is much lower than the error rate to IL pseudohomophones: 19.0 %. However, if the corresponding phonological foil pairs are also removed from analysis in order to limit analysis to only yoked pairs, the mean error rate to the remaining IL pseudohomophones is

Table 3.6 Mean Percentage False Positive Errors for Four Problem Orthographic Control Foils and their Yoked IL Pseudohomophone Foils for Native Thai Subjects

Category	Real Exemplar	Phonological Foil	% Errors	Orthographic Control Foil	% Errors
clothing	*blouse*	Brouse	45.8	Boulse	29
a language	*Spanish*	Spanich	54.2	Spanist	45.8
a religious place	*church*	Chursh	45.8	Churth	50
a part of the human body	*throat*	Throad	25	Thorat	75

11.1 %. The difference between this and the error rate to orthographic controls is not significant by items t(11) +0.42, $p>.33$ or by subjects t(23) = 1.10, $p>.14$. This offers no support for hypothesis 8a.

There was no significant difference between the error rates to the remaining set of 12 orthographic control foils compared to the nonexemplar pseudowords for the native English subjects by subjects: t(22) = 1.28, $p > .10$. However, for the native Thai subjects, there was a significant difference between the error rates by subjects: t(23) = 2.81, $p < .05$.

Response time data: For the native English subjects the mean correct no response time to IL pseudohomophone foils was lower than to the orthographic control foils. The difference was significant by items: t (15) = -1.85, $p < .05$ and by subjects: t (22) = -2.30, $p < .05$. While this result does not contradict the prediction made in hypothesis 7b, it is unexpected. For the native Thai subjects the mean correct no response time to IL pseudohomophone foils was not significantly higher than to the orthographic control foils by items: t (15) =0.78, $p > .22$ or by subjects: t (23) = 0.15, $p > .44$. Thus, there is no support for hypothesis 8b.

In summary: Significant findings based on the error rate data for experiment I are presented in table 3.7. Results which confirm hypotheses are presented in bold.

Table 3.7 Summary of Error Rate Data for Experiment I

Foil Type	Native English Subjects	Native Thai Subjects
Homophones	Not significant (error rate to phonological foils slightly higher)	**Significant**
Pseudohomo-phones	**Weakly significant**	Not significant (high error rate to both phonological and orthographic foils)
IL homophones	**Not significant**	**Significant**
IL Pseudo-homophones	**Not significant**	Not significant (high error rate to both phonological and orthographic foils)

Significant findings based on the response time data for experiment I are presented in table 3.8. Results which confirm hypotheses are presented in bold.

Table 3.8 Summary of Response Time Data for Experiment I

Foil Type	Native English Subjects	Native Thai Subjects
Homophones	Not significant (RT to homophone foils slightly faster. RT to homophone & orthographic foils faster than nonexemplars.)	Not significant (RT to homophone foils slightly faster. RT to homophone & orthographic foils faster than nonexemplars.)
Pseudohomo-phones	**Significant**	**Weakly significant**
IL homophones	**Not significant**	Not significant
IL Pseudo-homophones	Significant in opposite direction to hypothesis	Not significant

EXPERIMENT II: PHONOLOGICAL CODES IN SENTENCE COMPREHENSION--SENTENCE JUDGMENT TASK

Experiment two was a sentence judgment task. All false positive error response data and correct no response time data were subjected to one-tailed paired Student's t-tests of significance. The comparisons between sentences containing phonological and yoked orthographic foils were computed by items and by subjects. The comparisons between sentences containing orthographic foils and unrelated foils were computed by subjects only because these items were not yoked. All proportion scores were first subjected to the arcsin transformation (Winer, 1971) before statistical analysis. All response times over three standard deviations above the grand mean correct response time for all trials for all subjects of the same first language were removed before analysis.

Homophone Foils

The first set of key trials were anomalous sentences each containing either a homophone foil or a yoked orthographic control foil. The homophone foils sounded like words that would make the sentences sensible, and the yoked orthographic control foils looked like these words. The following hypotheses were proposed:

Hypothesis 1: In comparison to the sentences containing orthographic control foils, for the sentences containing homophone foils, the native English subjects would:

a. make a higher number of false positive errors.

b. have longer correct no response times.

Hypothesis 2: In comparison to the sentences containing orthographic control foils, for the sentences containing homophone foils, the native Thai subjects would:

a. make a higher number of false positive errors.

b. have longer correct no response times.

Mean percentage of false positive errors and mean correct no response times for target anomalous sentences containing homophone foils, yoked orthographic control foils and foil words that did not look or sound like a word which would make the sentence sensible are presented in table 3.9.

Table 3.9 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for Anomalous Sentences Containing Homophone, Yoked Orthographic Control and Anomalous Foils

	Native English Subjects		Native Thai Subjects	
Foil Type	% Errors	Correct no RTs[1]	% Errors	Correct no RTs[1]
Homophones	11.0	2044	21.5	3690
Orthographic controls	3.7	1962	12.1	3589
Anomalous words	2.1	2013	5.0	3247

[1]in milliseconds

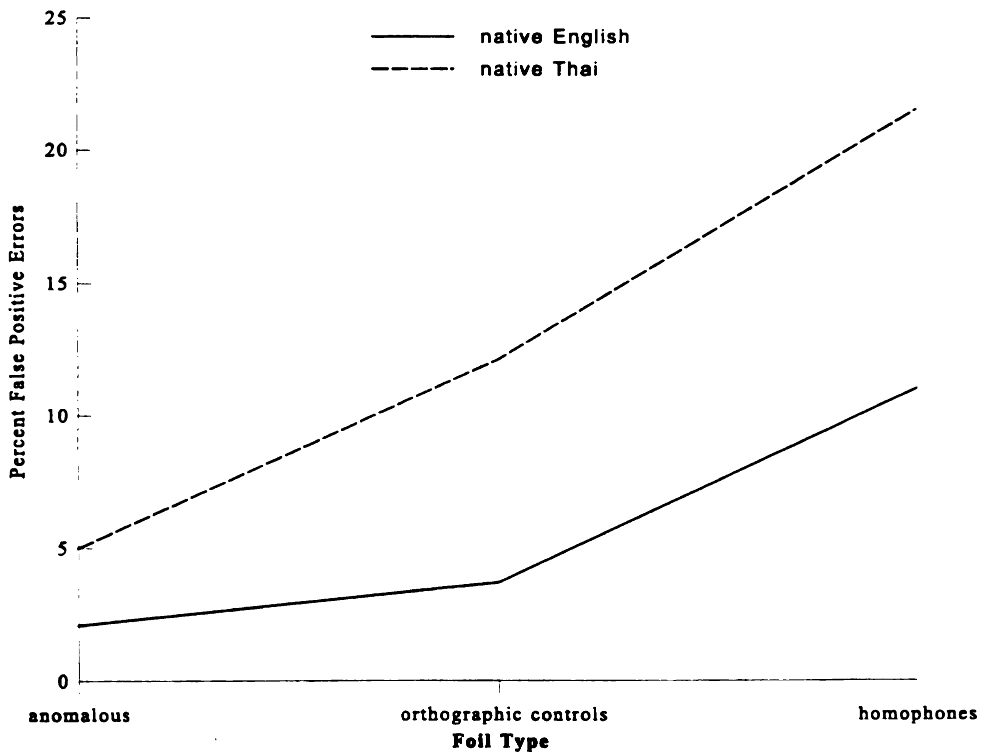

Figure 3.5 Mean Percentage of False Positive Errors for Sentences Containing Homophone, Yoked Orthographic Control and Anomalous Foils

Error rate data: The error rate data is depicted in figure 3.5. For the native English subjects the mean percentage error rate to sentences containing homophone foils was significantly higher than to sentences containing their paired orthographic foils by items: t(9) = 2.05, $p < .05$ and by subjects: t(23)=3.17, $p < .05$. This supports hypothesis 1a. For the Thai subjects the mean percentage error rate to sentences containing homophone foils was also higher that to sentences containing their paired orthographic foils. The difference was not significant by items: t(9) = 1.13, $p > .14$, but was significant by subjects: t(23) = 4.84, $p < .05$. This offers some support for hypothesis 2a.

There was no significant difference between the mean error rate to sentences containing orthographic control foils and those containing unrelated anomalous foils for the native English subjects by subjects: t(23) = 1.0, $p > .16$. In contrast, for the native Thai subjects, the mean error rate to sentences containing orthographic control foils was significantly higher than to those containing unrelated anomalous foils by subjects: t(23) = 3.64, $p < .05$.

Response time data: For both the native English and native Thai subjects the mean correct no response times to sentences containing phonological foils was slightly higher than to sentences containing paired orthographic control foils. However, the difference was not significant for the native English subjects by items: t(9) = 1.23 $p > .12$ or by subjects: t(23) =

1.33, $p > .09$, nor for the native Thai subjects by items: $t(9) = .75$, $p > .24$ or by subjects: $t(23) = 1.24$, $p > .11$. Thus, no support was found for hypotheses 1b and 2b.

IL Homophone Foils

The second set of key trials were anomalous sentences each containing either an IL homophone foil or a yoked orthographic control foil. In the IL phonological system of native Thai speakers of ESL, the IL homophone foils might sound like words that would make the sentences sensible. The orthographic controls foils looked like these words. The following hypotheses were proposed:

Hypothesis 3: In comparison to the sentences containing orthographic control foils, for the sentences containing IL homophone foils, the native English subjects would:

a. NOT make a higher number of false positive errors.

b. NOT have longer correct no response times.

Hypothesis 4: In comparison to the sentences containing orthographic control foils, for the sentences containing IL homophone foils, the native Thai subjects would:

a. make a higher number of false positive errors.

b. have longer correct no response times.

Two of the target stimulus sentences were removed from analysis along with their yoked pairs for half of the sentence frames because these two sentences should have been anomalous, but could be interpreted as sensible sentences: *The frame burned my finger* and *The police chart speeding cars*. Mean percentage of false positive errors and mean correct no response times for the remaining target anomalous sentences containing IL homophone foils, yoked orthographic control foils and foils words that did not look or sound like a word which would make the sentence sensible are presented in table 3.10.

Table 3.10 Mean Percentage of False Positive Errors and Mean Correct No Response Times (RT) for Anomalous Sentences Containing IL Homophone, Yoked Orthographic Control and Anomalous Foils

Foil Type	Native English Subjects		Native Thai Subjects			
	% Errors	Correct No RTs[1]	% Errors		Correct No RTs[1]	
			Not Adj	Spelling Test Adj[2]	Not Adj	Spelling Test Adj[2]
IL Homophones	2.3	1767	17.11	14.9	3199	3118
Orthographic controls	3.0	1742	11.4	11.8	3588	3554
Anomalous words	2.1	2014	5		3247	

[1]in milliseconds [2]after removing trials according to the spelling test results

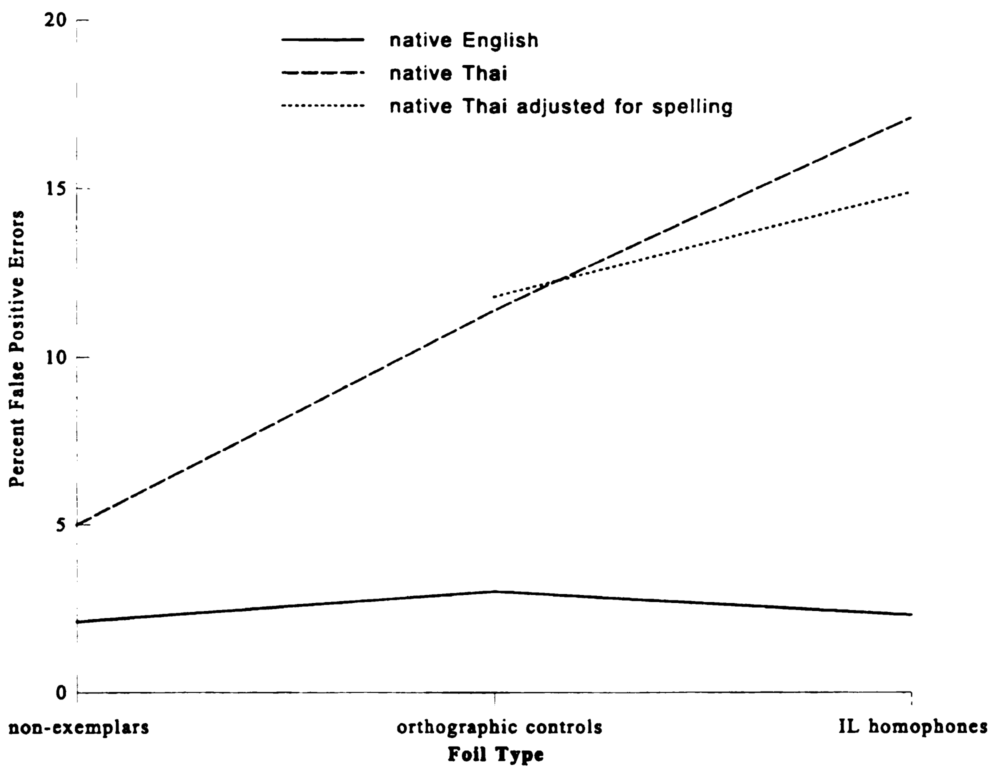

Figure 3.6 Mean Percentage of False Positive Errors for Sentences Containing IL Homophone, Yoked Orthographic Control and Anomalous Foils

Error rate data: The error rate data is depicted in figure 3.6. For the native English subjects, there was no significant difference between the mean percentage of false positive errors to sentences containing homophone foils and to sentences containing their paired orthographic control foils by items: $t(19) = -0.72$, $p > .23$ and by subjects: $t(23) = -0.16$, $p > .43$. This supports hypothesis 3a.

