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A COMPONENT SKILLS APPROACH TO ADULT ESL READING: EVIDENCE FROM NATIVE SPEAKERS OF FARSI

by

Hossein Nassajizavareh

A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education of the University of Toronto

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ABSTRACT
A Component Skills Approach to Adult ESL Reading: Evidence from Native Speakers of Farsi

Doctor of Philosophy, 1998
Hossein Nassajizavareh

Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education
University of Toronto

The role of basic language processing components, in general, and that of lower-level phonological and orthographic processing skills, in particular, is not well understood in second language reading. Most research in second and foreign language (L2) reading has followed top-down models, focusing almost exclusively on the role of higher-level processes such as background knowledge and the knowledge of syntactic and semantic structures in processing text. Therefore, the lower-level dimensions of text, particularly phonological and orthographic processes, have not received attention relative to more top-down processes. The present study addressed this gap in current knowledge by investigating basic language processing skills in adult English as a second language (ESL) readers who were native speakers of Farsi. Measures of lower-level phonological and orthographic processing skills in conjunction with higher-level syntactic and semantic processing skills were used while controlling for aspects of cognitive ability relevant to reading such as working memory and speed of lexical access. Participants were 60 advanced ESL readers (all adult native speakers of Farsi residing in Canada). Three measures of reading were criterion variables: reading comprehension, silent reading rate, and the ability to recognize individual words out of context. Data were analyzed using correlations and hierarchical multiple regressions. Correlational analyses revealed that both speed and accuracy on second language phonological, orthographic, syntactic, and semantic measures correlated significantly with each other and with various indices of ESL reading proficiency. Hierarchical multiple regressions revealed that efficiency in phonological and orthographic processing contributed to the prediction of individual differences on the reading measures. In particular, efficiency in orthographic processing
contributed unique variance to the reading measures over and above the variance contributed by higher level syntactic and semantic skills.

The results challenge the common assumption in L2 that the availability of higher-level processes in L2 reading comprehension reduces significantly the contribution of lower-level processes. They also challenge the idea that proficient L2 readers, that is, those with a basic command of L2 vocabulary, syntax, and discourse markers, move away from using lower-level skills and rely instead on higher-level semantic and syntactic skills. Rather, the results indicate that in addition to more general language proficiency indices such as semantic and syntactic knowledge, individual differences in ESL reading need to be understood in respect to individual differences in lower-level processes, particularly, the efficiency with which readers process phonological and orthographic information. The role of these processes should not be overlooked in ESL reading even when readers are proficient adult L2 readers.
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CHAPTER 1
INTRODUCTION TO THE STUDY

Research Problem and its Significance

Research has placed considerable importance on investigating the role of basic component processes in first language (L1) reading. In second language (L2) reading research, much less is known about the relationship of these processes to L2 reading. Prompted by top-down psycholinguistic views of L1 reading, most research in second and foreign language reading has focused on the role of higher-level knowledge sources such as background knowledge and the reader’s knowledge of syntax and semantics (e.g., Barnett, 1986; Carrell, 1984, 1985; Carrell & Eisterhold, 1983; Clarke, 1980; Cziko, 1980, 1978; Floyd & Carrell, 1994; Hatch, Polin, & Part, 1974; Hudson, 1982; Johnson, 1982; Lee, 1986; Lee & Riley, 1990; Tang, 1992). According to Bernhardt (1991), a high percentage of the empirical studies in L2 in the past decade have followed top-down psycholinguistic models, particularly those of Goodman (1968) and Smith (1971).

Conceptualizing reading as a game of guessing, sampling, predicting and verifying top-down hypotheses, the psycholinguistic models emphasize the role of higher-level syntactic and semantic skills, minimizing, to a great extent, the role of basic lower-level phonological and orthographic processes. According to these L1 reading models, reading problems derive, for the most part, from the inability of readers to use syntactic and semantic cues rather than lower-level graphophonic information (Goodman, 1971, 1976; Smith, 1971).

While the literature in L2 reading research is overwhelmingly dominated by L1 psycholinguistic frameworks, the pendulum in L1 research has swung back towards a more
balanced view regarding the role of different component processes in L1 reading. Taking an information-processing perspective, many L1 reading researchers conceptualize reading as a complex information-processing operation, which draws on many sub-component processes, any of which can be a potential source of individual difference in reading (Daneman, 1996). In this view, efficient lower-level graphophonic skills are considered an integral component of fluent reading (Adams, 1990; Barron, 1986; Berninger, 1994; Bruck & Waters, 1990; Carr & Levy, 1990; Cunningham, Stanovich, & Wilson, 1990; Perfetti, 1985, 1991; Stanovich, 1980, 1986, 1996, 1993). Indeed, researchers have argued that it is the efficient lower-level processes that allow the limited-capacity system of human cognition to be devoted to processing higher-order information during reading comprehension (e.g., Perfetti & Lesgold, 1977; Stanovich, 1996).

An extensive body of research on L1 reading supports this view. In particular, L1-based studies have demonstrated that lower-level phonological and orthographic processing skills not only predict early stages of learning to read but continue to predict reading skills even among adult native readers (Bell & Perfetti, 1994; Cunningham et al., 1990; Stanovich & West, 1986; Stanovich, West, & Cunningham, 1991).

The question remains as to what extent these lower-level processes contribute to reading a second language. In a recent study, Bernhardt and Kamil (1995) found that general language proficiency, defined as syntactic and lexical knowledge, along with L1 reading ability accounted for less than 50% of the variance in L2 reading comprehension among adult Spanish as L2 readers. Leloup (1993, cited in Bernhardt and Kamil, 1995) found that only about 10% of the variance in L2 reading could be accounted for by background knowledge.
plus interest in the topic. Taking all these factors into account, there is thus still a large amount of variance unexplained in L2 reading comprehension. Might phonological and orthographic processing skills account for part of the variance in L2 reading, particularly in advanced second language reading? This is a central issue addressed in the present thesis.

Presently, there are a few studies on the role of phonological and orthographic processes in adult L2 reading (e.g., Akamatsu, 1996; Segalowitz, 1986; Wade-Woolley, 1996). However, these studies are too limited in number to produce enough evidence for the contribution of these processes to L2 reading. Moreover, they have been mostly at the word recognition level. Therefore, the extent to which phonological and orthographic processes contribute to reading connected text in L2 remains unclear. Furthermore, most of the recent research on the role of component processes in L2 has taken a single-level approach, centering on variables from only one level of the reading process (Haynes & Carr, 1990). Therefore, the extent to which these processes make any independent contribution to L2 reading over and above the contribution made by higher-level processes, such as semantic and syntactic processes, is not clear. If phonological and orthographic processes can be shown to make independent contributions to L2 reading, this would provide significant insights into models of L2 reading comprehension and reading development.

To address the above issues, the present thesis used a component skills design, utilizing measures of lower-level phonological and orthographic processing skills in conjunction with measures of higher-level syntactic and semantic processing skills, while controlling for aspects of cognitive ability such as working memory and speed of lexical access. I hoped that such a design would yield a less biased picture of the role of both lower-
level and higher-level language-processing skills in ESL reading than had appeared in earlier studies. As such, it would provide important insights to the current debate in the L2 reading literature concerning the role and nature of different cognitive and linguistic abilities that underlie L2 reading.

**Organization of the Thesis**

The thesis is organized in the following manner. Chapter 2 provides a review of the relevant literature. It discusses two theoretical positions, the psycholinguistic and the information-processing perspectives, and their main contentions and positions about the role of lower-level processing in both L1 and L2 reading. First, the chapter considers the psycholinguistic position. It presents a review of the major L2 research within this framework and outlines the major methodological and interpretational problems associated with the psycholinguistic framework in both L1 and L2 reading research. The second section considers the information-processing perspective. It discusses the role of lower-level processes, particularly, phonological and orthographic processes in fluent reading and examines the major studies conducted so far on the role of these processes in both L1 and L2 reading. The chapter concludes with the rationale for the present study.

Chapter 3 outlines the methods of the research. It includes a description of the participants, their L1 writing system, the tasks and tests used, and the procedure whereby data were collected.

Chapter 4 presents the results of the study, deriving from the different statistical procedures used to analyze the data. First, the chapter presents the results for a comparison
between skilled and less skilled readers on the variables in the study. Then it provides a
description of the results of correlational and regression analyses, followed by a schematic
representation of the role of the different linguistic and cognitive variables studied and ESL
reading comprehension. Finally, the chapter presents the results of a simple commonality
analysis using lower-level and higher-level component variables as predictor variables and
ESL reading comprehension as the criterion variable.

These findings are discussed in Chapter 5. This chapter concludes the thesis,
presenting the theoretical and the pedagogical implications of the study as well as its
limitations and suggestions for future research.
CHAPTER 2
REVIEW OF THE LITERATURE

Reading is not a single-factor process. It is a multivariate skill involving a complex combination and integration of a variety of cognitive, linguistic, and nonlinguistic skills ranging from the very basic low-level processing skills involved in decoding print and encoding visual configurations to high-level skills of syntax, semantics, and discourse, and to the still higher-order knowledge of text representation and the integration of ideas with the reader's global knowledge. Because reading is not a mere sum of different components, but a highly complex interaction and integration of these sub-processes in a most intricate fashion, many researchers believe that by analyzing and studying the nature of these components, we should be able to arrive at a better picture of reading processes and a better understanding of the sources of individual differences in reading (Carr et al., 1990; Rayner & Pollatsek, 1989).

There has been a heated debate in publications about reading in the last two decades as to the relative importance of each of the processing levels to skilled reading. Some have attributed primary importance to higher-level syntactic, semantic, and text integration skills, downplaying to a large extent the role of basic lower-level processes (e.g., Goodman, 1976; Smith, 1971, 1994). Others have argued for the importance of lower-level visual orthographic and word recognition processes (e.g., Adams, 1990; Carr, Brown, Vavrus, & Evans, 1990; Cunningham et al., 1990; Perfetti, 1991; Stanovich, 1980, 1991). Giving different weights to different levels of reading process, these two positions have represented themselves in the reading literature under the two theoretical camps of "psycholinguistic models" and "information-processing theories" of reading process. In what follows, I review these two
theoretical positions in both L1 and L2 reading research, discussing their main contentions and positions on the role of different language processing skills in reading.

**The Psycholinguistic Perspective**

Notable among the reading models that have influenced highly the literature on reading in the past few decades are Goodman's and Smith's psycholinguistic models. The main thesis of these models is that reading is a "psycholinguistic guessing game" (Goodman, 1967). Goodman described the psycholinguistic view as follows:

Reading is a selective process. It involves partial use of available minimal language cues selected from perceptual input on the basis of the reader's expectation. As this partial information is processed, tentative decisions are made to be confirmed, rejected or refined as reading progresses. More simply stated, reading is a psycholinguistic guessing game. (Goodman, 1976, p. 498).

The psycholinguistic view downplays, to a large degree, the contribution of basic lower-level visual word recognition processes to reading. In this view, individual differences in reading are best understood in terms of differences in higher-level knowledge sources. Reading problems are believed to derive, for the most part, from the inability of readers to use syntactic and semantic cues rather than from problems in processing lower-level graphophonic information. Smith (1971) asserted that, "the cause of the difficulty is inability to make full use of syntactic and semantic redundancy, of nonvisual sources of information" (p. 221).

Considering his own view as a strong representative of a top-down approach to reading, Smith (1994) argued that reading is only incidentally visual. According to Smith, using syntactic and semantic knowledge, readers reduce their reliance on the graphophonic aspects
of the text. Goodman (1973) argued that "readers are able to use syntactic and semantic cues to such a considerable extent that they need only minimal graphic cues in many cases" (p. 26). What is emphasized in this view is prediction, topical knowledge, and guessing strategies.

Smith stated that "prediction is the core of reading" (Smith, 1994, p. 18), and guessing is "the most efficient manner in which to read and learn to read" (Smith, 1979, p. 67).

In the above view, the fact that written language is composed of orthographic symbols is of limited importance to fluent reading. Smith (1994) maintained that there is no difference between a word read in an alphabetic language like English and a word read in a nonalphabetic language such as Japanese. Goodman (1973) pointed out that the role of the actual writing system is trivial in reading. He claimed that there is a universal process underlying and applicable to reading in all languages irrespective of their orthographies, whether alphabetic or non-alphabetic. That is what Goodman (1973) called "the reading universal hypothesis".

From the above perspective, not only is the role of visual component processes involved in recognizing written words of limited importance to reading, but the identification of words is deemed unnecessary in fluent reading. Smith (1994) maintained that fluent reading does not require the identification of individual words. He argued that word level processing is a memory-inundating and time-consuming process; therefore, to overcome the limitations of short-term memory, fluent readers need to bypass this processing level. Smith went even further than that and considered word identification detrimental to reading comprehension. He called it "a snag, a hindrance, not a help to comprehension" (1971, p. 207).
The Psycholinguistic Perspective in Second Language Reading

The field of L2 reading has been heavily influenced by L1 psycholinguistic views. Several ESL researchers have advocated and at times have developed models very similar to what Goodman and Smith proposed for L1 reading (Coady, 1979; Rizzardi, 1980). Coady (1979), for example, formulated a framework very similar to Goodman and Smith's psycholinguistic models for L2 reading. Coady described his reading model as consisting of three basic components: a) a higher-level conceptual abilities component, b) a background knowledge component, and c) a process strategies component. Conceptual abilities, according to Coady, refer to general intellectual abilities that underlie success in learning an L2. Coady did not elaborate on background knowledge. He just referred to it in passing as a kind of knowledge that a particular cultural or language group carries with them, which might be different from that of another cultural or linguistic group. Process strategies refer to abilities such as the knowledge of language, cognitive skills, as well as affective variables.

In Coady's view, the role of top-down, conceptually driven processes outweighs that of data-driven processes. Coady believed that although L2 readers might begin by paying attention to the stimulus-driven processes, such component processes lose their importance as the reader becomes more proficient. Efficient reading, he argued, can be described as a move away from using the visual, stimulus-driven components of reading to using more abstract semantic and syntactic information. He stated:

The typical reader acquires the skills of reading by moving from the more concrete process strategies to the more abstract. In a psycholinguistic model the reader is reconstructing the meaning of a text based on the sampling he has taken (p. 8).
Moreover, to Coady the shift from the more concrete data-driven processing to the more abstract one is a conscious move taking place "as the reader decides that a particular skill or combination of skills is not working" (p.8).

At present, these psycholinguistic models are no longer dominant in L1 reading research. However, while the pendulum has swung back towards a more balanced view regarding the role of different component processes in L1 reading, such top-down models are still overwhelmingly dominant in L2 reading research (Koda, 1994; Paran, 1996).

This dominance has been so strong that it has even influenced the way the more recent interactive views of the reading process have been interpreted in L2 reading. While cognitive psychologists interpret the term "interactive" as referring to an interaction among various component processes involved in reading (e.g., Perfetti & Roth, 1981; Stanovich, 1992), L2 researchers have tended to interpret the term in a general sense as an interaction between the text and the reader, and the interactive models as top-down, reader-driven models (Barnett, 1989; Grabe, 1991). Consequently, although some of the proponents of interactive models have acknowledged the role of lower-level processes (Carrell, Devine, & Eskey, 1988; Devine, Carrell, & Eskey, 1987), there has not yet been a complete understanding of the implications of interactive models for research into L2 reading (Carr & Haynes, 1991). Rather, research in this area continues to focus on the interaction between the reader and the text, rather than on interactions among various component processes of L2 reading (Horiba, Broek, & Fletcher, 1994).

There are several theoretical and practical factors contributing to the dominance of the top-down views in L2 reading literature. One factor might be the replication and spread of the
psycholinguistic models of L1 reading in L2 reading research, which was discussed above. Another factor might be the fact that the idea of "prediction", typical of the psycholinguistic perspective, has been strongly echoed in other areas of L2 research. Oller's (1979) "expectancy grammar" is an example. Oller's observation is quite reminiscent of Goodman's (1976) "reading as a psycholinguistic guessing game". According to Oller, the language processor is driven along the line of comprehension mainly by a syntactic processing system, filling in the gaps through an anticipatory mechanism. This idea has been paralleled in the context of L2 reading; it underlies the rationale for the use of cloze, fill-in-the-blank procedure as a measure of L2 reading competence (e.g., Oller, 1972).

Another factor that contributes importantly to the dominance of top-down views in the L2 reading literature might be the scarcity of research on the unique processes involved in L2 reading. Although in recent years a growing number of studies have focused on basic reading processes in L2, the majority of the studies of L2 reading in the past decade have been conducted within a top-down psycholinguistic framework. These studies have typically produced evidence for the role of higher-level semantic and syntactic contextual processes in L2 reading, which in turn has been taken as support for a top-down view of L2 reading. In what follows, I will review some of the major studies of this kind. However, before accepting their top-down conclusions, a number of issues need to be considered. First, it is important to realize that evidence for the role of semantic and syntactic processes produced in these studies does not necessarily rule out the role of basic lower-level graphophonetic word recognition processes in L2 reading. It is doubtful whether such studies can reveal much about the extent to which different skills and subskills from different levels of processing contribute to L2
reading. Second, there are certain methodological and interpretive problems associated with most of the studies conducted within a top-down psycholinguistic framework (see the subsequent section). These problems are enough to make one cautious about the legitimacy of the conclusions drawn by many psycholinguistic studies of L2 reading.

**Psycholinguistic Studies in L2 Reading**

One well-known study within the psycholinguistic framework in L2 is by Hatch, Polin, and Part (1974). This study aimed to demonstrate the effect of syntactic knowledge on the reading performance of foreign language readers. In this study, Hatch et al. used a canceling task in which ESL university students were to cross out the e's while reading the text as quickly as possible. The results showed that the ESL students marked the letter 'e' everywhere in the text, both in content words (i.e., nouns, adverbs, verbs) and in function words. On the other hand, native readers were more likely to cancel more e's in content words than in function words. Hatch et al. concluded that the ESL students showed little sensitivity to the different syntactic patterns. These researchers argued that ESL readers processed the function words and the content words in a similar fashion because they relied mainly on visual cues. The native readers, on the other hand, did not rely as much on the printed stimuli. Using their proficient syntactic and semantic skills, native readers made predictions and hypotheses about the upcoming text and just picked up enough cues to make guesses about what has appeared in the printed page. The researchers then concluded that Goodman's hypothesis that reading is a psycholinguistic guessing game provides an accurate description of the reading process.
Another well-known study following the psycholinguistic theory in L2 is by Cziko (1978). Cziko investigated the role of syntactic, semantic, and discourse constraints in reading French as an L2. He used four groups of readers with varying degrees of L2 proficiency: three beginners to advanced groups of L2 readers and one group of native speakers of French. The participants were given three types of text: meaningful, anomalous, and random. Cziko reported that all four groups were capable of making use of syntactic constraints in the anomalous texts, but it was only the most proficient groups who could take advantage of semantic constraints in the meaningful texts. Moreover, he found that only the advanced L2 and the native groups were able to benefit from discourse constraints in reading the texts. Based on these results, Cziko contended that much of the success of a reader in an L2 depends upon the previous ability to make use of the syntactic, semantic, and discourse constraints of the text.

The most frequently cited support for the psycholinguistic perspective in ESL reading, however, comes from a study by Clarke (1980). Using an oral reading miscue analysis technique, Clarke analyzed the L1 and ESL reading behavior of adult Spanish speakers of English. He found that good readers produced fewer miscues in both Spanish and English in comparison to poor readers. Clarke then concluded that his adult readers exhibited 'guessing' strategies by using their knowledge of syntax and semantics in much the same way as had been exhibited in L1 reading. This conclusion was presented as a partial justification for the "reading universal hypothesis" as put forward by Goodman (1973), the idea that "the reading process will be much the same for all languages" (1973, p. 27). According to Clarke, his study provided important support for the psycholinguistic perspective in L2 reading.
Methodological and Interpretive Problems with Psycholinguistic Research

Miscue analysis and oral reading techniques have been the primary sources of data for psycholinguistically oriented research. These techniques have been used as the main research methods on the basis of which the psycholinguistic models have been formulated, tested, and further developed (Goodman, 1988). Miscue analysis is a procedure that compares the reader's observed responses to expected responses as the person reads a text orally. In this procedure, oral errors are detected and further analyzed to see if there are any similarities or differences between the errors and what is actually in the text.

Although this procedure might yield useful information about the ways in which readers interact with text (Cziko, 1980), researchers have questioned the technique as a valid and reliable means of gathering data in research. Leu (1982), for example, identified three major problems in the use of the miscue procedure: a) a lack of an appropriate miscue classification system; b) a lack of attention to the passage difficulty and its effects on error types; and c) difficulty in determining the exact sources of problems. Wixson (1979) argued that research has shown inconsistency between readers' reading comprehension profiles and the processing strategies as indicated by their miscue patterns. According to Wixson, miscue patterns can be a function of a host of other variables, which might not necessarily be related to the reader's reading proficiency in general.