For the native Thai subjects, the results are presented in two forms. The unadjusted figures reflect the mean responses for all the subjects for all the stimuli. The spelling test adjusted figures reflect the mean responses for only those stimuli for each subject remaining after the results of the spelling task were used to eliminate all trials that may have been affected by inaccurate spelling or word knowledge. The results of the spelling test for the 20 appropriate words corresponding to the IL homophone foils embedded in the anomalous sentences are presented in table 3.11. A large number of errors were made on this productive form of spelling test. As indicated in the first row in the table, in many cases, subjects apparently did not know or understand the spoken definition and word. This instrument may have inflated error rates and may not be a valid measure of spelling knowledge needed for sentence comprehension in this task. Four additional Thai readers, similar to these subjects, were later asked informally under no time pressure to choose the correct spelling from a list of the phonological foil, orthographic control foil and the correct word. Only two errors were made on the entire list of target trial stimuli for experiment two. Nevertheless, if in the spelling test a subject indicated she did not know the word or misspelled it in any way other than those errors resulting in a true homophone, the corresponding phonological and orthographic foil trials were eliminated from the data analysis. Before adjusting for spelling, there was a higher mean percentage of false positive errors to sentences containing homophone foils than to sentences containing their paired orthographic foils. The difference was not significant by items: $t(19) = 1.09$, $p > .14$, but was significant by subjects: $t(23) = 2.02$, $p < .05$. This offers some support for hypothesis 4a. However, after adjusting for spelling, the difference was no longer significant by items: t(19) = 0.91, $p > .18$ or by subjects: t(23) = 1.06, $p > .14$. This result does not support hypothesis 4a.

Table 3.11 Spelling Task Errors to the appropriate word corresponding to the 20 IL Homophone Foils

Subjects' Incorrect Response Types	An Example Response *(correct word):* response	% Errors to Words tested[1]	% of Corresponding False Positives eliminated [2]
Word unknown, misunderstood or misspelled changing meaning or sound	(*bright*): light	4.6	7.2
Word misspelled resulting in the IL homophone foil	(*clown*): crown	2.5	10.8
Word misspelled resulting in a true homophone (not eliminated)	(*hurt*): hert	0.8	

[1]total percentage of errors made on the 20 words tested
[2]total percentage of false positive errors to sentences containing IL homophone foils in experiment 2 which are eliminated because of errors made to the corresponding true exemplars in the spelling task.

For the native English subjects, there was no significant difference between the error rate to sentences containing orthographic control foils and sentences containing unrelated anomalous foils by subjects: t(23) = 0.46, $p > .3$. For the native Thai subjects, the spelling test adjusted error rate to sentences containing orthographic control foils was significantly higher than to those containing unrelated anomalous foils by subjects: t(23) = 3.66, $p < .05$.

Response time data: For the native English subjects the mean correct no response times to sentences containing IL homophone foils was not significantly different than to sentences containing their paired orthographic control foils: by items: t(19) = 0.70 $p > .24$ or by subjects: t(23) = 0.81, $p > .21$. This supports hypothesis 3b. For the native Thai subjects, however, the mean correct no response times to sentences containing IL homophone foils was significantly lower (not higher) than to those containing their paired orthographic control foils both before adjusting for spelling test results: by items: t (19) = -2.09 , $p < .05$ and by subjects: t (23) = -4.57, $p < .05$ and after adjusting for spelling test results: by items: t(19) = -3.60, $p < .05$ and by subjects: t(23) = -5.07, $p < .05$. This is result is contrary to the predictions of hypothesis 4b.

In summary: Significant findings based on the error rate data for experiment II are presented in table 3.12. Results which confirm hypotheses are presented in bold.

Table 3.12 Summary of Error Rate Data for Experiment II

Foil Type	Native English Subjects	Native Thai Subjects
Homophones	**significant**	**weakly significant** (error rate to orthographic controls was high)
IL Homophones	**not significant**	not significant (**weakly significant** before adjustment for spelling test & offset by RT effect in opposite direction)

EXPERIMENT III: IMPLICATIONS OF PHONOLOGICAL CODES BASED ON IL PHONOLOGY IN PASSAGE, SENTENCE AND WORD COMPREHENSION

Experiment three included three tasks: a passage reading task, a sentence judgment task and a word semantic categorization task. Data were subjected to one-tailed paired Student's t-tests of significance. All proportion scores were first subjected to the arcsin transformation (Winer, 1971) before statistical analysis.

Passage reading task

Subjects read and answered comprehension questions for two matched passages: a control passage and a target passage loaded with words which are appropriate to the context but which are potential IL homophones with words that would not be sensible in the context. The following hypotheses were proposed:

Hypothesis 1: In comparison to the control passage, for the passage loaded with potential IL homophones Native English subjects would:

a. NOT have longer reading times

b. NOT make more errors on comprehension questions

Hypothesis 2: In comparison to the control passage, for the passage loaded with potential IL homophones Native Thai subjects would:

a. have longer reading times.

b. make more errors on comprehension questions.

Mean passage reading times for the two passages and mean percentage of correct answers to the four comprehension questions are presented in table 3.13. For the reading time data, all reading times over 2 standard deviations above the grand mean for all subjects of the same first language were removed before analysis. This resulted in the elimination of one subject's reading times for each of the subject groups.

Table 3.13 Mean Reading Times and Mean Percentage of Correct Answers to Comprehension Questions for the IL Homophone Loaded and Control Passages

	Native English Subjects		Native Thai Subjects	
Passage Type	Reading time[1]	% correct responses to questions	Reading time[1]	% correct responses to questions
IL Homophone Embedded	107065	88.5	191323	74.0
Control	101760	95.7	166366	88.5

[1]in milliseconds

Reading time data: For the native English subjects the mean reading time for the IL homophone loaded passage was higher than for the control passage. Contrary to the prediction stated in hypothesis 1a, the difference was significant: $t(22) = 2.22$, $p < .05$. For the native Thai subjects the mean reading time was higher for the IL homophone loaded passage than for the control passage. According to the prediction stated in hypothesis 2a, the difference was highly significant: $t(22) = 4.36$, $p < .05$.

Comprehension question response data: For the native English subjects the mean number of correct responses to the comprehension questions was higher for the control passage than for the test passage. Contrary to the prediction stated in hypothesis 1b, the difference was significant by subjects t (23) = 2.07, $p < .05$. For the native Thai subjects the mean number of correct responses to the comprehension questions was also higher for the control passage than for the test passage. The difference was significant by subjects t (23) = 2.60, $p < .009$ which supports hypothesis 2b.

Sentence judgment task: Included among the stimuli in the sentence judgment task in experiment 2, were 10 sensible sentences each containing a potential IL homophone. The IL homophone was appropriate for the sentence, but its sound-alike pair would not be appropriate for the sentence frame. In addition there was a set of 20 sensible matched control sentences which did not contain any IL homophones. The following hypotheses were proposed:

Hypothesis 3: In comparison to control sentences, for the sentences containing IL homophones, native English speakers would:

a. NOT have longer correct yes response times.

b. NOT make more false negative errors.

Hypothesis 4: In comparison to control sentences, for the sentences containing IL homophones, native Thai speakers would:

a. have longer correct yes response times.

b. make more false negative errors.

Mean percentage of false negative errors and mean correct yes response times for target sentences containing IL homophone and control sentences are presented in table 3.14.

Table 3.14 Mean Percentage of False Negative Errors and Mean Correct Yes Response Times (RT) for sentences containing IL homophones and for Control Sentences

	Native English Subjects		Native Thai Subjects	
Sentence Type	% Errors	Correct yes RTs[1]	% Errors	Correct yes RTs[1]
IL Homophones	2.1	1894	20.8	3450
Controls	1.7	1825	9.6	3385

[1]in milliseconds

Response time data: For the native English subjects, there was no significant difference between the mean correct yes response time to sentences containing IL homophones compared to paired control sentences: by items: $t(9) = 0.69$, $p > .25$ or by subjects: $t(23) = 1.57$, $p > .06$. This supports hypothesis 3a. For the native Thai subjects, there was also no significant difference between the mean correct yes response time to sentences containing IL homophones compared to paired control sentences: by items: $t(9) = 0.42$, $p > .34$ and by subjects: $t(23) = 0.92$, $p > .18$. This does not support hypothesis 4a.

Error rate data: For the native English subjects, there was no significant difference between the mean percentage of correct yes responses to sentences containing IL homophones compared to paired control sentences: by items: $t(9) = 0.26$, $p > .4$ and by subjects: $t(23) = 0.36$, $p > .3$. This supports hypothesis 3b. For the native Thai subjects, the mean percentage of correct yes responses to sentences containing IL homophones was lower than to paired control sentences. The difference approached significance by items: $t(9) = 1.81$, $p = .052$ and was significant by subjects: $t(23) = 4.05$, $p < .05$. This offers some support for hypothesis 4b.

Word categorization task: Included among the stimuli in the lexical semantic categorization task used in experiment 1, were 12 target IL homophones which were correct exemplars of the semantic category, but their sound-alike pairs would not be. In addition, there was a matched control set of 24 correct exemplars which were not homophones or IL homophones. The following hypotheses were proposed:

Hypothesis 5: In comparison to the control exemplars, for the IL homophone exemplars the native English speakers would:

a. NOT have longer correct yes response times.

b. NOT make more false negative errors.

Hypothesis 6: In comparison to the control exemplars, for the IL homophone exemplars the native Thai speakers would:

a. have longer correct yes response times.

b. make more false negative errors.

Mean percentage of false negative errors and mean correct yes response times for target trials containing IL homophone and control exemplars are presented in table 3.15.

Table 3.15 Mean Percentage False Negative Errors and Mean Correct Yes Response Times (RT) to correct exemplars for IL homophones and controls

	Native English Subjects		Native Thai Subjects	
Exemplar Type	% Errors	Correct yes RTs[1]	% Errors	Correct yes RTs[1]
IL Homophones	2.9	740	11.5	1082
Controls	2.4	691	6.1	891

[1]in milliseconds

Response time data: For the native English subjects, there was no significant difference between the mean correct yes response time to IL homophone exemplars compared to paired control exemplars: by items: $t(11) = 1.28$, $p > .11$ and by subjects: $t(22) = 1.47$, $p > .07$. This supports hypothesis 3a. For the native Thai subjects, the mean correct yes response time to IL homophone exemplars was significantly higher than to control exemplars by items: $t(11) = 2.24$, $p > .05$, and by subjects: $t(23) = 4.56$, $p < .05$. This supports hypothesis 6a.