Similar concerns have been raised in the context of L2 reading research. Bernhardt (1986, 1987), for example, questioned the methodology underlying miscue analysis, namely, oral reading as an appropriate measure for the investigation of L2 reading comprehension.
processes. She argued that in the miscue technique it is not possible to determine reliably whether an error is a miscue or a mispronunciation. Citing her research (Bernhardt, 1983) as evidence, Bernhardt (1986) stated that the miscue technique procedure consistently impedes reading comprehension in an L2 because reading comprehension is, after all, a silent reading process, which might be qualitatively different from reading aloud. Devine (1987) also considered oral reading methods problematic for L2 reading research. She argued that the oral language proficiency of many L2 readers is limited as compared to L1 readers, making this procedure inappropriate for L2 reading research.

In addition to the above methodological problems, there are certain interpretive problems associated with the use of miscue analysis. In analyzing the miscues, it is usually observed that skilled readers' oral reading miscues are semantically and syntactically appropriate whereas less skilled readers' errors do not show such signs of contextual advantages. This observation is usually taken as evidence that skilled readers rely mainly on semantic and syntactic contextual cues to process text rather than using the visual orthographic information available in the print (e.g., Goodman, 1981). According to Stanovich (1992), however, this kind of interpretation is problematic. This interpretation, he argued, results mainly from a failure to take into account the difficulty level for skilled and less skilled readers of the materials used in an experiment. According to Stanovich, the increased difficulty level of the materials for less skilled readers as compared to the skilled readers in an experiment prevents the less skilled readers from decoding the text as efficiently as the skilled readers do. Consequently, this less efficient lower-level processing of the text results in less adequate contextual information available for the less skilled readers to use. On the other
hand, the more skilled readers, due to the fact that they are more skilled, have more efficient lower-level decoding skills as well. It is this efficient lower-level processing that makes more contextual information available for them to use. Thus, if skilled readers make more contextually appropriate errors than less skilled readers do, this should not be taken as an extra ability on the part of the skilled readers to make more use of semantic and syntactic resources than of visual resources. Rather, it could be taken as evidence for the skilled readers being more skilled at decoding such they that have more contextual information at their disposal to use.

These above methodological and interpretive problems with miscue analysis technique should make one cautious in accepting the conclusions of the psycholinguistic research in which such procedures have been used to gather data. By the same token, one should be cautious in accepting the conclusions of Clarke's (1980) study—that in L1 and L2 alike the reading process is largely a guessing process. There is another problem with Clarke's (1980) study as well. Clarke determined his participants' reading comprehension on the basis of retelling the texts they had previously read. Although retelling has sometimes been used as a reading comprehension measure, there are certain doubts about its being a valid measure for testing reading comprehension ability, particularly in an L2. Retelling involves recalling the text, which in turn involves not only a much heavier memory load but also different cognitive processes than does online text comprehension. Retelling also involves production skills such as reflection and organization of the incoming information, which while related to comprehension, are not themselves comprehension processes. These differences make retelling not only different but also much more difficult than comprehending, particularly for
L2 learners for whom language production may be far more demanding than language comprehension.

**An Information-Processing Perspective**

In contrast to the psycholinguistic perspective that considers reading as a process involving only partial sampling of visual cues, the information-processing view conceptualizes reading as a process involving rapid and accurate response to print as well as coherent orthographic, phonological, and semantic patterns (Adams, 1991). In this view, fluent reading reflects not less reliance on visual cues, but a high degree of efficiency in processing lower-level stimuli. According to Adams (1990), normal readers process even "the individual letters of print" (p. 105) fully and efficiently. The idea of reading as a "guessing game" is strongly rejected by the proponents of information-processing theories. According to Stanovich (1991), instead of being imprecise guessers, "[G]ood readers are efficient processors in every sense: they completely sample the visual array and use fewer resources to do so" (p. 21). And if any guessing occurs during reading, it is done only as a last resort to compensate for the reader's poorly developed and unautomatized stimulus-driven word recognition processes (Stanovich, 1980, 1986).

Two cognitive psychological principles are central to the characterization of reading as an information-processing operation. One is the notion of the hierarchical structure of skills and subskills in reading (LaBerge & Samuels, 1974). According to LaBerge and Samuels (1974), reading, as a very complex cognitive skill, can be best conceptualized as a hierarchical structure consisting of different subtasks and sub-components. The successful execution of a
higher-level process in this hierarchy depends on the efficient execution of the lower-level ones. Lower-level processes refer primarily to processes involved at the word level and include visual recognition of features, letters, and the utilization of phonological and orthographic information (Barron, 1986; Perfetti, 1985, 1986). Higher-level processes are comprehension processes and have more to do with linking the text together and making a representation of the text by integrating the textual information with prior knowledge based on the reader's overall semantic, syntactic, and contextual knowledge (Kintsch & van Dijk, 1978; Van Dijk & Kintsch, 1983).

Another central idea in conceptualizing reading as an information-processing operation is the idea of 'limited attentional resources', as employed in the 'limited-capacity model' of Perfetti and Lesgold (1977). According to this principle, readers' attentional capacity is limited; therefore, in order to read effectively, readers need to make optimal use of this cognitive system.

The proponents of the psycholinguistic models assume that readers simply bypass the visual and word level processes in order to overcome limited attentional capacity, and that they instead rely on higher-level contextual redundancies for comprehension. Within the information-processing perspective, however, the limitation imposed by short-term memory does not mean that word-level processes should be bypassed but rather that the language processing mechanism should include an efficient cognitive component that can process the incoming data within attentional limits (Adams, 1990; Rayner & Pollatsek, 1989; Rieben & Perfetti, 1991, Stanovich, 1981). The former perspective denotes that the process of formulating and testing hypotheses operates faster than efficient word-level processes.
However, from an information-processing perspective, it is much faster and more reliable for skilled readers to go from efficient lower-level word identification to meaning rather than from higher-order contextual meaning to word identification (Perfetti, 1985). It is argued that it is unlikely that a top-down procedure based on complex syntactic and semantic analyses can be carried out in a shorter period than the few hundred milliseconds that a fluent reader requires to recognize most words (Stanovich, 1980).

In its strong version, the information-processing view predicts that failure at low-level, data-driven component processes will result in an inevitable and irreversible failure in reading comprehension. Most of the early information-processing theories took such a strong position, considering reading as a complete data-driven process involving a series of successive stages, starting with visual analysis then moving to syntactic analysis, and then to semantic assignment in a sequential fashion (e.g., Gough, 1972; LaBerge & Samuels, 1974).

However, current versions of information-processing models are strongly interactive in that they view the processing of information during reading to be cyclical rather than linear. The interactive idea in reading was first conceived of by Rumelhart (1977). Rumelhart proposed that the information-processing system in reading consists of different levels of processing which work independently of one another and which operate in a parallel manner. That is, while the data-driven processing level is doing visual analysis, syntactic, and semantic processing systems are also operating, generating hypotheses about the interpretation of the visual information coming from visual analyses. The output of each of these processing levels is then transferred to a central organizer in the form of hypotheses which can be confirmed or rejected in light of the total information accumulated from all other sources in this message.
center. Comprehension then results from the combination and integration of all these different knowledge sources contained in the message center.

Stanovich (1980) formulated a similar but more elaborate version of the interactive model. Like Rumelhart, Stanovich viewed comprehension as an outcome of a pattern "based on information provided simultaneously from several knowledge sources (e.g., feature extraction, orthographic knowledge, lexical knowledge, syntactic knowledge, semantic knowledge", p. 35). However, to account for individual differences in reading, Stanovich supplemented his model with a compensatory mechanism: the idea that information at one level of processing might influence and compensate for deficiencies at other levels of processing.

In the interactive-compensatory view, while lower-level visual and orthographic information as well as higher-level semantic and syntactic information play a significant role in reading, the reading process is mainly oriented to lower-levels of processing. In this view, a deficiency at lower-level processing can be compensated for by higher-level knowledge sources in reading. However, it is argued that this operation is associated with an inevitable cost. It will be carried out but at the expense of cognitive capacity and an extra burden on the reader's attentional resources, which in turn results in fewer resources left for comprehension processes (Stanovich, 1984). In order to prevent such a costly operation, it is argued that the reader must be highly competent in lower-level graphophonic processing operations, so that s/he "will exhaust little attention developing higher-level contextual expectancies", and consequently can be left with enough attention for comprehension (Stanovich, 1982, p. 83).

This view is currently shared by many cognitive psychologists who argue that reading
involves a complete processing of the visual input and that a less skilled reader is one who is slower at processing lower-level graphophonic data rather than one deficient at processing higher-level conceptually-driven data (Just & Carpenter, 1987; Perfetti, 1985; Perfetti & Roth, 1981; Rayner & Pollatsek, 1989). Perfetti and Roth (1981) argued that although reading is an interactive process, lower-level and higher-level processes are not used reciprocally. The lower-level processes can be carried out reasonably well without top-down processes. However, the reverse is not possible.

An extensive body of research in L1 reading, including detailed studies on eye movements and a number of studies on context effects as well as the role of phonological and orthographic processing and word recognition skills, supports this view. Recent research on eye movements has demonstrated that fluent reading involves a detailed processing of visual features on the page. The typical pattern of eye movements in reading has been shown to be more or less word-by-word (Pollatsek, 1993). Research in this area indicates that most content words and a great number of function words are directly fixated during reading (Carpenter & Just, 1986; Pollatsek, 1993; Rayner, 1986; Rayner, & Pollatsek, 1989). There is also evidence that words are processed visually even if they are highly predictable in the context (Balota, Pollatsek, & Rayner, 1985). These findings suggest that reading depends on visual information to a much greater extent than had commonly been assumed in previous theories of reading.

Another line of evidence comes from research on word recognition skills. Skills in word recognition, that is, the ability to read and identify words quickly and accurately (Adams, 1990), has been described as one of the fundamental processes in fluent reading. It is
argued that this important process is highly lower-level oriented, being little affected by skills in generating and testing hypotheses based on contextual expectancies provided by higher-level knowledge sources such as syntactic and semantic resources (Stanovich, 1980; 1984; 1986; 1991; Stanovich & West, 1989; Stanovich, West, & Freeman, 1981; West & Stanovich, 1978; West, Stanovich, Freeman, & Cunningham, 1983). In a series of studies, Stanovich and West (1979, 1983) found that contextual information produced differential effects for processing words depending on the time available to readers. At short delay intervals, sentential context produced positive effects only. However, at longer delays, it produced positive effects that were associated with certain costs. Stanovich and West (1983) argued that with longer delays (associated with both costs and benefits) the people they studied employed a conscious prediction mechanism as suggested by top-down theorists. However, with short delay intervals (which produced only a positive effect with no costs), words were identified through automatic priming flowing from the previous words in the context to the lexical entry of the next possible words in the sentence. According to these researchers, the facilitative effect of contextual information in fluent reading comes from the sum of priming effects, which occur intra-lexically, and not from a process operating in a top-down fashion.

In another study comparing the facilitative effects of sentential context on word recognition in two groups of skilled and less skilled readers, West, Stanovich, Freeman, and Cunningham (1983) found that the use of context facilitated the word recognition of skilled and less skilled readers in term of reaction times. The effect was more dominant for the skilled readers. However, the use of sentential context, while producing facilitative effects, produced more inhibition effects in the less skilled readers. This phenomenon was then viewed as
indicating that the contextual effect in the less skilled readers was via a mechanism guided by conscious prediction rather than by automatic activation. In skilled readers, on the other hand, the contextual effect was solely due to automatic spreading-activation mechanisms (Stanovich, 1984).

In addition to the above studies, studies have also shown that the use of contextual information during word identification is costly, and it is highly possible that it will go wrong. Studies in instructional contexts, for example, have shown that readers are less able than is often assumed to use contextual information appropriately and as an effective strategy to arrive at word meanings (e.g., Jenkins, Matlock, & Slocum, 1989; Schatz & Baldwin, 1986). Schatz and Baldwin (1986), for example, found a very low level of accuracy (14%) in guessing meanings for words from context. There is also evidence that readers are not good at predicting words even if they are given a large amount of time and instruction (Graves, 1986; Nagy, Anderson, & Herman, 1987; Nagy, Hermann, & Anderson, 1985). Nagy et al. (1985, 1987), for example, found that although context helped students to learn the meaning of words, the gain was very small. Moreover, they found that context rarely provides enough information about word meanings to facilitate such processes. Bensoussan and Laufer (1984) found that the effect of context in helping EFL students to guess word meanings was minimal. Context could help guessing for only 24% of the words with no positive effect on the remaining 76% of words in their study. The researchers also found that most often the use of context led to wrong guesses.

However, it seems premature at this stage to argue definitely for or against the role of context in reading comprehension and word recognition. There are still a host of questions
about how context influences stimulus analysis on the one hand and comprehension processes on the other. However, what can be concluded from the above studies is that visual word recognition is mainly a lower-level process depending heavily on the reader’s skills in efficiently processing the graphophonic features of the print. This process is less affected by conscious prediction based on syntactic and semantic skills than assumed by top-down theories of reading.

**Phonological and Orthographic Processes**

Although there is debate over the exact mechanisms whereby word recognition takes place, and on the exact processes whereby readers access the mental lexicon, there is a general agreement that phonological and orthographic processes are two important aspects of word recognition processes (Barron, 1986; Vellutino, 1982). According to Perfetti (1985) and Stanovich (1981), it is indeed those who are less able to use these two lower-level knowledge sources who resort to using semantic and syntactic sources during the word recognition process.

**Phonological Processing**

Phonological processing refers to the use of phonological information and the systematic relationship that exists between the visual configuration and the phonological representation of the letter strings that comprise the written words when processing print (Vellutino, 1982; Wagner & Barker, 1994). While the nature of the relationship of phonological processing skill to reading ability has been the focus of considerable debate,
many researchers believe that this lower-level processing skill is critical to normal reading (Adams, 1990; Perfetti, 1992; Van Orden, 1987; Van Orden, Johnson, & Hale, 1988). According to Adams (1990), without phonological skill, "even skilled readers would find themselves faltering for fluency and comprehension with all but the very easiest of texts" (p. 157).

However, there are different views about how lexical access occurs and how meaning is activated in the lexicon. According to one popular model, i.e., the dual-route model (Baron & Strawson, 1976; Coltheart, 1978, 1980; Humphreys & Evett, 1985; Seidenberg, 1985; Paap, Noel, & Johansen, 1992), there are two routes to lexical access: a direct visual orthographic route whereby the lexicon is accessed via use of the orthographic properties of words, and a phonological route whereby the lexicon is accessed via use of phonological information. According to this view, phonological processing enables the reader to convert the printed stimuli into a sound code which is then used for accessing the lexicon (Barker, Torgesen, & Wagner, 1992).

While some of the proponents of the dual route model believe that the phonological and orthographic processes occur in parallel during word identification (e.g., Carr & Pollatsek, 1985; Coltheart, 1980), there are some who argue that the use of either of the two routes depends on the degree of the individual's reading ability. It is argued that access via the phonological route is slow in comparison to access via the orthographic route. Hence, while phonological processing is an important component of reading in general, the phonological route is mostly used by beginning readers. According to this view, as readers become more skilled they shift from an indirect phonological route to a direct access route. In the latter
case, the semantic representation of words is directly activated without any intermediate phonological processing (Backman, Bruck, Herbert, & Seidenberg, 1980; Coltheart & Laxon, 1990; Jared & Seidenberg, 1991). Therefore, it is argued that phonological processing does not play as much an important role in skilled reading as it plays in less skilled reading (e.g., Coltheart; 1978; Green & Shallice, 1976; Saarnio, Oka, & Paris, 1990; Vellutino, 1982).

Studies, however, diverge in showing which of the two processes should be emphasized in the different stages of reading development. On the one hand, there is empirical evidence supporting the view that phonological processing, while important, is not an obligatory component for word-level recognition processes and reading comprehension in skilled reading. Saarnio, Evelyn, Oka, and Paris (1990), for example, found that the pattern of the contribution of phonological skill changed as the reader became more skilled in reading. Investigating the contribution of phonological skill, defined as the reader’s knowledge of the relation between graphemes and phonemes, as well as some other cognitive and strategic variables to the reading comprehension of third and fifth grade L1 readers, these researchers found that while phonological skill contributed significantly to the reading ability of the two ability groups, it did not contribute as much to the fifth graders who were more effective readers. Similar results were also found in Juel, Griffith, and Gough (1986). These researchers found that phonological knowledge as indicated by phonemic awareness contributed significantly to the reading performance of both first and second graders; however, its contribution was less among second graders than among first graders.

In contrast, a number of experimental studies have shown that phonological processing contributes not only to very late stages of reading acquisition (e.g., Bruck & Waters, 1990;
Byrne, Freebody, & Gates, 1992; Juel, 1988) but to highly proficient adult skilled reading as well (e.g., Bryant, Maclean, & Bradley, 1990; Coltheart, Laxon, Richard, & Elton, 1988; Cunningham, Stanovich, & Wilson, 1990; Juel, 1988; Levy & Hinchley, 1990; Liberman, Shankweiler, Fischer, & Carter, 1974; Stanovich, Cunningham, & Freeman, 1884; Van Orden, 1987; Van Orden et al., 1988). In one study, for example, Bruck and Waters (1990) found that sixth graders' reading comprehension ability was significantly related to their knowledge of grapheme-phoneme correspondence rules measured by different word and nonword spelling tasks. Coltheart et al. (1988) found that both children and skilled adult readers used phonological information to a significant degree when reading for meaning. They found that it was difficult for all the reading ability groups tested to reject sentences containing a homophonic word that made the sentence sound correct but look incorrect (e.g., *He threw out the rubbish*) versus sentences that both sounded and looked incorrect (e.g., *He thought a ball to him*). This effect was also observed when the sentences included homophonic nonwords (e.g., *The sky was bloo. vs. The bloa dress was new*).

Van Orden (1987) and Van Orden et al. (1988) found that phonological mediation contributed importantly when high school and college L1 readers read sentences for comprehension. Using semantic categorization tasks, Van Orden (1987) found that college readers semantically categorized far more erroneously homophonic words with their category exemplars than they did nonhomophonic control words. In these tasks, people were presented with a phrase that indicated a category name (e.g., *a flower*) followed by a target word which was either a homophone of the category name (e.g., *rows*), or a nonhomophone (e.g., *robs*). The participants then had to decide whether the target word belonged to that semantic.
category or not. Van Orden found that 18.5% of categorization errors were produced by homophones versus 3% produced by nonhomophones. According to Van Orden, the reason for these errors was that the phonology of the word *rows* activated the lexical entry related to *rose*, which was then classified erroneously as a flower.

In a different study with a different group of adult L1 readers, Van Orden et al. (1988) replicated the same finding. This time, in addition to the role of phonological processing, the researchers also examined whether the phonological effect produced by the homophone target words was due to a computed phonological representation or a direct word-specific phonological representation. To this end, the researchers used a different version of Van Orden's (1987) semantic categorization tasks. Instead of word homophone and word nonhomophone targets, they used nonword homophone and nonword nonhomophone target words (e.g., the nonword target word *sute* for the category *an article of clothing*). According to the researchers, since there is not a pre-existing lexicon for *sute*, if the readers erroneously interpret it as belonging to that semantic category, it should not be because of a word-specific phonological representation, but because of a phonological representation computed from the spelling features of the target nonword. As in Van Orden's study, the researchers found that the rate of false positive categorization errors produced by nonword homophones was far greater than that produced by nonword nonhomophones. This was then taken as evidence for computed phonological codes being an important source of information in word identification in the process of reading for meaning.

Finally, examining the role of word recognition skills in reading comprehension, Cunningham et al. (1990) found that phonological skills as measured by a pseudoword
decoding task contributed significantly to reading comprehension among adult college-level readers. In their study, phonological processing was found to contribute to reading even after the contribution of general language ability, intelligence, and memory was accounted for. Similarly, Bell and Perfetti (1994) compared three groups of skilled and less skilled college English L1 readers on several lower-level processing tasks such as letter matching, decoding pseudowords, and lexical decision tasks. They found that both accuracy and speed of performing word level processing tasks, particularly pseudoword decoding tasks, reliably distinguished skilled from less skilled L1 readers. Using regression analysis with reading comprehension as the criterion variable and listening comprehension, vocabulary, reading speed, and pseudoword decoding as predictor variables, these researchers found that pseudoword decoding emerged as an independent predictor of reading comprehension after the contribution of the individual differences in the other three indicators of general language ability was partialled out.