Error rate data: For the native English subjects, there was no significant difference between the mean percentage of false negative errors to IL homophone exemplars and to control exemplars: by items: $t(11) = 0.48$, $p > .3$ and by subjects: $t(22) = 0.57$, $p > .28$. This supports hypothesis 5b.

For the native Thai subjects, the mean percentage of false negative errors to IL homophone exemplars was significantly higher than to paired control exemplars both by items: $t(11) = 1.96$, $p < .05$ and by subjects: $t(23) = 2.59$, $p < .05$. This supports hypothesis 6b.

In summary: Significant findings based on the reading response time data for experiment III are presented in table 3.16. Results which confirm hypotheses are presented in bold.

Table 3.16 Summary of Reading Response Time Data for Experiment III

Task Type	Native English Subjects	Native Thai Subjects
Passage	significant	**highly significant**
Sentence	**not significant**	not significant, but in the right direction
Word	**not significant**	**significant**

Significant findings based on the error rate data for experiment III are presented in table 3.17. Results which confirm hypotheses are presented in bold.

Table 3.17 Summary of Error Rate Data for Experiment III

Task Type	Native English Subjects	Native Thai Subjects
Passage	significant	**significant**
Sentence	**not significant**	not significant, but in the right direction
Word	**not significant**	**significant**

CHAPTER IV

DISCUSSION & CONCLUSIONS

PHONOLOGICAL CODES IN WORD COMPREHENSION

Error rates

The first aim of this research was to look for evidence that phonological codes play a role in the activation of semantic codes in word comprehension in SLR as has been demonstrated in FLR in English (e.g., Jared and Seidenberg, 1991; Van Orden, 1987, Van Orden et. al., 1988). The lexical semantic categorization task in experiment 1 included homophone and pseudohomophone foils in order to investigate this question. To simplify discussion, the following terminology will be used: a "homophone effect" means that subjects had a significantly higher false positive error rate to incorrect homophone or pseudohomophone foils than to yoked orthographic control foils of actual category exemplars. A homophone effect indicates that phonological codes were activated for the foils and these codes activated semantic codes for the similar sounding correct category exemplars resulting in the incorrect acceptance of the foil. The significantly lower error rate to the yoked orthographic foils rules out the possibility that the foil's orthographic similarity alone is responsible for the errors. Furthermore, if the error rate to the orthographic control foils does not differ significantly from that of the orthographically unrelated nonexemplars, this further demonstrates that orthographic similarity alone is insufficient to activate semantic codes for the correct category exemplars. Such results constitute evidence that phonological codes play a significant role in the activation of semantic codes. A homophone effect was predicted for both the homophone and pseudohomophone foils for both the native Thai and native English subjects.

Native English subjects

For the native English subjects, a homophone effect was observed for the pseudohomophone foils. The error rate to their yoked orthographic control foils was also not significantly different than to unrelated pseudoword nonexemplars further demonstrating that orthographic similarity alone did not cause this effect. Thus, this study finds that phonological codes contribute significantly to semantic code activation in the comprehension of novel or highly unfamiliar words in FLR as has been reported elsewhere (e.g. Van Orden et. al., 1988). These phonological codes may be assembled codes because there would be no corresponding lexical entry for orthographic codes for pseudowords to map on to in order to access addressed phonological codes.

The homophone effect is not likely the result of inaccurate spelling knowledge. Although the native English subjects were not tested for spelling knowledge due to the need to shorten the experimental session, it has been reported elsewhere that deficient spelling knowledge does not account for the homophone effect in similar semantic categorization studies of FLR (most convincingly, Coltheart et. al., 1994). Subjects in Coltheart et. al. (1994, experiment 1) made very few errors on a receptive spelling test and most of these were to less common words than those used in this experiment. They also found that the homophone effect remained when the data were adjusted according to the results of the spelling test. However, they also pointed out that the homophone effect might be increased if subjects accept the homophone foils initially because they believe them to be unintentional typing errors. In the study reported here, subjects were not explicitly instructed on what to do about misspellings, so this may have contributed to the error rate. However, two thirds of the subjects had already completed the sentence comprehension task before doing this task, so they may have already become aware of the fact that similar sounding and looking foils were likely to be an intentional feature of the experiment. In fact, this may be one cause for the low error rates found in this experiment.

Contrary to the experiment hypotheses, no homophone effect was found for the homophone foils for the native English subjects. The error rate to homophone foils was higher than to the yoked orthographic control foils, but the difference was not significant. Nevertheless, the insignificant results are not due to the orthographic similarity of foils to correct exemplars. The error rate to the yoked orthographic control foils was not significantly different than to the unrelated nonexemplar words.

In fact, the error rate to homophone foils was lower but not significantly different than to the pseudohomophone foils. Thus, phonological codes may also have played a role in comprehending these medium frequency words, but it appears that the error rates were too low to obtain an effect. The error rates in this study for pseudohomophone foils (9.1%) and homophone foils (5.7%) were lower than in the error rates reported in other similar studies, in which a significant homophone effect was usually obtained for both homophone and pseudohomophone foils. In a similar task with a somewhat different set of stimuli and no orthographic mask, Van Orden et. al. (1988, experiment 1) reported a homophone effect for both homophone and pseudohomophone foils for native English speaking high school students. Error rates to the two foil types were the same and substantially higher than this study: 21%. In a replication of that experiment, Coltheart et. al. (1994, experiment 1) also reported a homophone effect for both foil types and the error rates were similar and fairly high: homophone foils: 18% and pseudohomophone foils: 15.7%. However, in an earlier replication with older subjects, Coltheart et. al. (1991, experiment 4) reported a homophone effect for only the pseudohomophone foils (perhaps due to a high error rate to one orthographic control foil for the homophone foils). Error rates were quite low, but were similar between the two foil types: homophone foils: 9.5% and pseudohomophone foils: 11.4%. Thus, there is considerable variation in error rates even in repetitions using the same task and stimuli but with subjects varying in age. Error rates may be lower for older readers who have more experience in reading. They may be more either rely on orthographic codes more or may be more proficient at using orthographic information to eliminate errors since increased exposure to print is correlated with increased proficiency at orthographic coding (Stanovich, 1989). The subjects in this study were university students or older. A number of them were graduate students with considerable reading experience.

Coltheart et. al. (1994) summarized five manipulations to the semantic categorization task to which the homophone effect is apparently sensitive. Three are relevant to this discussion. First, the homophone effect is sensitive to the frequency of the true category exemplars and possibly to a lesser extent to the frequency of the foils as well. More errors are made to phonological foils of lower frequency true category exemplars and perhaps to lower frequency foils themselves. This may explain partly why error rates appear to be lower for older readers such as the subjects in this study. Older, more experienced readers may be more familiar with the stimulus set than younger readers. The stimulus set for the Van Orden et. al. (1988) study and its replications included a number of foils to lower frequency exemplars like *sleet* and *cellar* as well as lower frequency foils like *tee* and *hare*. The foil words and correct category exemplars in this study reported here did not include such low frequency words. Medium frequency words were chosen in an attempt to select stimuli known to the Thai subjects while avoiding highly familiar words. This design feature would tend to decrease the error rates to phonological foils for the native English subjects, especially for the older subjects who have had extensive reading experience in graduate school and elsewhere. In fact, some of these subjects had very fast response times and made very few errors to foils. The error rate to pseudohomophone foils was slightly higher than to homophone foils perhaps because these two foil types differ greatly in familiarity, although the correct category exemplars should have been similarly familiar.

Secondly, manipulations that cause subjects to use more cautious strategies in responding to stimuli reduce the homophone effect. This includes any manipulation that increase the subjects' awareness that the stimulus set includes intentional foils which are similar to correct category exemplars. In this study an orthographic mask replaced the stimulus exemplar or nonexemplar in the viewing screen after 200 msec. This was included to reduce the time available for additional strategic verification procedures so that responses would reflect the effects of codes used early on in semantic access. It was thought that the native Thai subjects in particular might employ very cautious checking strategies if given much time because they would be accustomed to using very careful strategies for taking English tests. However, the onset of this orthographic mask is not early enough to eliminate the possibility of strategic orthographic checking processes especially for the faster native English subjects (see Van Orden, 1987). In an unmasked semantic categorization task, Coltheart et. al. (1994) found that when subjects are explicitly told to reject misspellings, the homophone effect decreases markedly, though not entirely. In studies without such explicit instructions, more errors are generally made on foils presented earlier in the stimulus set probably because subjects adopt more conservative strategies as they notice more and more foils (Coltheart et. al., 1994). In this study, subjects were not told to reject misspellings. The percentage (21%) of all types of phonological foils (including both IL and true homophone word and pseudoword foils) in the stimulus set was low and similar to the proportion used in the Van Orden et. al. (1988) task (20%). However, two thirds of the subjects had already completed the sentence judgment task in experiment 2 prior to completing this task. Several of the native English subjects commented at the end of the entire study that they had noticed these similar sounding true and IL foils. If subjects noticed these phonological foils early on or even before beginning the semantic categorization task, they would be more likely to adopt a more cautious strategy which could have decreased error rates to phonological foils. Coltheart et. al. (1988) found that error rates to pseudohomophone foils decreased more than to homophone foils when subjects used more cautious strategies because they were instructed to reject misspellings. In contrast, in this experiment, error rates to pseudohomophones were actually slightly (but not significantly) higher than to homophones and a homophone effect was observed only for pseudohomophones. Consequently, the low error rates to homophone foils may be primarily a result of higher word familiarity.

Finally, a third factor may account for this unexpected difference between the two foil types. Coltheart et. al. (1988, 1994) reported that errors to phonological foils were not evenly distributed across items, but tended to concentrate on foils in which *ee* was replaced by *ea* or vice versa. When Coltheart et. al. (1994, experiment 3) further investigated this, they found that when spelling knowledge was taken into consideration, all sound alike foils differing in a single letter from the correct exemplar attracted similar and significantly higher error rates than other less similar phonological foils. The orthographic similarity to the correct exemplar was not enough in itself to increase error rates as demonstrated by consistently low error rates to equally similar looking orthographic control foils. Instead, the combination of sound alike and look alike features seems to greatly enhance the homophone effect. They concluded that "the overall level of orthographic overlap is the major determinant of the size of the word homophone effect" (p. 948). This manipulation was not considered in choosing stimuli for this study. The phonological foils and their yoked orthographic foils were matched for orthographic similarity and the homophone and pseudohomophone foils had similar mean orthographic similarity ratings according to the Van

Orden's (1987) procedure for measuring this. This procedure incorporates a broad range of orthographic features in its calculation. Quite by accident it turns out that the homophone foil set contained 3 words that differed by a single letter from their correct category exemplar, whereas the pseudohomophone foil set contained 6 such pseudowords. In fact, the highest error rates occurred for the two homophone foils and three pseudohomophone foils containing *ea* in place of *ee*. In Van Orden et. al.'s (1988, experiment 1) 4/10 of both the word and pseudoword foils contained *ea* in place of *ee* or vice versa. This factor may have had a significant impact on the difference in locus and strength of the homophone effect in this study.

In conclusion, previous semantic categorization tasks in FLR of English have repeatedly demonstrated that phonological codes contribute to the activation of semantic codes in this kind of task. However, the extent of this contribution or the extent to which it is observable in this task is subject to variation according to the manipulation of subject and task variables. The native English results in this experiment demonstrate less of a homophone effect than reported elsewhere perhaps because of such manipulations. Nevertheless, they do not contradict this general finding which offers support for the claim that phonological codes contribute to the activation of semantic codes in WR in advanced FLR of English.

Native Thai subjects

For the native Thai subjects, there was a homophone effect for the homophone foils. In addition, there was no difference between the error rate to these yoked orthographic foils and to the unrelated nonexemplar words. This offers evidence that phonological codes also contribute significantly to the activation of semantic codes in word comprehension for these advanced SL readers, at least in this sort of semantic word categorization task for these types of foils.

These results are not likely to be due to the subjects' inaccurate spelling knowledge. Nevertheless, this possibility cannot be ruled out because these foils were not included in the spelling knowledge test due to the need to shorten the experimental session. These subjects were tested for spelling knowledge for the IL homophones. Even though the results of this test were likely inflated by the test instrument, when the false positive categorization error data was adjusted accordingly, the homophone effect remained for these foils. In addition, a similar group of four native Thai readers were asked under no time pressure to choose the correct spelling for each correct category stimulus from a printed choice of three spellings: the orthographic foil, phonological foil and the correct exemplar word. Only one error was made for the entire set of foils for experiment 1. As mentioned previously, because subjects were not explicitly instructed what to do about misspelled foils, this may have increased error rates to homophone foils if subjects assumed misspelled homophones were typing errors that should be overlooked.

The mean error rate to the pseudohomophone foils was also high and was not significantly different than to homophone foils. This suggests that for novel words, assembled phonological codes may activate semantic codes for similar sounding correct category words. However, no homophone effect was demonstrated for these pseudohomophone foils because the error rate to the yoked orthographic control foils was surprisingly high as well. This error rate was significantly higher than to the unrelated pseudoword nonexemplars. Thus, it may be argued that the high error rate to pseudohomophone foils may actually result from their orthographic similarity rather than their phonological similarity to correct category exemplars. This would seem to indicate that orthographic codes are the predominant influence in semantic code activation for these SL readers.

However, orthographic features do not appear in themselves to be sufficient to cause this high error rate because the error rate to yoked orthographic controls for the homophone foils was not significantly different from the error rate to unrelated word foils. Likewise, pseudoword status alone also does not appear to cause this high error rate because errors to unrelated pseudoword foils were not significantly higher than to unrelated word foils, nor were errors to pseudohomophone foils higher than to homophone foils. Instead, it may be that the combination of similar orthographic features and pseudoword status increased error rates to these orthographic foils.

Pseudowords should not relate correctly to any semantic codes which might inhibit the activation of false look-alike or sound-alike candidates. Thus, higher false positive error response rates may occur if subjects are unable to recognize that these foils are nonwords. These activation levels may be further increased by priming or expectancies from the semantic category especially for the native Thai subjects who had much slower decision times. The native English subjects may be more adept at recognizing and eliminating these foils early on because they are nonwords. Based on these results alone, it is difficult to determine the relative influence of phonological codes over orthographic codes on the activation of semantic codes for unfamiliar words.

In fact, orthographic control foils share orthographic as well as some phonological features with the correct category exemplars. The extent of this may be especially difficult to predict for the SL readers because the SL reader's phonological system deviates from that of natives and phonological codes may relate to semantic codes with less specificity in general. A post hoc view of the stimulus set indicates that some of these foils may not only look similar but also sound quite similar to their correct category exemplars according to the IL phonological system of these subjects. This concern was raised in chapter 3 for one of the orthographic control foils: *biran*. When this pair was removed from analysis, there was a homophone effect by subjects for these pseudohomophone foils.

Thus, this unexpected result may not indicate a difference in kind between these native and non-native readers in the role of phonological codes in WR. Instead, there is evidence that phonological codes do contribute to the activation of semantic codes in WR in both FLR and SLR. For both the native English and native Thai subjects, there is evidence that error rates are increased to foils that sound similar as well as look similar. Although the native Thai subjects' error rates to the homophone and pseudohomophone foils were more distributed across items than the native English subjects' were, the highest error rates similarly occurred to foils where *ea* replaced *ee*. If foils which differ from correct category exemplars in a single letter attract more errors, this feature may be an important design feature which was not controlled for in this experiment. As it turns out, the pseudohomophone orthographic controls included 80% of such items whereas the homophone orthographic controls included only 30% of such items. These orthographic controls may share enough similar sounds as well as similar orthographic features with their corresponding true category exemplars to lead to a false positive error rate as high as to the pseudohomophone foils. The native English subjects may not have been effected by this similarity as much because of a greater ability to recognize and eliminate nonwords as well as more skillful use of orthographic verification procedures.

SLR in comparison to FLR

In conclusion, a homophone effect was demonstrated for one foil type each for the native English and native Thai subjects. The failure to demonstrate an effect for the other foil type may be due to task variables to which the effect is sensitive. Most importantly, for the native English subjects, the homophone foils may have been very familiar words and for the native Thai subjects, the pseudohomophone orthographic controls may have shared too many similar sounding features with correct category exemplars. Other studies have demonstrated a homophone effect for both foil types for native English subjects (e.g. Van Orden et. al., 1988). Further studies in which these task variables are manipulated are needed to determine whether a homophone effect can be demonstrated for both foil types in SLR. In particular, further studies are needed to determine whether the high error rates to pseudoword foils for the native Thais reflect a greater dependence on orthographic codes for less familiar words or whether this resulted because the subjects adopted a special strategy for this particular stimulus type in this task. It would be informative to repeat the task using less familiar, real words which are known by the subjects.

From this study alone, it does not appear that the reading processes employed in this task by the SL readers differ categorically from those of the FL readers. The SL readers are less proficient at the task, but phonological codes appear to play a significant role in the word comprehension processes of both groups. Doctor & Klein (1992) argued that non-optional phonological codes mediate access to the lexicon in SLR. Although this study makes no claims about the necessity of phonological code mediation, it does confer that phonological codes are utilized in SLR. Moreover, previous studies by Segalowitz & Herbert (1990) and Doctor & Klein (1992) have demonstrated that phonological codes are employed in SLR in lexical decision tasks which may not implicate the activation of semantic codes. This study offers new evidence that phonological codes contribute to the activation of semantic codes in SL word comprehension as well. In addition, this study demonstrates that phonological codes are not simply generated because the SL orthography is the same as the FL orthography. SL readers reading in a different orthography from their FL make use of phonological codes as do FL readers in that same language. Results do not support the suggestion that for these advanced SL readers, WR is fundamentally different in nature from FLWR in English (Segalowitz & Herbert, 1990).

This conclusion does not make any claims about the extent of semantic code activation via phonological codes for either FL or SL readers. Although the native Thai subjects had higher error rates to homophone foils: 21.7% and pseudohomophone foils: 18.3% in comparison to the native English subjects: 5.7% and 9.1%, this difference may not necessarily reflect greater reliance on phonological codes but rather a general difference in reading proficiency between the two subject groups. In comparison to the native English subjects, the native Thai subjects demonstrated less proficiency in this task in general. They had higher false positive baseline error rates to unrelated foils: 5.1 % for real word foils and 3.8% to pseudoword foils compared to 3.3% and 1.3% respectively for the native English subjects. In comparison to the native English subjects, they had longer correct yes mean response times: 27% and 35% longer for homophone and pseudohomophone foils respectively. If processing times are slower, the orthographic mask could have had a greater impact on decreasing strategic orthographic verification processes and subjects may have had less time to attend to and develop strategies for reducing errors to the phonological foils. Finally, the Thai subjects were less familiar with these medium frequency words. This is evident in that they made more false negative errors to correct filler trial exemplars. Increased false positive error rates are generally observed with less familiar target exemplars. It would be informative to compare error rates for native and nonnative subject groups matched for some measure of reading proficiency, in order to investigate the possibility of differences in the extent of phonological coding in FLR compared to SLR.

Response times

It was predicted that correct no response times to both homophone and pseudohomophone foils would be higher than to orthographic controls for both native English and native Thai subjects as has been reported in similar studies for native readers of English (Van Orden et. al., 1988 and Coltheart et. al., 1994). This prediction follows from the assumption that phonological codes generated on the basis of these foils activate semantic codes for sound alike correct category exemplars. In order to reject these incorrect meanings, extra time might be required to conduct additional processing such as an orthographic verification procedure. Significantly longer response times for correct no responses to phonological foils have been reported elsewhere for native English readers (Van Orden et. al., 1987, Coltheart et. al. 1994). In this study there was a significant difference for the native English subjects for the pseudohomophone foils and for the native Thai subjects for these foils when the item pair *biran - brane* was removed. However, no significant difference was found for the homophone foils for either subject group. This result is not surprising for the native English subjects whose error rates to homophones were low. However, the native Thai subjects would be expected to have longer response times to homophone foils if indeed the generation of phonological codes requires additional processing time to reject.

Response time data may not reflect word comprehension processing time very directly because a portion of the time reflects the time taken to decide whether the word is an exemplar of the category or not. These times may have varied across stimuli depending on how familiar the words were to the subjects and how much the subjects felt the category exemplars fit the categories as well as how much the foils did not. It was not possible to limit the study to only words from the Uyeda and Mandler (1980) list of prototypicality norms as has been done in the Van Orden et. al. (1988) study and its replications. Even for words from this list, it is not known whether the native Thai subjects would have rated their prototypicality similarly. In an informal set of ratings elicited from 4 additional native Thai readers similar to those participating in this study, only one item received a mean rating of 2 or below out of 4 indicating it was not considered a good or typical exemplar. Foils were not tested for how strongly they were perceived as nonexemplars of the categories.

In conclusion, there is some evidence that processing times are lengthened for unfamiliar sound-alike foils for both natives and non-natives which suggests that phonological codes may be activated. However, there is no parallel evidence for more familiar word foils as would be expected for the native Thai subjects in particular. Thus, if there was an effect of phonological codes on processing times, the effect was either too small or was masked by features of this particular task.

PHONOLOGICAL CODES IN SENTENCE COMPREHENSION

Error rates

The second aim of this research was to look for further evidence that phonological codes are employed in sentence comprehension in SLR as has been demonstrated in FLR in English (e.g., Coltheart et. al., 1991; Coltheart et. al., 1988; Doctor, 1978; Treiman et. al., 1983). Some previous studies have demonstrated that phonological codes are employed in sentence comprehension in SLR in various languages (Chitiri et. al., 1991; Khaldieh, 1991; Segalowitz & Herbert, 1990). To investigate this question, the sentence judgment task in experiment 2 included anomalous sentences each containing a homophone foil or yoked orthographic control foil word. These foils sounded or looked like words that would render the sentences sensible. Again, in order to simplify discussion, the term, homophone effect will be used. In this task a homophone effect means that subjects made significantly more errors to sentences containing homophone foils in comparison to sentences containing their yoked orthographic controls. A homophone effect was predicted for both the native English and native Thai subjects. This prediction was confirmed for the native English subjects and partially for the native Thai subjects. There was a homophone effect by items and subjects for the native English subjects, but only by subjects for the native Thai subjects. Thus, there is some evidence for both subject groups that phonological codes play a role in sentence comprehension, at least in this type of single sentence judgment task.

The possibility that these results are due to the subjects' lack of spelling knowledge cannot be ruled out because the native English subjects were not tested for spelling and these stimuli were not included in the native Thai subjects' spelling task due to the need to shorten the experimental session. However, a similar group of four native Thai readers were asked under no time pressure to choose the correct spelling for each word that would make the sentence sensible from a printed choice of three spellings: the orthographic foil, phonological foil and the correct meaningful word. No errors were made. Subjects were not explicitly instructed what to do about sentences with misspellings and, as discussed above, this could have inflated error rates to sentences containing homophone foils if subjects assumed that these errors were merely typing errors that should be overlooked. Conversely, the fact that 2/3 of the subjects completed other tasks before this could have deflated error rates if subjects noticed the foils and adapted a more cautious strategy as a result.

For the Thai subjects only, error rates to sentences containing the yoked orthographic controls were significantly higher than to those containing unrelated anomalous foils. Thus, a foil's similar appearance to the correct word may be sufficient to generate higher error rates. This suggests that the error rate to phonological foils may in part be due to their orthographic similarity to the appropriate word rather than as a result of the activation of phonological codes. However, as discussed above in experiment 1, the heightened error rates for the orthographic foils could actually result from the combination of both shared orthographic and phonological features with the appropriate word. The error rate to orthographic foils might be higher for these SL readers because coding is noisier or less accurate in general. However, the error rate to orthographic foils is lower than to homophone foils perhaps because the match to sound is not as close as with the homophones. Thus, phonological codes may still play a predominant role in sentence comprehension processing and this is the reason for the error rate to orthographic foils as well for the higher rate to phonological foils.