The Post-Lexical Role of Phonological Processing

In addition to the role of phonological processing in facilitating lexical access during word recognition processes, it has been suggested that phonological information contributes to reading postlexically as well. It is clear that in order to comprehend the text, in addition to identifying words and their appropriate meanings, a reader needs to interpret the whole string of words based on their syntactic and semantic relationships and work out their relationships with the relevant background knowledge. For this higher-order processing to occur, the reader needs to have a good memory of the sequences of words just encountered in print. It
has been shown that phonological information facilitates the storage of information in temporary working memory by providing a more sustainable representation of linguistic information in short-term memory than does visual information (Baddeley, 1979; Baddeley & Lewis, 1981; Levy, 1977; McCutchen & Perfetti, 1982; Perfetti, 1985). This then facilitates the efficient processing of higher-order information such as semantic integration, syntactic parsing, and propositional encoding in working memory (Glanzer, Fischer, & Dorfman, 1984; White, 1989).

**Orthographic Processing**

Another aspect of word identification is orthographic processing. Orthographic processing refers to the use of orthographic information when processing written code (Wagner & Barker, 1994). There are two kinds of orthographic information contained in a word. One is the information related to the combination of letters that comprises that specific word. This information, which is sometimes referred to as word-specific information (Baron, 1978), distinguishes one word from other words. The other is general information, which is derived from the combination of letters that a word has in common with other words (Vellutino, 1982). Venezky and Massaro (1987) distinguished between two types of such general orthographic information: statistical redundancy and rule-governed regularity. Statistical redundancy has to do with indices that are derived from the probability of occurrence of certain letters or letter combinations in words. These indices can be derived from words or word tokens and can include letters, letter sequences or any other similar classifications (Venezky, 1995). Rule-governed regularity refers to the orthographic
conventions which are generalized from an evaluation of orthographic patterns that govern the combination of letters in certain positions of words. In English these are usually determined by phonological and orthographic constraints. It is these orthographic conventions that make some combinations of letters likely and some unlikely (Massaro & Sanocki, 1993).

There is less consensus on the role of orthographic knowledge and the way this knowledge source facilitates the reading process, than there is about phonological knowledge. However, the ease and speed with which skilled readers process print is argued to be linked largely to the extent to which the learners have learned about such positional constraints and the particular ways letters are ordered and combined in words (e.g., Adams, 1990). Currently there are different accounts of how orthographic information is used in reading. Corcos and Willows (1993), for example, explained the contribution of orthographic knowledge within a direct access model to word recognition. According to these researchers, it is possible that orthographic information, with spelling pattern as its central unit, facilitates the holistic processing of words. Massaro and Sanocki (1993), on the other hand, interpreted the contribution of orthographic knowledge within the Fuzzy Logical Model of Perception (FLMP). The FLMP conceptualizes visual processing in reading as a pattern recognition process. Within this model, identification processes consist of three operations: feature evaluation, feature integration, and decision. Consequently, word recognition is viewed as a continuous process of evaluating, integrating, and matching its visual features with the relevant prototype descriptions in memory. Two sources of information are considered relevant in this process. One is stimulus information, which comes from the actual letters composing the words, and the other is the information gained from previous experience with
words already stored in memory, such as knowledge of the orthographic constraints on the basis of which valid spelling patterns are distinguished from nonpermissible spelling patterns. These constraints, while not allowing certain letter combinations, make some combinations more likely in certain positions than others. According to Massaro and Sanocki (1993), this type of information contributes to reading by constraining the number of interpretations during the word identification process, which otherwise might lead to misidentification of the stimuli. This account of how orthographic information is used in reading is very similar to the one provided by Perfetti (1985). According to Perfetti, the orthographic system in any language yields a constrained number of options for any string of letters in that language. These principles restrict the choices for interpreting the orthographic strings as words. The knowledge of these principles then helps a skilled reader with the constrained set of admissible letter strings so that the reader can identify them with minimal reliance on context.

As far as research is concerned, the role of orthographic processing has received much less attention than has the role of phonological processing (Berninger, 1995). However, there are presently a few L1-based experimental studies that have produced evidence that orthographic processing contributes to L1 reading as well. Stanovich and West (1989), for example, found that individual differences in orthographic processing skill contributed significantly to word recognition ability. Using hierarchical multiple regression, they found that the contribution of orthographic processing was even independent of that of phonological processing as measured by pseudoword naming and phonological choice tasks. In another study, Cunningham and Stanovich (1990) replicated the same findings. They found that orthographic processing contributed significantly to word recognition skills among L1 third
and fourth graders and that orthographic processing continued to contribute even when the contribution of other factors such as phonological processing, memory, and non-verbal intelligence was taken into account. More recent support for the role of orthographic processing skill in L1 comes from Barker, Torgesen, and Wagner (1992). In this study, the researchers investigated the contribution of orthographic processing skills to five different reading tasks: two out of context word recognition tasks (one timed and one untimed), oral reading and silent reading of words in context as well as accuracy for reading nonwords. The researchers found that orthographic processing skills made a significant contribution to performance on all the reading measures used. Moreover, the results of hierarchical regression analyses indicated that the contribution of orthographic processing skills was even independent of that of phonological processing skills as measured by phonological choice and phoneme deletion tasks.

**Lower-Level Processes in Second Language Reading**

A similar approach to conceptualizing reading as a multivariate, cognitive information-processing skill has recently been echoed in the context of research on L2 reading (Bernhardt, 1990, 1991; Geva & Ryan, 1993; McLaughlin, 1987, 1991; McLaughlin, Rossman, & McLeod, 1983; McLeod & McLaughlin, 1986, Segalowitz, Poulsen, & Komoda, 1991). McLaughlin (1990), for example, considered L2 reading as a complex cognitive processing skill, the learning of which is characterized as passing through three hierarchical stages: (a) the development of an adequate knowledge of the rules governing lower-level graphophonic processing, (b) a progressive refinement and automatization of word-level decoding.
operations, and (c) the development of a complex set of processing skills for comprehension built on the automated basic processing skills. Bernhardt (1990) also formulated a multivariate L2 reading model in which lower-level graphophonetic and word recognition processes are considered important parameters of L2 reading comprehension. Her model incorporated two main components: text-based and extratext-based components. Text-based components refer to phonemic, graphemic decoding and word and syntactic feature recognition. Extratext-based components have to do with the reconciliation of the different parts of the text with what precedes and follows, prior knowledge, and metacognition. Examining her model with adult L2 readers, Bernhardt found important support for the role of word recognition and phonemic/graphemic text-based components in her model. Using recall protocols, she found that these basic reading components played an important role in the way text was perceived and meaning was constructed by her L2 German readers.

Researchers such as Grabe (1991), Haynes and Carr (1990), Koda (1994), and Segalowitz (1986) have also emphasized the information-processing nature of reading and the importance of lower-level component processes in L2 reading. Haynes and Carr (1990) argued that lower-level visual and orthographic processing skills are necessary for an adequate development of second language reading skill. According to these researchers, it is highly possible that a deficiency in lower-level processing might negatively influence L2 reading efficiency. Koda (1994) argued that the presence of many sub-component processes is essential to successful reading comprehension. She then suggested that systematic research is necessary to examine the consequences of limited phonological and orthographic processing skills for L2 reading. Grabe (1991) also described the investigation of basic word-level.
processes as one of the important areas of research that should remain prominent in the L2 reading research literature in the 1990s.

So far, only a handful of studies have attempted to examine the role of lower-level component processes in L2 reading. Haynes and Carr (1990) explored the role of knowledge of the writing system in ESL reading among Chinese university students. Their study demonstrated a significant relationship between knowledge of the writing system, as measured by efficiency on same-different visual matching tasks, and ESL reading success among Chinese students. Using multiple regression analyses, the researchers found that individual differences in such knowledge types was a significant predictor of the learning of new words from context and speed of reading.

Koda (1992) investigated the contribution of letter identification and word recognition to L2 Japanese reading comprehension among American college students. Using cloze, paragraph comprehension, and sentence comprehension as reading ability measures, Koda found that efficiency in such lower-level processing skills made a significant contribution to reading comprehension of both sentences and text. One problem with Koda's study, however, is that she did not take into account the contribution of the readers' general language knowledge. Therefore, it is likely that the contribution she found for lower-level identification processes was also a function of the reader's general L2 proficiency. It would be worthwhile to replicate Koda's research in a study in which the reader's general L2 proficiency level is carefully controlled.

There are also a few cross-lingual studies that have provided evidence for the role of lower-level processes in reading among bilinguals (Favreau, Komoda & Segalowitz, 1980;
Geva, Wade-Woolley, & Shany, 1993, 1997; Segalowitz, 1986). In quest of whether differences in the reading rate of L1 and L2 readers could be accounted for by lower-level processing skills, Segalowitz (1986) reported a study on bilingual and monolingual English-French adults. In their study, half of the bilinguals were of an equal rate and half were of an unequal rate of reading in the two languages. The researchers used a sentence verification task, in which people were to decide whether sentences each containing a critical word were meaningful or not. The task included sets of four sentences. One of the sentences, for example, contained a homophone (e.g., *They detected the FLARE coming out of the woods.*) while the second sentence contained a control word (e.g., *They detected the FLAME coming out of the woods.*). The third sentence was meaningless but phonologically congruent (e.g., *They detected the flair coming out of the woods.*); and the fourth sentence was meaningless and phonologically incongruent (e.g., *They detected the stare coming out of the woods.*). The results showed that participants made more errors in both their L1 and their L2 in the congruent conditions than in the incongruent conditions. However, in the meaningful homophone condition, the unequal-rate readers made more errors than the equal-rate readers in their L2. Segalowitz suggested that this could be due to the lower skill of the unequal bilinguals in processing the phonological code in their L2.

In another study, Favreau et al. (1980) found that even advanced L2 readers were different from L1 readers in the efficiency with which they used orthographic redundancies. They found that skilled L2 readers were less efficient in responding to L2 orthographic conventions as compared to L1 readers.
The finding that L2 readers are slower than L1 readers in processing text is, however, interpreted by top-down theorists as evidence for the idea that the readers are weaker in using higher-level strategies when reading. The proponents of these theories contend that readers may possess the necessary syntactic and semantic knowledge, but they still may lack adequate guessing strategies to sample the text rapidly (Clarke & Silbertein, 1979), or that such readers may just fail to use syntactic and semantic knowledge when reading for comprehension. Carrell (1983) contended that it is a natural tendency on the part of foreign language readers to be bound to text; although they might have appropriate background knowledge, many L2 readers just fail to tap that knowledge to make the necessary connection between the text and what they know when reading.