Deficits in the native Thai subjects' knowledge of English could further complicate results. Error rates may be inflated in some cases, not because foil words are misread, but because according to the IL of these subjects, the anomalous sentences containing foils seem to be correct, sensible sentences. The sentence frames containing the homophone foils were reversed with those containing the orthographic foils in half the trials in order to reduce the effects of sentence comprehension, but it is still possible that the foil seems acceptable in one frame but not the other to these SL readers. For example, there was a high error rate to the orthographic foil: *blur*, in the sentence frame: *His blur tie is ugly*. But not in the alternate frame: *He wants a blur boat*. The foil's shared visual and phonological features with the appropriate word: *blue*, may have increased errors, or subjects may have lacked grammatical knowledge needed to reject this anomalous sentence. It would be useful to include the sentence frames with the correct filler words and to more carefully test sentence frames for readability for the subjects in order to minimize this potentially confounding effect.

Response times

Correct no response times to sentences containing homophone foils were higher than to sentences containing their yoked orthographic control foils for both the native English and native Thai subjects. However, these differences were not significant. Thus, there is no evidence that extra time is used for orthographic verification and rejection of semantic codes activated via phonological codes for these foils. The response time data may not reflect comprehension processing time very directly because a portion of the time reflects the time taken to decide whether the sentence is acceptable or not. These times may have varied across the different stimuli depending on how subjects understood semantic and syntactic features of the sentences.

In summary, this study offers some evidence that phonological codes play a significant role in sentence comprehension in FLR at least in this sort of single sentence judgment task as has been demonstrated elsewhere (Coltheart et. al., 1991; Coltheart et. al., 1988; Doctor, 1978; Treiman, et. al., 1983). In addition, this study offers some evidence that phonological codes also contribute to sentence comprehension for advanced SL readers of English. This evidence concurs with similar findings in sentence judgment tasks in SLR in other languages: Chinese (Chitiri et. al., 1991), Arabic (Khaldieh, 1991), and English and French among slower readers only (Segalowitz & Herbert, 1990).

The results of the first two experiments taken together show that although these SL native Thai subjects have advanced language proficiency, and the words and sentences in these two tasks were fairly common, the process of word and sentence comprehension is slower and less accurate for them in comparison to the FL readers. The SL readers had longer mean correct no response times and higher mean false positive error rates on both word and sentence comprehension tasks on all foil types across the board. This suggests that their despite advanced level proficiency and considerable experience in the SL, lower level processes do not function as efficiently or accurately as native readers of the same age. Lower level processes appear to be hindered by limited linguistic knowledge. Coding processes are slower and noisier. However, there is no evidence that this is associated with categorical differences in the use of phonological codes. These first two experiments demonstrate that comprehension processes in advanced SLR by readers from a shallow FL orthography are not fundamentally different in nature from those in proficient FLR in English. Like FL readers, there is some evidence that these SL readers generate phonological codes which activate semantic codes. Furthermore, phonological codes are employed in sentence comprehension perhaps in order to assist in retaining these codes in short term memory while the reader constructs sentence meanings and makes acceptability judgments. There were some difference between the two subject groups, but these may reflect different effects of task variables due to differences in reading ability rather than categorical differences in reading processes between the two subject groups. Further research is needed to address the issue of whether there are categorical differences in the extent to which phonological codes contribute to comprehension processes between these two groups.

PHONOLOGICAL CODES BASED ON IL PHONOLOGY

Word comprehension

Phonological codes appear to play a significant role in word and sentence comprehension processes in both FLR and advanced SLR of English. However, the performance of many SL users who have begun language learning after early childhood suggests marked phonological deviations from native speaker norms. The third aim of this research was, therefore, to look for evidence that such deviations in turn lead to observable deviations in SLR processes implicating phonological codes. Phonemic neutralizations were used as a test case. The semantic categorization task in experiment one included a set of IL homophone foils and IL pseudohomophone foils. The are word and pseudoword nonexemplars which in the IL phonological system of the native Thai ESL subjects might sound like correct category exemplars. For each of these foil types there was a set of yoked orthographic control foils.

IL Homophone foils

A homophone effect was predicted for both IL homophone and IL pseudohomophone foils for the native Thai subjects but not for the native English subjects. In fact, for the IL homophone foils no homophone effect was found for the native English subjects, confirming this prediction. This indicates that any phonological codes generated for these words were not similar enough in sound to lead to the activation and acceptance of the correct category exemplar. In contrast, for the native Thai subjects, there was a homophone effect for the IL homophone foils both before and after these error rates were adjusted to reflect the results of the spelling knowledge test. Errors did not occur to all the word foils. Some foils may not have sounded similar to the correct category word according to the phonological system of some of the SL subjects. However, the mean error rate for these IL homophone foils was similar to that of the true homophone foils. Thus, it appears that the phonological codes generated by these SL readers for many of these foil words resulted in the activation and acceptance of semantic codes for other words that are not similar sounding to native speakers. The SL readers' were no more successful at detecting and eliminating such errors for these foils than they were for errors resulting from true homophones. Although the error rate to the yoked orthographic foils was significantly lower, this rate was also significantly higher than to unrelated word foils. Thus, there is some evidence that orthographic similarity in itself may result in some errors. Therefore, error rates to phonological foils may be due in part but not in whole to their orthographic similarity to their corresponding correct category exemplars. Alternatively, errors to orthographic foils may be heightened because for these subjects they share a significant proportion of similar sounds with the correct category exemplar.

IL Pseudohomophone foils

The error response rates to the IL pseudohomophone foils were contrary to predictions. For the native English subjects, the mean error rate to IL pseudohomophone foils was low as was expected. However, error rates to the yoked orthographic controls were surprisingly significantly higher than to the IL pseudohomophone and unrelated pseudoword foils. As noted in chapter 3, an unusual high error rate occurred to one orthographic foil: *a part of the human body: thorat*. It was noted that the foil may sound very similar to the correct category exemplar: *throat* and unintentionally to an additional low frequency correct category exemplar: *thorax*. When this item and it's paired IL pseudohomophone foil were removed from analysis, these differences were no longer significant. Thus, if this one foil is invalid, the results confirm the predictions. Either way, the low error rate to phonological codes suggests that any phonologcial codes generated for these IL pseudohomophone foils did not apparently sound similar enough to activate semantic codes for the correct category exemplar for these native English subjects.

For the native Thai subjects, the mean error rate to the IL pseudohomophone foils was even slightly higher than to the IL homophone foils. This suggests that phonological codes were assembled for these foils, and these codes sounded like the correct category exemplar in the IL phonological system of these native Thai subjects. However, no homophone effect was observed for these IL pseudohomophones because the error rate to the yoked orthographic controls was almost identical. This result is similar to the result found for pseudohomophones. Again, it is, therefore, possible that the error rate to these IL pseudohomophones is due to their orthographic similarity, although in itself this doesn't seem likely. Alternatively, it is possible that some of these orthographic controls sounded as well as looked like the correct category exemplars, and this caused the inflated error rate for these nonwords. In chapter 3 it was suggested that several of the orthographic controls, including *thorat*, were invalid because they may also sound very similar to the correct category exemplar for these Thai subjects. These orthographic controls all had unusually high error rates. When they were removed from the analysis, the error rate to orthographic foils decreased substantially. However, when the yoked phonological foils were also removed in order to limit analysis to only the yoked pairs, this error rate also dropped and the difference between the two foil types was still not significant. Further study is needed to investigate what characteristics of the foils are responsible for this error rate. As discussed above, the pseudoword status of these foils and the SL reader's noisier coding system might mean that all codes which share a substantial proportion of phonological and orthographic features have a greater chance of activating the correct category exemplar particularly in the case of pseudowords if SL readers are not adept at detecting and rejecting them.

Response times

The correct no response times to IL homophone and IL pseudohomophone foils were not significantly higher than to their yoked orthographic control foils for the native Thai subjects nor for the native English subjects after *thorat* and *throad* were removed from analysis. Thus, response time data offers no further evidence that phonological codes are generated for correct category exemplars for these IL phonological foils. Phonological codes may not increase processing time substantially or, as noted above, response time data may not directly reflect their impact.

Sentence comprehension

The sentence judgment task in experiment two included a set of anomalous sentences each containing an IL homophone foil or a yoked orthographic control foil. In the IL phonological system of these subjects, the IL homophone foils may sound like words that would make the sentences sensible, and the yoked orthographic control foils looked like these words. A homophone effect was predicted for the native Thai subjects but not for the native English subjects. As predicted, there was no homophone effect for the native English subjects. This suggests that any phonological codes generated for these words were not similar enough to the appropriate word in order to lead to the false acceptances of the sentence. In addition, error rates to orthographic foils did not differ significantly from error rates to sentences containing unrelated word foils indicating similar appearance alone was insufficient to lead to their acceptance as well.

For the native Thai subjects, there was a high error rate to sentences containing IL homophone foils. However, the error rate to sentences containing orthographic controls was also quite high. As a result there was a homophone effect by subjects but not by items before the response data was adjusted for spelling knowledge. After adjusting the data for spelling knowledge, the homophone effect was eliminated. As noted in chapter 3, the spelling knowledge task probably produced inflated error rates. Nevertheless, the error rate to sentences containing orthographic controls was significantly higher than to anomalous sentences containing unrelated foils. A similar result occurred for these subjects for the anomalous sentences containing true homophone foils. Again, it appears that orthographic similarity, perhaps in combination with similarity in some phonological features is sufficient to activate semantic codes for the corresponding sensible words for these orthographic foils for these subjects. It is also possible that error rates were inflated by subjects' inaccurate syntactic knowledge. To resolve this question, the stimuli should include a set of sensible control sentences with the correct filler word used in the same sentence frame and the foils word used correctly in a similar sentence frame.

Response times

The mean correct no response times to sentences containing IL homophone foils were not significantly higher than to sentences containing their paired orthographic control foils for either the native English subjects or the native Thai subjects. Thus, the mean response times do not offer further evidence that phonological codes are generated for context appropriate IL homophones for these foils. If they do, there is no evidence that they increase the time required to comprehend and reject these foil sentences as was predicted. As previously noted, the response time data may not reflect comprehension processing time very directly and subjects' misunderstandings of semantic and syntactic features of the sentences may have a more significant impact on response times.

In summary, like FL readers of English, these advanced SL readers appear to make use of phonological codes in the access of semantic codes in word reading and perhaps in the maintenance of semantic codes in sentence reading. However, these SL readers differ from FL readers in their ability to construct phonological codes that map accurately onto semantic codes. These results indicate that some phonological codes generated by these advanced SL readers contain underdifferentiated phonemic representations. As a result, such phonological codes would map onto a greater number of semantic representations for inappropriate words. In effect, the number of homophones is greatly increased for these SL readers. To compensate for this problem, these readers may rely more on orthographic codes perhaps for spelling verification. The higher error rates to orthographic foils support this prediction. In contrast, the response time data do not demonstrate increased response times which are expected when orthographic verification processes are entailed, although. response times for the Thai subjects are substantially slower across the board in comparison to the native English subjects.

IMPLICATIONS OF IL PHONOLOGICAL CODES ON READING COMPREHENSION

These results indicate a potential difference in fundamental comprehension processes in FLR and SLR. Although phonological codes play a significant role in both FLR and SLR, the impact may differ because of fundamental differences in ability to generate accurate phonological codes. Because of the resilience of the SL users' IL phonological system, even advanced SL readers may generate phonological codes in which phonemic distinctions are underdifferentiated or neutralized. These phonological codes may then map onto semantic codes for a larger number of same or similar sounding words. Thus, the phonological codes generated for such words may relate to semantic codes with less specificity, potentially increasing the chance that the wrong candidate will be selected or increasing the processing time and resources needed to select the correct candidate perhaps with the help of some orthographic verification procedure. Higher level reading comprehension processes dependent on fast, efficient and accurate word recognition, could be adversely affected. Thus the final aim of this research is to investigate whether potential IL homophones result in decreased comprehension or reading speed presumably because of the burden created by the activation of multiple semantic codes on the basis of underdifferentiated phonological codes. The scope of investigation includes word comprehension in isolation, embedded in sentences and embedded in an extended piece of discourse. The focus of these investigations is the comprehension of correct, meaningful or context appropriate IL homophones rather than of foil IL homophones.

Comprehension of isolated IL homophones

A set of correct category exemplar words which are potential IL homophones with nonexemplar words were included in the semantic categorization task in experiment 1. It was predicted for the native Thai subjects, but not the native English subjects, that correct positive response times and false negative error rates to these targets would be higher than to a matched set of non-homophone correct category exemplar words. These predictions were confirmed. There were no significant differences between response times or error rates to the two sets of words for the native English subjects. However, the native Thai subjects had significantly longer correct yes response times and significantly greater false negative error rates to the IL homophones than to nonhomophones. This result suggests that comprehension of potential IL homophones may be slower and less accurate. Phonological codes generated for these words may excite semantic codes for not only the correct category exemplars, but also for incorrect similar sounding nonexemplars. If the latter codes win out, the words may be incorrectly rejected or more processing time may be needed to correct errors and secure the correct candidate perhaps with the help of an orthographic verification procedure. Although the two types of targets were matched for frequency, it is possible that the difference in error rates and times reflects differences in the subjects' familiarity with or comprehension of these targets. Thus, these conclusions are tentative.

Comprehension of IL homophones embedded in sentences

A set of words were embedded in sensible sentences in the sentence judgment task in experiment 2. These words were potential IL homophones with other words which would make the sentences anomalous. It was predicted that for the native Thai subjects but not the native English subjects that correct positive response times and false negative error rates to these targets would be higher than to a set of syntactically similar sensible sentences containing no such homophones. There was no significant difference between the mean correct yes response times to these two sentence types for the native English subjects as was predicted and also for the native Thai subjects contrary to predictions. In accordance with predictions, there was no significant difference between the false negative error rate to the two sentence groups for the native English subjects, but the error rate to sentences containing IL homophones was higher for the native Thai subjects. The difference approached significance by items and was significant by subjects. This offers some minimal evidence that for these SL readers, comprehension of sentences containing potential IL homophones may be impeded because phonological codes generated for these words result in the activation of semantic codes for similar sounding words which render the sentences anomalous. However, there was no corresponding effect on response times. Results are tentative because, although the IL homophone and non-homophone target filler words were matched for frequency and sentence frames were matched for syntactic structure, it is possible that the difference in error rates and times reflects differences in the subjects' familiarity with or comprehension of these targets or frames.

Comprehension of IL homophones embedded in passages

A passage was loaded with words which are appropriate to the context but which are potential IL homophones with words that would not be sensible in the context. It was predicted for the native Thai subjects but not for the native English subjects that reading times would be longer and comprehension question scores would be lower for this passage in comparison to a matched passage containing no such IL homophones. These predictions were confirmed for the native Thai subjects. However, this was also true for the native English subjects although the difference was much greater for the Thai subjects. The difference for the native Thai subjects may be due in part to the effect of inappropriate semantic codes activated by phonological codes generated for these IL homophones. However, there appears to be a general difference in passage difficulty due to the experimenter's zeal in loading the target passage with IL homophones which resulted in a more contrived test passage in comparison to the control passage. Future studies should use passages more accurately matched for difficulty.

As a whole, the results from these three tasks offer some preliminary indications that phonemic neutralizations by SL readers may result in decreased comprehension speed and accuracy in reading processes utilizing phonological codes. However, further research is needed in order to address this question with more certainty.

SUMMARY

This set of experiments offers evidence that phonological codes contribute to the activation of semantic codes and possibly the maintenance of those codes during subsequent processing in advanced SLR of English. Thus, differences in the acquisition of FLR do not obviate the use of phonological codes by these SL readers. Nevertheless, processing relying on these codes demonstrates that they contain underdifferentiated phonemic contrasts. The phonological codes of these SL readers may, therefore, map onto a greater number of inappropriate semantic codes or may relate to the correct codes with less specificity. This increases WR processing times. Moreover, SL readers may need to rely more on orthographic codes or contextual information to select the appropriate meanings. This suggests that even in advanced SLR by readers with a great deal of experience in English, the efficiency and accuracy of low level processes may not be presumed. In fact, the response times and error rates of these SL readers were consistently well below those of the native English readers. Given the fundamental and crucial role of low level processes in reading, these differences may be critical to determining the overall success and efficiency of reading.

IMPLICATIONS & RECOMMENDATIONS

These preliminary studies demonstrate the importance of studying low level coding processes in order to contribute to a fuller understanding of SLR. Furthermore, the role of low level processes should not be overlooked in instruction in SLR. Whether training in specific phonological distinctions could facilitate phonological coding processes in SLR is an empirical question. What is clear is that helping SL learners improve in reading may not be simply a matter of developing higher level processing skills. In FLR, specific training aimed at increasing phonological awareness may improve reading skills for poor readers. In addition, reading experience is thought to develop phonological knowledge which in turn facilitates reading. There may be interesting parallels in SLR which are worthy of investigation. It is possible that when the orthography specifies a phonemic distinction which the learner has difficulty hearing or producing, reading may gradually help learners to develop these distinctions and these in turn may facilitate spoken perception and production. These are all potentially interesting areas for future research.

As much as the unique features of SLR invite research, they also complicate research. This study ran into numerous challenges which complicated the interpretation of the results. Because the pool of available Thai SL subjects was small, it was not possible to conduct extensive pretests. This would have helped eliminate some problematic items in advance and improved this study. In addition, all three experiments were conducted in one session with the same subjects. As subjects proceeded through the tasks, they most likely became more aware of the foil design and as result of this may have made more strategic adjustments. This would be expected to lead to decreased errors to phonological foils. In addition, it would have been helpful to know more information about the spelling and semantic knowledge of these SL readers. However, it was not feasible to increase the experimental session time as it was already quite long.

While the semantic categorization and sentence judgment tasks have the advantage of requiring semantic information, they are difficult to apply to the study of SLR. Studies of FLR rely heavily on word frequency lists. However, the vocabularies of SL readers are much harder to predict. This complicates the choice of homophone foils. In selecting stimuli for this study, it was very difficult to find foils that were not high frequency words, but likely to be known by all the subjects and which were clearly not exemplars of the categories but whose corresponding homophones were clearly true exemplars. Likewise, it is difficult to ensure that sentence frames and filler words in the sentence judgment task are easily comprehended by the subjects. It would be useful to verify how well these criteria are met by more extensive post-tests. One way to reduce some of these complications would be to measure syntactic and lexical competence with an additional instrument. Another useful modification would be to use more high frequency stimulii in a brief exposure masked presentation in order to reduce the impact of orthographic verification, which may impede observation of phonological codes. Other tasks which provide an early window on phonological coding such as limited exposure masked semantic priming and the backward masked priming may help better elucidate the role and nature of phonological codes in SLR. It would be especially informative to test for the effect of sound to spelling consistency on processing time. Stone, Vanhoy, & Van Orden (1997), have argued that processing time increases as the number of spellings that relate to a phonological code increases because of feedback phonology. This present study tested for such an effect in the comprehension of IL homophone exemplars in comparison to nonhomophones. However, a much more detailed analysis of this could be carried out by carefully controlling the stimuli according to the head body distinction laid out in Stone et. al. (1997). The sentence frames in the judgement task could also be more precisely modified according to processing difficulty which is directly related to the use of phonological codes.

In conclusion, it is hoped that this study will contribute to the small but growing body of research on phonological codes in SLWR as well as stimulate further interest in this much needed area of study.

APPENDICES

APPENDIX 1

LANGUAGE AND READING SURVEY OF SUBJECTS

Native Speakers of English

subject #	age	gender
1	33	m
2	28	m
3	29	f
4	29	m
5	33	m
6	33	f
7	31	f
8	36	f
9	26	m
10	31	m
11	32	f
12	30	f
13	23	m
14	19	f
15	18	m
16	24	m
17	20	f
18	18	f
19	19	m
20	19	m
21	18	f
22	18	m
23	19	m
24	19	m
average	25.2	14 males
std dev	6.14	10 females

Native Speakers of Thai (Non-native Speakers of English)

subject	age	gender	age of first exposure to English	months lived in English environment	reading ability[1]	pronun-ciation ability[1]	amount of reading[2]
1	22	f	22	3	6	3	5
2	26	f	26	3	5	6	2
3	24	f	24	3	5	5	2
4	23	m	23	3.5	7	6	5
5	22	m	22	3	7	6	2
6	22	f	22	63	7	6	3
7	23	m	23	5	6	3	2
8	25	m	25	3	6	4	4
9	35	f	20	4	8	8	5
10	24	f	23	5	8	7	5
11	26	f	25	20	3	3	2
12	18	f	16	29	6	8	3
13	25	f	22	36	8	6	3
14	22	m	17	12	7	5	2
15	24	f	22	24	5	5	1
16	23	m	22	12	6	5	2
17	37	m	36	15	7	5	3
18	25	f	23	30	5	6	2
19	27	m	26	18	8	6	4
20	23	m	21	18	7	7	3
21	25	f	23	24	6	6	2
22	25	m	22	42	8	5	3
23	25	f	23	36	7	6	3
24	26	f	10	28	6	6	4
average	24.9	14 fem					
std dev	3.84	10 mal					

[1]Subjects rated their ability on a scale of 1(very low) - 10 (very high).

[2]Subjects rated the amount of reading they currently do in English in comparison to the average college student: 1 (much less), 2 (less), 3 (about the same), 4 (more), 5 (much more)

APPENDIX 2

EXPERIMENT 1: SEMANTIC CATEGORIZATION TASK STIMULI
Homophone foils

semantic category	correct exemplar	freq[1]	typ. rat.[2]	phonol foil	freq	o.s.[3]	orthogr foil	freq	o.s.
a part of a plant	*flower*	78	3	flour	8	.74	floor	170	.75
a part of a car	*brake*	9	4	break	228	.62	brick	24	.48
a leader	*prince*	40	1	prints	10	.63	price	164	.84
a part of a building	*stair*	49	3.25	stare	95	.60	stars	26	.60
a form of money	*cent*	181	2.5	sent	75	.57	tent	30	.57
an animal	*bear*	24	3.5	bare	28	.56	belt	36	.51
a metal	*steel*	48	3.75	steal	39	.74	steep	7	.72
an animal	*deer*	13	3.5	dear	45	.72	dare	45	.45
a means of communication	*mail*	49	3.5	male	43	.53	mall	3	.72
a flower	*rose*	18	3.75	rows	16	.53	robs	1	.53
mean		51	3.2		59	.62		51	.62

[1]word frequency rating (Francis and Kucera, 1982)

[2]average typicality rating by 4 Thai SL readers of English on a scale of 0-4 (0 = not an example, 1 = a very poor/untypical example, 4 = a very good/typical example of the category)

[3]Van Orden's (1987) index of orthographic similarity

Pseudohomophone Foils

semantic category	correct exemplar	freq[1]	typ. rat.[2]	phonol foil	o.s.[3]	orthogr foil	o.s.
a grain	*wheat*	9	3.5	wheet	.78	wheth	.60
a leader	*queen*	51	1.25	quean	.74	quern	.70
an animal	*fox*	9	3.25	focks	.51	fop	.59
Furniture	*couch*	13	2.5	cowch	.78	corch	.98
a part of the human body	*brain*	64	3.25	brane	.60	biran	.70
a sticky substance	*glue*	7	3.75	glew	.53	glud	.66
a kitchen utensil	*bowl*	26	3	boal	.72	borl	.72
a security device	*chain*	60	2.75	chane	.78	chaun	.78
a kind of meat	*beef*	32	3.75	beaf	.67	belf	.67
a weather phenomenon	*snow*	56	3	snoe	.66	snoy	.66
mean		33	3		.67		.71

[1]word frequency rating (Francis and Kucera, 1982)

[2]average typicality rating by 4 Thai SL readers of English on a scale of 0-4 (0 = not an example, 1 = a very poor/untypical example, 4 = a very good/typical example of the category)