However, there is evidence that challenges the above speculations. Comparing L2 readers’ text recall with that of L1 readers, Horiba et al. (1994) found that L2 readers were not only capable of using higher-level information about the causal structure of the text but they used it even more extensively than L1 readers did. In another study, McLeod and McLaughlin (1986) found that L2 readers were indeed able to use higher-level prediction strategies on the basis of their semantic and syntactic knowledge. However, the readers were still processing the text in a slow, word by word fashion. According to McLeod and McLaughlin (1986), the readers in their study did not approach the task as 'a psycholinguistic guessing game' even though evidence from their cloze test indicated that they were capable of guessing and making predictions on the basis of their general language knowledge. Macnamara (1970) found that although Irish-English bilingual students knew all the words and structures used in the texts, they were still reading at a lower rate and with less
understanding in their L2 as compared to reading in their L1. These findings suggest that if L2 readers are slow, it may not be because of lack of ability to use higher-level guessing strategies based on their semantic and syntactic knowledge. It is possible that these readers have not yet developed enough efficiency and automaticity at using lower-level word recognition processes to enable them to use their higher-level knowledge sources as quickly as required in fluent reading.

The Role of L1 Orthography in L2 Reading Processes

Another central issue in L2 reading research is the effect of L1 orthographic properties on L2 reading processes. Cross-linguistic studies have demonstrated that discrepancies between an L1 and an L2 orthography might have an important impact on lower-level processing components in L2 reading (Akamatsu, 1996; Bernhardt & Everson, 1988; Chitiri, Sun, Willows, & Taylor, 1992; Koda, 1992, 1995; Wade-Woolley, 1996). In an eye movement study of two groups of native speakers of English reading German and Chinese, Bernhardt and Everson (1988, cited in Chitiri et al., 1992) found that while the eye movements of the German as L2 readers were similar to those of native readers, the Chinese as L2 readers' were not. This difference was attributed to the difference between the English orthographic system and that of Chinese.

Similarly, as part of their study, Chitiri et al. (1992) analyzed the word recognition patterns of two groups of English-Greek bilinguals and monolingual readers in terms of two phonologically defined properties, syllable and stress within specific content and function words. Using a letter cancellation task, Chitiri et al. (1992) found that although the English
bilinguals were of high levels of language proficiency, their word recognition patterns were different from their English monolingual counterparts. Neither of the two groups showed any syllabic effect. However, the English bilinguals exhibited stronger stress effect in processing content and function words than did the monolinguals. This difference was attributed to the difference between the orthographic characteristics of the English bilinguals' first language (which was Greek) and their L2 (which was English). While both languages are alphabetic, English has a more irregular and a more complex orthography in terms of letter-sound correspondences than does Greek (Chitiri et al., 1992).

In another study, Koda (1990) investigated the effects of L1 orthographic structures on phonological coding strategies in L2 reading among four language groups: 3 groups of adult L2 learners of English from 3 different orthographic backgrounds, Arabic, Spanish, and Japanese, and one native English group. Koda asked participants to read texts in two different conditions. In one condition (i.e., the control condition), certain critical names in the texts had been replaced by pronounceable English nonwords. In the experimental condition, those names had been replaced by Sanskrit symbols, which had no phonological information associated with them. Koda found that the reading efficiency of the four groups was differentially affected by the extent to which they were provided with phonological information in the texts. When phonological information was absent in the visual configuration of words, the reading performance of the L2 readers with alphabetic L1 backgrounds was seriously impaired. The magnitude of the effect was greatest on English L1 readers, followed by Spanish, and then Arabic readers. The reading performance of the Japanese readers was
least affected, suggesting that Japanese readers, due to their L1 orthographic characteristics, did not rely as much on phonological information in processing words.

Further support for the effect of L1 orthography on L2 reading processes comes from Chikamatsu (1996). Comparing the lexical decision performance of native English and native Chinese readers reading Japanese as an L2, Chikamatsu found that Chinese participants depended more on orthographic information in processing L2 Japanese words whereas English participants relied more on phonological information. According to the researcher, this difference indicated that L2 readers utilize different strategies in processing L2 words depending on their L1 orthographic properties.

The above findings have important implications for theory and research in L2 reading. They suggest that L1 orthography has an impact on the way skilled readers process L2 written texts and that L2 readers from different L1 orthographic backgrounds may transfer their L1 processing strategies when they read in an L2. Therefore, part of the individual differences among L2 readers in processing L2 text may be accounted for by the differences between their L1 and their L2 orthography. Thus, it is essential that researchers investigate L2 reading issues with respect to the type of L1 the L2 readers possess.

**Summary Remarks and Rationale for the Present Study**

As reviewed earlier, most of the research in L2 reading tends to suggest that the main problem that L2 readers face is that of incomplete grammatical and lexical/semantic knowledge. However, given the evidence from L1 reading research and the recent cross-linguistic studies, it is reasonable to assume that these general L2 knowledge sources, while
important, may not account sufficiently for the processes involved in the development of fluent L2 reading. Although a low level of language knowledge can short-circuit L2 reading comprehension (Clarke, 1980), it is difficult to specify a single source for this short-circuit (Haynes & Carr, 1990).

Language proficiency is multifaceted and almost no research on L2 reading has adequately addressed the relative contribution of the various knowledge sources to comprehension of L2 texts. Even those studies that have attempted to investigate the contribution of syntactic and semantic dimensions of knowledge have not directly investigated the contribution of these two processes to L2 reading (Bernhardt, 1991). Moreover, studies in this domain have produced inconsistent results. For example, Berman (1984) reported a study that investigated the role of syntactic knowledge in reading English as L2 by Hebrew-speaking college students. Administering two versions of a text, the original versus a syntactically simplified one, to two groups of L2 readers, Berman found that those who read the syntactically simplified version were consistently superior to readers of the original text in reading comprehension.

In contrast, using almost the same methodology, Ulijn and Strother (1990) found that simplification of the syntactic structures of L2 technical texts did not lead to better comprehension among L2 readers. Based on their findings, Ulijn and Strother (1990) claimed that L2 reading does not require much syntactic processing but it needs more lexical semantic processing. On the other hand, Barnett (1986) found that the relationship between L2 reading comprehension and semantic knowledge was highly dependent upon the student’s level of
syntactic knowledge. She then argued that having semantic knowledge without adequate syntactic knowledge does not contribute much to L2 reading.

Despite the discrepancy in results pertaining to the relative importance of lexical and syntactic knowledge in L2 reading, there is no doubt that syntactic and semantic knowledge in general is important for successful L2 reading. What is doubtful is whether support for the role of these knowledge sources in L2 reading can be taken as evidence that lower-level graphophonic processes do not play a role. As pointed out earlier, Hatch et al. (1974) contended that native readers canceled fewer e’s in function words as compared to L2 readers because the former group did not need to rely on the printed stimuli; they just used their proficient syntactic and semantic skills and made guesses about what they saw on the printed page. Similarly, based on his study, Cziko (1978) argued that much of the success of an L2 reader depends upon his/her ability to make use of the syntactic, semantic, and discourse constraints of the text.

However, the fact that native readers canceled fewer e’s in function words does not indicate that they did not process function words. Rather, it could indicate that native readers do process function words, but due to superior efficiency and automaticity at processing such words, they do not use as much cognitive and attentional effort in processing them as L2 readers do. In other words, fluent native readers do not need to focus their attention on processing function words and can therefore devote more attention to meaning. Therefore, Hatch et al.’s findings could readily be taken as support for the need to develop efficient and automatic lower-level processing in L2 reading. By the same token, although Cziko found an advantage on the part of skilled readers in benefitting from syntactic, semantic, and discourse
constraints, this may not indicate that the skilled readers are not using lower-level processing knowledge. Rather, it is possible that one reason for the skilled readers being able to use their higher-level knowledge sources more efficiently is that they are more efficient at processing lower-level information as well.

However, whether success in L2 reading depends primarily upon the ability to make use of the syntactic, semantic, and discourse constraints of the text or whether it also involves other component processes warrants much further empirical investigation. As reviewed earlier, studies have emerged on the nature of component processes in L2 reading. But, to date, these studies are too limited in number and kind to produce sufficient evidence to specify precisely the contributions of these processes to L2 reading. Moreover, as far as the role of phonological and orthographic processes is concerned, there are several issues which are still highly controversial in theories of both L1 and L2 reading.

One issue has to do with the separate role of phonological and orthographic processes. In general, the role of phonological knowledge as an essential factor for word recognition and reading comprehension has been firmly established in studies of L1 reading. However, the role of orthographic knowledge, and the way this knowledge type contributes to reading, is much less clear (Berninger, 1994). As discussed earlier, orthographic processing has been defined as the ability to use visual-orthographic information found in the orthographic structure of words when processing written code. Some argue that fluent reading depends also upon the reader’s ability to process orthographic information and that the ease and speed with which skilled readers process print is largely linked to the extent to which they have learned about the orthographic structure of words and the particular ways letters are ordered
and combined in words (Corcos & Willows, 1993; Massaro & Sanocki, 1993). According to this view, orthographic information facilitates the nonmediated visual processing of words (Backman, Bruck, Herbert, & Seidenberg, 1984).

One of the reasons for less attention being directed towards studying the role of orthographic processing in research is the methodological problem of dissociating orthographic from phonological processing (Berninger, 1994). Phonological and orthographic processing are highly integrated in reading, and it is very hard to devise orthographic tasks without any phonological component. Despite this problem, however, evidence is now accumulating for the separate role of orthographic processing skill from that of phonological skills in L1 reading. As reviewed earlier, recent L1-based studies have demonstrated that orthographic skills account for variance in reading independent of the variance accounted for by phonological skills (Barker et al., 1992; Olson, Forsberg, & Wise, 1994; Stanovich et al., 1991). Therefore, while the role of orthographic skills is implicated in L1-based studies, the extent to which these lower-level skills contribute to L2 reading is much less clear.