[3]Van Orden's (1987) index of orthographic similarity

IL Homophone Foils

semantic category	correct exemplar	freq	typ. rat.	phonol foil	freq	o.s.	orthogr foil	freq	o.s.
a security device	*lock*	28	3.5	rock	91	.57	lick	14	.72
furniture	*lamp*	24	2.75	ramp	7	.57	camp	92	.57
a kind of seafood	*clam*	5	3.5	cram	3	.72	calm	22	.69
a weather phenomenon	*cloud*	64	2.75	crowd	39	.65	clown	6	.58
a man-made material	*glass*	128	3	grass	55	.74	class	292	.63
clothing	*coat*	52	3	code	55	.51	cope	30	.51
a part of a plant	*root*	53	3.75	rude	6	.33	roam	10	.44
used to tie things	*rope*	19	4	robe	10	.72	role	138	.72
a form of money	*cash*	32	3.75	catch	146	.67	cast	28	.66
a flammable thing	*match*	77	2.5	mash	4	.67	march	37	.78
an appliance	*washer*	2	2.75	watcher	2	.79	waiter	15	.72
a land feature	*shore*	66	2.75	chore	23	.61	score	65	.78
a gardening tool	*rake*	8	2	wreck	13	.11	woke	15	.42
a sharp object	*blade*	26	3.75	bled	1	.51	blare	2	.78
a direction	*west*	142	3.75	vest	4	.5	nest	22	.57
a beverage	*wine*	97	3.75	vine	12	.57	nine	81	.57
mean		51	3.2		29	.59		54	.63

IL Pseudohomophone Foils

semantic category	correct exemplar	freq	typ. rat.	phonol foil	o.s.	orthogr foil	o.s.
transportation	*plane*	21	2.75	prane	.78	clane	0.61
clothing	*blouse*	2	4	brouse	.90	boulse	0.75
a fruit	*lemon*	16	3.75	remon	.61	bemon	0.81
a grassy area	*lawn*	20	2.75	rawn	.57	hawn	0.57
a language	*spanish*	31	4	spanich	.85	spanist	0.74
a religious place	*church*	451	2.25	chursh	.82	churth	0.82
a kind of seafood	*shrimp*	2	4	chrimp	.64	thrimp	0.64
a weather phenomenon	*rain*	73	3.75	ren	.56	raln	0.72
a kind of meat	*steak*	14	1.75	steck	.78	sterk	0.78
used for cleaning	*soap*	25	4	soab	.67	sorp	0.72
plumbing equipment	*pipe*	27	4	pibe	.72	pife	0.72
a part of the human body	*throat*	63	3	throad	.73	thorat	0.71
clothing	*skirt*	22	4	skird	.70	skith	0.6
a part of the human body	*hip*	17	3.25	hib	.59	hik	0.59
a season of the year	*winter*	82	3.75	vinter	.70	zinter	0.64
a kind of cloth	*wool*	10	3.25	vool	.60	mool	0.6
mean		55	3.4		.70		0.66

UNSYSTEMATIC FOILS

WORDS

category	*exemplar*	*frequency*
a beverage	pool	129
a gardening tool	honest	47
a grain	echo	15
a kind of cloth	magic	21
a flammable thing	pilot	54
a language	silver	22
a part of a car	pencil	38
a season of the year	leather	26
a sticky substance	curl	17
a way of cooking	tool	73
furniture	flavor	18
plumbing equipment	jazz	99
transportation	salt	52
mean		47

PSEUDOWORDS

category	*exemplar*
a direction	blin
a flower	hust
a fruit	quane
a grassy area	keemer
a group of people	yimp
a land feature	solly
a man-made material	zook
a metal	sarn
a religious place	dolm
a sharp object	genich
an appliance	skortle
an opening	stook
used for cleaning	tairst

UNSYSTEMATIC CORRECT EXEMPLAR FILLER TRIALS

category	*exemplar*	*frequency*
a beverage	beer	36
a beverage	sherry	6
a beverage	milk	49
a direction	forward	97
a direction	north	97
a flammable thing	oil	111
a flammable thing	coal	40
a flower	daisy	3
a flower	tulip	6
a form of money	check	53

a form of money	coin	18
a form of money	dollar	144
a form of money	quarter	62
a fruit	apple	15
a fruit	banana	5
a fruit	grape	10
a gardening tool	hoe	1
a gardening tool	shovel	8
a grain	oat	8
a grain	barley	6
a grassy area	meadow	23
a grassy area	prairie	13
a group of people	team	108
a group of people	union	213
a kind of cloth	cotton	36
a kind of cloth	silk	11
a kind of meat	chicken	49
a kind of meat	lamb	14
a kind of meat	pork	14
a kind of seafood	fish	33
a kind of seafood	lobster	1
a kitchen utensil	knife	86
a kitchen utensil	plate	44
a land feature	cave	15
a land feature	hill	119
a land feature	mountain	98
a language	Chinese	38
a language	English	86
a language	German	62
a leader	captain	99
a leader	lord	77
a leader	mayor	47
a leader	queen	51
a man-made material	paper	208
a man-made material	plastic	56
a means of communication	phone	53
a means of communication	radio	126
a metal	copper	68
a metal	tin	12
a part of a building	attic	15
a part of a building	ceiling	32
a part of a car	trunk	13
a part of a car	engine	69
a part of a plant	bark	13
a part of a plant	branch	5
a part of a plant	leaf	33
a part of a plant	stem	44
a part of the human body	neck	80
a part of the human body	ear	67
a part of the human body	elbow	17
a part of the human body	lung	36

a part of the human body	tongue	39
a religious place	shrine	11
a religious place	temple	41
a season of the year	autumn	22
a season of the year	summer	151
a security device	alarm	15
a security device	chain	60
a security device	fence	46
a security device	gun	142
a sharp object	pin	20
a sharp object	scissors	1
a sticky substance	grease	12
a sticky substance	honey	25
a way to cook food	bake	15
a way to cook food	boil	27
a weather phenomenon	drought	8
a weather phenomenon	fog	25
a weather phenomenon	storm	31
a weather phenomenon	thunder	12
a weather phenomenon	wind	74
an animal	cow	46
an animal	monkey	10
an animal	mouse	20
an animal	rabbit	16
an animal	tiger	9
an appliance	stereo	11
an appliance	oven	8
an opening	gap	19
an opening	vent	12
clothing	dress	63
clothing	jacket	39
clothing	pants	9
clothing	sock	10
clothing	sweater	18
furniture	cabinet	22
furniture	desk	69
furniture	dresser	3
plumbing equipment	drain	15
plumbing equipment	sink	12
transportation	train	86
transportation	truck	80
used for cleaning	bleach	7
used for cleaning	mop	2
used to tie things	ribbon	18
used to tie things	string	34
mean		43

12 additional correct IL homophone exemplars are listed in Appendix 9

APPENDIX 3

EXPERIMENT 1: INSTRUCTIONS FOR SEMANTIC CATEGORIZATION TASK

Description: You will read a list of 120 words and decide whether each one is an example of a given category.

Instructions:
Place one finger of your left hand on the key marked NO on the left side of the keyboard. Place one finger of your right hand on the key marked YES on the right side of the keyboard. Watch the center of the computer screen. Read the category name that appears there. (ex: a sport) It will disappear after two seconds and will be replaced by a +. Focus on the +. It will disappear and a word will appear in the same place for a brief time. (ex: football) Read the word. Press YES if it is an example of the preceding category and press NO if it is not. (ex: yes) If you do not know the word, press NO because it is not an example of the category according to your knowledge of the English language. Press YES only if you feel it is an example of the category. Respond as quickly as you can. When the word disappears, in its place you will see XXXXXXXXXX. This will disappear when you respond. After you respond, there will be a brief pause before another category appears followed by a +, a new word and XXXXXXXXXX. Part way through the experiment, you will see the following sentence in place of the category name: TAKE A BREAK! and in place of the word: READY? Relax for as long as you want. When you are ready to continue, press yes. The experiment will continue.

Examples:	a sport	a kind of food	a kind of bird
	tennis	smile	osprey
	XXXXXXXXXX	XXXXXXXXXX	
	XXXXXXXXXX		
correct answer:	*yes*	*no*	*yes*

Do you have any questions? Now try the practice set of 16 categories and words.

Practice trials:

CATEGORY	TARGET
a color	yellow
a family member	sister
a part of a book	demble
a color	farm
a kind of tree	oak
a part of a book	page
a family member	market
a kind of tree	skin
BREAK	READY?
a color	purple
a part of a book	chapter
a kind of tree	goam
a family member	daughter
a color	butter
a family member	frozen
a kind of tree	poplar
a color	magenta

APPENDIX 4

EXPERIMENT 2: STIMULI FOR SENTENCE JUDGEMENT TASK

HOMOPHONES

meaningful word	freq[1]	phonol foil	freq	o.s.[2]	orthogr foil	freq	o.s.	sentence frame 1	sentence frame 2
meet	339	meat	57	.67	melt	32	.67	They will ___ the president.	Please ___ us at the airport.
guessed	7	guest	99	.65	gushed	5	.53	She ___ my age correctly.	He ___ who she was.
heal	11	heel	41	.72	hole	95	.48	The medicine did not ___ her.	Broken bones ___ slowly.
rays	7	raise	188	.50	rains	4	.69	He saw bright ___ of light.	There were ___ of light.
claws	3	clause	13	.57	class	292	.78	Tigers have sharp ___.	Dogs use their ___ to dig.
blue	126	blew	52	.53	blur	7	.66	His ___ tie is ugly.	He wants a ___ boat.
bored	11	board	285	.68	beard	31	.58	The lecture ___ the students.	I am ___ of studying this.
son	202	sun	117	.61	sin	67	.61	She looked at the setting ___.	The earth goes around the ___.
tail	31	tale	41	.53	talk	275	.53	The cat licked its ___.	Her horse has a long ___.
ate	16	eight	104	.09	aunt	27	.39	He ___ a green apple.	She ___ too much cake.
mean	75.3		99.7	.56		83.5	.59		

[1] word frequency rating (Francis and Kucera, 1982)

[2] Van Orden's (1987) index of orthographic similarity

IL HOMOPHONES

meaningful word	freq	phonol foil	freq	o.s.	orthogr foil	freq	o.s.	sentence frame 1	sentence frame 2
climb	65	crime	49	.48	chime	1	.48	They ___ up the mountain.	Monkeys can ___ trees.
late	132	rate	303	.57	date	120	.57	He arrived ten minutes ___.	We were ___ for class.
lips	69	rips	14	.57	sips	1	.57	She kissed him on the ___.	The coffee burned my ___.
clown	6	crown	19	.78	clean	58	.66	The ___ told a joke.	The ___ wears funny clothes.
bloom	17	broom	2	.84	blood	122	.76	Flowers ___ in spring.	The flowers will soon ___.
flame	27	frame	96	.78	blame	32	.61	The water put out the ___.	The ___ burned my finger.
wash	83	watch	209	.68	waste	31	.50	___ your laundry by hand.	Use shampoo to ___ your hair.
share	105	chair	89	.21	speed	89	.36	I ___ a room with her.	We ___ the same opinion.
wish	161	witch	13	.69	wise	33	.66	I ___ I had more money.	I ___ you luck.
sheet	71	cheat	7	.39	shift	47	.67	He borrowed a ___ of paper.	I lost the ___ of paper.
beat	66	bead	5	.66	beer	33	.66	The man ___ his dog.	We will ___ the other team.
hit	126	hid	6	.59	hot	130	.61	She ___ me on my nose.	The car ___ the building.
tight	22	tide	14	.47	tire	46	.47	Those shoes are ___ on me.	The belt is not ___ enough.
bright	81	bride	40	.54	brick	24	.54	The sunshine is ___ today.	That child is very ___.
hurt	31	herd	26	.38	host	47	.56	The rocks ___ my feet.	These glasses ___ my eyes.
chase	7	chess	3	.56	chart	30	.58	The police ___ speeding cars.	The dogs ___ away strangers.

mean-ingful word	freq	phonol foil	freq	o.s.	orthogr foil	freq	o.s.	sentence frame 1	sentence frame 2
waste	31	west	142	.51	worst	34	.48	Do not ___ time watching tv.	This is a ___ of money.
peel	14	pill	23	.52	poll	19	.52	We ___ the apples.	He will ___ off the stickers.
worse	50	verse	37	.49	nurse	24	.49	My grades are ___ than yours.	I feel ___ than before.
wet	47	vet	1	.50	bet	18	.50	I got ___ in the storm.	My clothes are all ___.
mean	60.5		54.9	.56		47	.56		

UNSYSTEMATIC ANAMOLOUS SENTENCES

The man trees his left foot.
Water in easy the hole.
The yellow was angry.
I tried to go fill through.
She'll drink a long walk.
The ice soon began to library.
He goes anger a walk.
Their buy is my best time.
That soup reads different.
Do not car in the way.

FILLER SENSIBLE SENTENCES

Exercise is healthy for you.
He did not scare her.
You should eat more carrots.
They enjoy fishing in the ocean.
She goes outside to run.
The horse kicked the woman.
He took five pictures of me.
I saw that movie four times.
He forgot to warn us.
The man bought a gold ring.
The cat ran away.
She found keys in the car.
This medicine tastes terrible.
She gives him some money.
Fish swim in the ocean.
She will never forget his words.
She works on the fifth floor.
This chemical causes cancer.
He throws the garbage out.
She leaves the window open.
The air is polluted downtown.
I'll call you on the phone.
He sits beside me in class.
She knows his new address.
The clerk counted the money.
The cows walk across the field.
They caught him stealing.
The old man lived alone.
He drinks a bottle of juice.
She rarely makes mistakes.
Do not be late for dinner.
The radio is too loud.
She cut his hair short.
New cars are fun to drive.
I can play the guitar.
The president is powerful.
He travels a lot on business.
He tries to do his best.
She sang the song quietly.
That man loaned me his bike.
She drives a truck to work.
She fixed the broken toy.
He is cooking eggs for lunch.
She is stronger than me.
The dog chased a rabbit.
The snake bit his ankle.
He must study for his exam.
The sign fell over.
These cards are wrinkled.
I do not drink coffee.
She wears expensive suits.
The desk is made of wood.
That man looks very young.
He took the magazine home.
Some students talk during class.

APPENDIX 5

EXPERIMENT 2: INSTRUCTIONS FOR SENTENCE JUDGEMENT TASK

Description: You will read a list of 135 unrelated sentences and decide whether the sentence make sense or not.

Instructions:
Place one finger of your left hand on the key marked NO on the left side of the keyboard. Place one finger of your right hand on the key marked YES on the right side of the keyboard. Watch the computer screen in front of you. You will see a dot in the center of the screen. When you are ready, press the space bar. A short sentence will appear. Read the sentence. Press YES if it makes sense (is meaningful). Press NO if it does not make sense (is nonsense). (ex: He went for a walk.--makes sense. His mother silly a dog.--does not make sense). Respond as quickly as you can. The sentence will disappear when you respond. A dot will appear again. Press the space bar when you are ready to view the next sentence.

Examples:	*correct answer*
She works at a bank.	*yes*
He cried a new computer.	*no*
The chisel broke the ice.	*yes*

Do you have any questions? Now try the practice set of 10 sentences.

Practice trials:

They bought new bikes.
We own an old simple.
This angry eats no vegetables.
His mother owns two stores.
The zoo can't number place.
Some buckets spilled find.
The leaves fell off the trees.
She pink to the movies.
I wrote down your address.
They forest an accident.
It might snow today.
This job is difficult.

APPENDIX 6

EXPERIMENT 3: READING PASSAGE STIMULI

HOMOPHONE EMBEDDED PASSAGE[1]

When Tim was a young child, his mother was *sick*. It was a *hard* disease to recover from and she needed to *rest* a lot in *bed*. She couldn't take care of Tim so she *chose* to *send* him out *west* to a boy's summer camp for three months. Before he left, she *made* him *vow* to *write* her a letter every week. She even gave him a special *code* to use in his letters to let her know how he was. An X would mean he wanted to *live* there and an O would mean he wished he could leave. She gave him a *pen* along with some *cards* and stamps. Tim assured her that he'd be all *right*. His words *made* her eyes *fill* with tears. She *bit* her *lip* and *hid* her face, so he couldn't see she was struggling not to cry. He *heard* her shaky voice and bowed his *head*. He looked down at his *food* and smiled a little *bit*. There was enough there in his bag to *feed* three boys for the whole trip. He knew she had taken all morning to *fill* his big bag with his favorite *fruit*, some *chips*, bread, cheese and meat. Everything was *fresh* and smelled *grand*.

Tim's mother wanted to *ride* to the camp on the bus with him, but she knew it would be *wrong* to travel so far in her condition. He had to go alone. She was worried and *sad* as they began to *head* slowly up the *hill* together to *catch* the bus. It was a warm, sunny day. When they got to the bus stop, they looked up and saw a small *crowd*. The bus would certainly be full. Tim put down his heavy bag on the side of the *road*. There was a *wide ditch* full of water that ran along beside the *road*, and he wanted to *wade* in it to cool off. He *tested* the water first with his finger. It felt great, so he pulled off his *shoes* and threw them aside on the *grass*. Then he *edged* into the water. It went up to his *shin*. His mom begged him "*Watch* your clothes. Don't *get* them *wet*." She shrugged her shoulders. "I'm hot and tired and *need* to *rest*," she thought to herself.

Fortunately, someone offered her a *chair* in the *shed* near the bus stop. She went in and sat down by the window to wait. Finally, she saw the bus coming down the *road*. It was *red*, which happened to be Tim's favorite color. Tim joined the other passengers getting on the bus. His mom was *growing* very proud of him as she *watched* him find a seat in the back *row*, *fit* his bag under it and wave goodbye. A week later, she got a *card*. It was from Tim. He *said* he was having a great time at camp and he was *praying* a lot every day for her to *get* better soon. At the bottom there was a huge X.

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[1] Potential IL homophones are noted in italics. They were not italicized in the format presented to subjects.

CONTROL PASSAGE

One day, a little girl named Ann and her dad went to a park near their house. Since it was a warm day she asked him to go swimming with her in the pool there. They had a fun time swimming together in the hot afternoon sun, and Ann's dad taught her how to dive into the water. After swimming she was hungry so they found a place to buy a snack to eat. Her dad bought two pieces of pizza and two cokes, but Ann spilled her coke on the table. Her dad teased her, helped her wipe it up and gave her his coke. After eating, they decided to play a game of ball. Ann's dad had played a lot of sports when he was a young boy, so he was eager for Ann to learn to play some. He always hoped that she would one day enjoy sports like he did.

Finding an open field, they began to toss the ball back and forth. It was a windy day. Suddenly, the wind caught the ball and blew it over a wall and into the street. A passing car bumped into the ball making it go rolling away out of sight. Ann was very upset because she didn't know what to do. She took her dad to look for the ball. Her dad thought he saw it beside a bike parked nearby, but when they got closer they realized it was only an old grocery bag. They couldn't find the ball anywhere. Ann's dad looked at her and felt sorry for her because he knew it was her favorite ball. It was orange and yellow and had an unusual pattern of dots on it. Her aunt and uncle had given it to her when she was two. Now it was lost and there was nothing Ann's dad could do about it. Then he thought of an idea. "There's a store not too far from here where we can buy a new ball," he suggested.

Ann walked to the store with her dad. As they passed a gas station, a car pulled out and turned onto the street in front of them. There was a big black dog sitting in the back seat, and the passenger was looking closely at Ann as the car went by. Ann didn't recognize the man. The car suddenly stopped. The passenger hopped out and called after them. His dog jumped out and ran down the sidewalk toward them. Ann was really scared. She yelled to her dad. He was totally surprised. He had not seen the car. Then Ann began to laugh. "What's going on?" her dad asked. Ann pointed to the dog. In the dog's mouth was her ball. The dog ran over to her and sat down. She put out her hands and the dog put the ball down. Ann was so happy, she hugged her dad and the dog. She asked her dad, "Can we still go to the store? I want to buy another ball for this dog."

PASSAGE INFORMATION

FEATURE	HOMOPHONE PASSAGE	CONTROL PASSAGE
character count	1949	1967
word count	509	509
line count	32	31
sentence count	43	44
short sentences	24	25
long sentences	0	0
paragraph count	3	3
average word length	3	3
average syllables/word	1.19	1.23
average words/sentence	12.75	11.56
maximum words/sentence	28	25
Flesch index of readibility	93	91
Possible IL homophones	57	

APPENDIX 7

EXPERIMENT 3: INSTRUCTIONS FOR PASSAGE READING TASK

Description: You will read 2 passages as quickly as possible and answer 4 multiple choice comprehension questions after each passage.

Instructions: For each passage: When you are ready to begin, turn to the next page. Press any key on the computer to start the timer. Read the passage one time as quickly as you can. Press any key on the computer to stop the timer. Turn to the next page. Choose the 1 best answer for each question and mark it on your answer sheet. You will not be able to look back at the passage to answer the questions. Do you have any questions? Turn to the next page when you are ready to begin the practice passage.

Practice trial:

Two children named Sam and Cathy were walking to school one day when they realized they left their books at home. Sam said he would run home and get the books. Cathy continued on walking to school. When she arrived at school, she told the teacher that Sam would be a little late. The teacher was just beginning the lesson when Sam arrived.

Press any key on the computer.

Turn to the next page now.

Choose the one best answer for the question. Circle your answer on the answer sheet.

1. The children _____ .
   a. were walking home from school
   b. forgot to bring their books to school
   c. found some books on the way to school
   d. gave their teacher some books

Turn to the next page when you are ready to begin the next passage.

APPENDIX 8

EXPERIMENT 3: SENTENCE READING TASK STIMULI

test word	freq[1]	IL homo pair	sentence stimuli	control sentence 1	control sentence 2
rips	14	*lips*	This material rips easily.	She sang the song quietly.	This medicine tastes terrible.
crime	49	*climb*	We must help reduce crime.	You should eat more carrots.	He must study for his exam.
chair	89	*share*	This chair is comfortable.	This chemical causes cancer.	The radio is too loud.
watch	209	*wash*	He likes to watch football.	He forgot to warn us.	He tries to do his best.
cheat	7	*sheet*	She will cheat on the exam.	I will call you on the phone.	She will never forget his words.
hid	6	*hit*	He hid from the police.	She found keys in the car.	He took five pictures of me.
bride	40	*bright*	The bride wears a white dress.	Fish swim in the ocean.	The cows walk across the field.
west	142	*waste*	The west coast is lovely.	Exercise is healthy for you.	The president is powerful.
pills	23	*peels*	She takes three pills a day.	She works on the fifth floor.	He travels a lot on business.
verse	37	*worse*	He sang the first verse again.	He took the magazine home.	I saw that movie four times.
mean	61.6				

[1]word frequency rating (Francis and Kucera, 1982)

APPENDIX 9

EXPERIMENT 3: WORD READING TASK STIMULI

semantic category	IL homophone exemplar	freq[1]	typ. rat.[2]	Sound-alike non-exemplar	freq	control exemplar 1	freq	control exemplar 2	freq
a direction	right	224	4	*light*	306	forward	97	north	97
a kitchen utensil	dish	36	4	*ditch*	12	knife	86	plate	44
a metal	lead	49	3.25	*late*	132	copper	67	tin	12
a part of a plant	seed	82	3	*seat*	68	branch	5	leaf	33
a part of the human body	wrist	16	3	*list*	154	ear	67	lung	36
a way of cooking	fry	8	4	*fly*	92	bake	15	boil	27
an animal	sheep	24	3.25	*cheap*	23	cow	46	tiger	9
clothing	shoe	58	.75	*chew*	16	pants	9	sock	10
furniture	chair	89	4	*share*	105	cabinet	22	desk	69
a kind of seafood	crab	2	3.75	*clap*	9	fish	33	lobster	1
transportation	ship	126	3.75	*chip*	19	train	86	truck	80
used to tie things	thread	9	3.75	*threat*	56	ribbon	18	string	34
mean		60	3.4		83		46		38

[1] word frequency rating (Francis and Kucera, 1982)

[2] average typicality rating by 4 Thai SL readers of English on a scale of 0-4 (0 = not an example, 1 = a very poor/untypical example, 4 = a very good/typical example of the category)

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