The second controversial issue has to do with the role of lower-level graphophonetic processes in advanced adult readers. In particular, some L2 researchers believe that the contribution of these lower-level abilities is specific to the proficiency level a person has in the L2 (e.g., Coady, 1979; Devine, 1988). They argue that the development of lower-level skills in L2 reading simply reflects the development of general language knowledge and that if lower-level processes play any role in L2 reading, their role is evident only when L2 readers have low language proficiency. Thus, while developmental and individual differences in basic word-level processes have been implicated in the L1 reading of skilled college level students
(e.g., Cunningham, et al., 1990; Bell & Perfetti, 1994), they have not been assessed systematically among advanced L2 readers, perhaps because their potential importance has been neglected.

The question, thus, remains as to what extent phonological and orthographic processing skills contribute to L2 reading. In a recent study, Bernhardt and Kamil (1995) found that language knowledge, defined as the knowledge of grammatical forms and lexical knowledge plus L1 reading ability, could account for only about 50% of the variance in L2 reading comprehension among adult Spanish as L2 readers with English as their L1. Leloup (1993, cited in Bernhardt and Kamil, 1995) found that only about 10% of the variance in L2 reading could be accounted for by background knowledge plus interest in the topic. Therefore, one may wonder whether phonological and orthographic processing skills can explain part of this variance in L2 reading, particularly in advanced adult L2 reading.

Recently, a few studies have documented the role of these processes in adult L2 reading and the way in which the learner’s L1 orthography affects the development of automatized execution of L2 word recognition processes (e.g., Akamatsu, 1996; Wade-Woolley, 1996); however, these studies have focused primarily on word recognition. Therefore, the extent to which these lower-level processes contribute to comprehending connected text in L2 reading remains unclear. Moreover, much of the present research on the role of component processes in L2 has taken a single-level approach, centering on variables from only one level of the reading process (Haynes & Carr, 1990). Therefore, the extent to which these processes make any independent contribution to L2 reading over and above the contribution made by higher-level processes such as semantic and syntactic processes is not
clear. If these processes can be shown to make any independent contribution to L2 reading, this would provide significant insights into models of L2 reading comprehension and reading development and to the current debate on the role of different language and cognitive processes in L2 reading.

To address the above issues, the present thesis used a component skills approach (Carr & Levy, 1990), utilizing measures of lower-level phonological and orthographic processing skills in conjunction with measures of higher-level syntactic and semantic processing skills, while controlling for aspects of cognitive ability relevant to reading, such as working memory and speed of lexical access. I assumed that such a design would yield a less biased picture of the role of lower-level and higher-level language-processing skills in L2 reading. As such, it would contribute importantly to the current debate in the theories of L2 reading concerning the role of different cognitive and linguistic abilities that underlie L2 reading.

**Hypotheses**

On the basis of the two contending theoretical positions reviewed above, two alternative hypotheses are considered. One is the notion that higher-level processes play a major role in understanding the reading comprehension of adult L2 learners with relatively high L2 proficiency, and that in such readers the contribution of phonological and orthographic processes is minimal. This hypothesis is compatible with the psycholinguistic perspective.

The alternative hypothesis is the notion that reading is a complex multiple-code operation, and that "reading ability is essentially the extent to which an individual can use
higher and lower-level language and information-processing mechanisms to read and comprehend written text” (Bell & Perfetti, 1994, p. 244). According to this hypothesis, successful and fluent accomplishment of higher-level operations while reading is partly dependent upon the efficiency with which information is supplied by lower-level graphophonic processing (Perfetti, 1985). Therefore, it predicts an important relationship between critical component processes such as phonological and orthographic processes and successful reading performance.

Individual differences in these processes in L2 may contribute to L2 reading comprehension and word recognition because of the following factors as well. First, there is a good deal of variability in lower-level processing in L2 readers, which is often much greater than that in L1 readers (Koda, 1992). Therefore, it is possible that this variation will account for some of the variation in L2 reading performance. Additionally, research has shown a positive relationship between lower-level processing and the difficulty level of the text read. Bell and Perfetti (1994), for example, found that as the difficulty level of the text read increased, the contribution of pseudoword decoding skills also increased among their adult L1 readers. Given that reading a text in L2 is presumably more cognitively and linguistically demanding than reading a similar text in L1 (considering that people are more fluent in their L1 than in their L2), it is possible that the role of lower-level processing may be highly pronounced when a text is read in an L2.

It is conceivable that variations in basic component processes contribute to a reader's reading rate as well. This possibility derives from the notion that (a) lack of efficiency at lower-level identification processes will cause a delay in processing higher-level interpretation
process involved in comprehending connected L2 text (Haynes & Carr, 1990), and (b) inefficient encoding processes will exhaust attentional resources causing more burden on the reader's working memory capacity (Lesgold & Perfetti, 1981). These factors then might negatively influence the speed of higher-level semantic and syntactic analysis by requiring readers to slow their pace of reading in order to be able to deal with the input they receive from the print and to process it within the limits of the attentional resources available to them.

Finally, it is hypothesized that the contribution of lower-level processing skills to L2 reading is independent of the contribution made by the more global L2 proficiency indices. L1 reading research on both beginning and adult readers suggests that lower-level phonological and orthographic processing skills are not simply a by-product of the development of higher-level processes, and that they may not develop concomitantly with other aspects of language knowledge such as semantic and syntactic knowledge (Koda, 1994). Therefore, lower-level phonological and orthographic processing skills may explain variance on L2 reading measures over and above the variance explained by semantic and syntactic processing skills.
CHAPTER 3
METHODS

Participants

As reviewed earlier, there is evidence that the nature of an L1 orthography may variably affect the reading performance of L2 readers. Therefore, the present study focused on L2 readers from only one language background, that is, Farsi, reading only one L2, English. Sixty adults with fairly advanced proficiency in English (all were native speakers of Farsi from Iran) participated in the study. They were graduate students studying in a university in Ontario, Canada. To solicit their participation, I individually contacted them in person, via electronic mail, or telephone. The majority of the Iranian graduate students at this university were male; therefore, I limited the selection of participants in this study to males; their ages ranged from 25 to 35. At the time of testing, they had been living in Canada for three to six years. Before they came to Canada to study at this university, they had at least 8 years of formal English courses at school and university in Iran. All the participants had met the English proficiency requirement to study as graduate students in Canada by taking either the TOEFL (Test of English as a Foreign Language), or an equivalent test developed and administered locally at the university. Given this background, I assumed them all to be advanced ESL readers. Moreover, they had all completed Bachelor's degrees in their home country, Iran. Therefore, I also assumed them to be highly literate in their L1 as well.
**Farsi Orthography**

Farsi is a branch of the Indo-European language family and a dialect of the Persian language. Its writing system is close to Arabic and different from the Roman alphabet. Although it is alphabetic, the writing system of Farsi is completely different from that of English in terms of both physical shape and the way the alphabetic letters combine to form an orthographic pattern. The Farsi alphabet consists of 32 characters and, unlike English, it is written from right to left.

Most of the alphabetic characters in Farsi can be grouped in pairs or sets of three or four letters which are nearly identical in shape but are differentiated from one another by the use of one, two or three dots placed either above, below, or inside the character. This point is illustrated in the following list (Figure 1), which shows all the Farsi alphabetic letters in their alphabetic order and their corresponding sounds in English.

Figure 1. Farsi Alphabetic Letters and their Corresponding Sounds in English

All the consonants in Farsi are indicated by alphabetic letters, but only half of the vowels, i.e., the long vowels, are represented by alphabetic letters. Short vowels are instead
represented by diacritics, which may be placed either above or below the letter associated with that sound in a word.

Ordinary written or printed Farsi does not use diacritics (Paper & Jazayery, 1955). Script with diacritics is only used for beginners, and at the very early stages of learning to read in L1. Typically, after the end of the first year of schooling, it is replaced by text without diacritics, though the vowels represented by alphabetic letters continue to be present. The manner in which Farsi is written is cursive. That is, in both printed and hand-written form, most of the letters composing a word are connected to the preceding and following letters. Due to their physical shape, some of the alphabetic letters, however, do not connect to their following letters. (Mahmoudi, 1967). Figure 2 shows some examples of Farsi printed words and the way alphabetic letters combine to form orthographic configurations.

![Figure 2. Examples of Farsi Printed Words](image)

Although alphabetic in nature, Farsi is different from English with respect to the degree of grapheme-phoneme correspondence. Like English, Farsi orthography can be characterized as a one-to-many phoneme-grapheme relationship. That is, a specific sound can be represented by different alphabetic letters. However, unlike in English, in Farsi, there is a complete one-to-one grapheme to phoneme mapping. That is, a specific letter has normally
one corresponding pronunciation. Therefore, Farsi has been described as having a shallower orthography than English (Baluch & Besner, 1991).

**Design of the Study**

A component skills design was employed in this study, consisting of three criterion (dependent) variables and seven predictor (independent) variables. The criterion variables consisted of measures of reading comprehension, silent reading rate, and out-of-context word recognition. Being the focus of much research, these three types of reading measures have been shown to be highly intercorrelated and have been considered as important aspects of reading skills in both L1 and L2 (e.g., Barker et al., 1992; Geva et al., 1997; Haynes & Carr, 1990; Mahon, 1986; Segalowitz, 1986). The predictor variables consisted of phonological, orthographic, syntactic, sentence-semantic, and lexical-semantic (vocabulary) measures. Two measures of aspects of cognitive ability relevant to reading, working memory and speed of lexical access, were also included as control variables of individual differences.

**Materials and Procedures**

**Dependent Variables**

*Reading Comprehension*. Reading comprehension was measured by a standardized reading comprehension test, the reading comprehension section of the Nelson-Denny reading test (form F). The test contains 8 reading passages with a total of 36 multiple-choice questions, each with 5 options. The test has a time limit of 20 minutes. In the analyses, I
employed the raw number of items that participants had correct. The reliability\(^1\) of the reading comprehension test (Cronbach's Alpha) is .85.

*Silent Reading Rate.* Silent reading rate was determined on the basis of the first minute of reading of the first passage of the Nelson-Denny reading test. The Nelson-Denny test yields an estimate of words-per-minute by indicating a score beside the line reached by the reader at the end of the first minute of reading the first passage for comprehension. Standard administration procedures were followed and the raw score (i.e., the estimate of words per first minute) on the test was used in the analyses.

*Out-of-Context Word Recognition.* Word recognition was defined as the ability to read individual words accurately out of context. To measure this ability, a standardized word recognition test, the word reading section of the Wide Range Achievement test (WRAT-3) (Wilkinson, 1993) was used. The test consists of two equivalent forms, each including 42 English words. In order to obtain a more comprehensive measure of the readers' word recognition ability, I used both forms and calculated a combined raw score for the test. I used standard administration procedures. That is, each participant was asked to read the words aloud at a normal pace. I scored as incorrect words that were read incorrectly as well as words that were read segment by segment or through grapheme-phoneme conversion rules. Following the manual's guidelines, I stopped testing when the participants made 10 consecutive errors. I employed the raw number of correct words read across both forms as an index of word recognition accuracy in the analyses. The equivalent-forms reliability of the test is .86.

\(^1\)All the reliability coefficients reported are from the current sample.
Independent Variables

Phonological Processing Skill. Phonological processing skill was defined as a systematic and rapid translation of spelling patterns into phonologically appropriate codes (Manis, Szeszulski, Holt, & Graves, 1990). This skill is more complex than knowing the simple relationships between single graphemes and phonemes. It involves the complex relationship between spelling units consisting of letter sequences and the ways they are phonemically encoded within a word-specific context (Venezky, 1995). Most previous research has used pseudoword pronunciation tasks to measure phonological processing skill. However, these tasks were considered inappropriate for the present study with ESL readers. Pseudoword pronunciation tasks are confounded with an articulation variable. Therefore, if the participants are not able to pronounce the pseudoword, it may not be simply because they have not developed an efficient skill in processing grapheme-phoneme correspondences, but it may also be because they have problems in articulating specific English phonemes which do not exist in their L1. In order to minimize this problem, instead of a pseudoword pronunciation task, I developed and used a pseudoword-matching task. Instead of asking the participants to articulate pseudowords, I asked them to judge whether the pronunciation of the members of pseudoword pairs matched or not.

The task was modeled after one used by Manis et al. (1990). It consists of a list of 30 pairs of pseudowords which either sound the same or different in English (e.g., thake-thack, flemb-flem, nurt-nert). The items were constructed on the basis of Venezky's (1970) analysis of English grapheme-phoneme relationships. To verify whether the constructed pairs matched or did not match in English pronunciation, the test was piloted with a group of highly .
educated native speakers of English. Ten native English-speaking graduate students from the Modern Language Centre of the Ontario Institute for Studies in Education/University of Toronto (OISE/UT) were instructed to proceed through the pilot items at their own pace and judge whether the pairs sounded the same or different. The pairs eventually selected were those on which there was at least 90% agreement among these native speakers of English (see Appendix A).

The participants of Farsi L1 were presented with the list of word pairs and were instructed to read each pair silently and decide as quickly as possible whether the two members in each pair sounded the same or different. They recorded their judgements by marking S ( ) for “same” or D ( ) for “different” next to each pair. Accuracy and the total time taken to perform the task were measured. The reliability of the task (Cronbach’s Alpha) is .77.

*Orthographic Processing Skill.* Different aspects of orthographic processing have been discussed in the literature, each emphasizing a particular dimension of this ability (see Berninger, 1994). Similarly, different tasks have been used for measuring orthographic processing skill. Depending on the purpose of their studies, reading researchers have used tasks ranging from letter identification tasks to real word tasks such as orthographic and homophone choice tasks (e.g., Barker et al., 1992; Stanovich, 1989; Wagner & Barker, 1994) or tasks consisting of nonwords, that is, strings of letters which are not real words (e.g., Siegel, Share, & Geva, 1995). Tasks involving real words have sometimes been criticized as being inappropriate orthographic tasks. It has been argued that these tasks involve information which is not necessarily orthographic. According to Massaro & Sanocki (1993), for example, in performing real word tasks, people might rely on word-specific (lexical) information rather
than general orthographic information, thus confounding word-specific knowledge with general orthographic knowledge (Vellutino, Scanlon, & Tanzman, 1994).

To avoid this confounding problem and to isolate orthographic knowledge as much as possible from word-specific knowledge, the orthographic measure designed for this study was a non-word task. The task was modeled after one used by Siegel et al. (1995). In such tasks, there is only one source of information available to readers: general orthographic information. Such tasks have been used in L1 reading research as measures of orthographic skills (e.g., Siegel et al., 1995; Molfese, Simos, & Sarkari, 1995). The task developed for this study consists of 30 pairs of monosyllabic non-words, each containing a sequence of letters (bigrams and trigrams) which either conforms or does not conform to English orthographic conventions in the position used (e.g., *filv*, *gnum*). The sequence `gm`, for example, never occurs in initial position in English words, but `gn` does. Some of the items used in the task were taken from Siegel et al.'s (1995) test of orthographic knowledge. However, to increase the task reliability, additional items were added. For further verification of the items, the task was piloted with a group of highly educated native speakers of English. As with the phonological processing task, 10 graduate students in the Modern Language Centre (OISE/UT), all native speakers of English, were asked to go through the list at their own pace and judge the conformity or non-conformity of the task items to English orthographic structure. The stimuli selected were those judged by at least 90% of the native speakers as conforming or not conforming to English orthographic conventions (see Appendix B).

For the thesis research, the participants of Farsi L1 were presented with the list of 30 printed orthographic non-word pairs and were instructed to look at each pair and decide as
quickly as possible which of the two members of the pair "looks more like a real word in English". Although orthographic tasks in general, and the one used in this study in particular, do not preclude the involvement of a sound code, correct decisions in the task were assumed to be mostly based on the reader's orthographic knowledge. I assumed that unless the participants had developed a good knowledge of English orthographic conventions, they would not have been able to do the task accurately and efficiently. Accuracy and the total time to perform the task were measured. The reliability of the task (Cronbach's Alpha) is .70.

**Syntactic Processing Skill.** The task used for testing the readers' English syntactic processing skill was a syntactic judgement task. The task consists of 30 sentences: 15 syntactically correct and 15 syntactically incorrect (e.g., for syntactically correct: *He answered the ringing telephone*.; and for syntactically incorrect: *The children's mother work very hard*.). The task was designed to test a wide variety of English syntactic properties such as function words, word order, phrase order, clause boundaries, pronominalization, tense markers, articles, subject-predicate agreement, particles, and copula words. To control for semantic knowledge, and to ensure as far as possible that the participants' performance would not be affected by lexical meaning, the task was constructed to contain items whose intended meanings were transparent (Bowey, 1994). To this end, only relatively high frequency words were used, based on West's (1953) *A General Service List of English Words*. The task was first piloted with 25 advanced adult ESL readers, coming from different language backgrounds and studying in a large ESL program at a major university in Ontario, Canada. Items which were extremely difficult (those answered incorrectly by all participants) or
extremely easy (those answered correctly by all participants) were revised or replaced with
new items (see Appendix C).

For the thesis research, the Farsi L1 participants were instructed to read each sentence
at a normal pace and decide whether it was syntactically correct or incorrect. They recorded
their judgements by marking "correct ( )" or "incorrect ( )" next to each sentence. Upon
completing the task, the participants were also asked to read the task again and mark any
words they did not know or any semantically vague sentences. None of the participants
indicated the presence of semantically vague sentences or difficult lexical items in the task.
Therefore, their performance was assumed to be a function of their syntactic processing skill
rather than their semantic knowledge. Total correct responses were calculated and the time
taken to perform the task was measured as well. The time required to carry out the task was
assumed to provide an indicator of the degree of processing difficulty in the application of the
syntactic rules in the task (Bley-Vroman & Masterson, 1989; Cook, 1994). The reliability of
the task (Cronbach's Alpha) is .68.

Semantic Processing Skill. Two tasks were used for measuring semantic processing
skill: a sentence-semantic task and a lexical-semantic (vocabulary) task. The lexical-semantic
task was the vocabulary section of the Nelson-Denny reading test (form F). The test consists
of 100 vocabulary items presented in a multiple-choice format, with each item followed by
five options. The participant has to select the option that best describes the meaning of the
vocabulary item intended. The test is a timed test with a time limit of 15 minutes. The raw
score based on number correct was employed in the analyses. The reliability of the task
(Cronbach's Alpha) for the people in the present study is .84.
Since semantic knowledge is not simply knowledge of the meanings of individual words but being able to make sense of them in context (Page & Pinnell, 1979), I also developed a sentence-semantic task in addition to the lexical-semantic task. The sentence-semantic task was a sentence judgement task consisting of 30 sentences: 15 semantically well-formed sentences, i.e., sentences that make sense (e.g., *The angry teacher punished the rude student.*) and 15 semantically ill-formed sentences, i.e., sentences that do not make sense (e.g., *A timid accident devastated a huge crop.*) To develop the task, initially 30 semantically well-formed sentences were generated. Fifteen of these sentences were then made semantically anomalous by manipulating one of the semantic relationships within the phrases constituting the sentence in such a way that it violated the semantic constraints of the lexical items forming the phrase. Furthermore, to ensure as far as possible that what made a sentence ill-formed was not its violation of English syntactic rules but its violation of semantic constraints provided by the meanings of the items and the selection restrictions governing them (Cziko, 1978), the task was controlled for syntactic structures. That is, all the sentences were constructed on the basis of one simple English syntactic structure, i.e., \( \{NP + V(t) + NP\} \), and each sentence included an equal number of lexical items selected from specific grammatical categories. As with the syntactic judgment task, the task was piloted with the same 25 advanced ESL readers. Items which were extremely difficult (those answered incorrectly by all participants) or extremely easy (those answered correctly by all participants) were revised or replaced with new items (see Appendix D).

For the thesis research, the Farsi L1 participants were presented with the list of sentences and were instructed to read each sentence silently at a normal pace and decide
whether the sentence was meaningful or meaningless. They then recorded their correct responses by marking "Yes ( )" or "No ( )" next to each item. Total correct responses were calculated and the time to perform the task was measured. The reliability of the sentence-semantic task (Cronbach's Alpha) is .67.

**Working Memory.** The complex task of reading comprehension involves basic cognitive processes in addition to linguistic skills. Reading is seen as a cognitive computational process whose subprocesses (from letter identification to syntactic computations to still higher-order processes of inference-making and text integration) require some sort of working memory system. Working memory has been defined as the system responsible for the temporary storage and processing of information in the performance of complex cognitive tasks (Baddeley, 1986). Researchers have found a critical relationship between the efficiency of this system and reading ability (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980; Geva, 1995; Geva & Ryan, 1993). Moreover, all the theoretical models based on limited-capacity models (e.g., Perfetti, 1985, 1986; Perfetti & Lesgold, 1977; Stanovich, 1984) make the assumption that such a short-term memory system is involved in reading. Therefore, it is reasonable to assume that part of differences in individual L2 readers is due to the difference in the efficiency of their working memory systems.

Researchers have used different measures to test the efficiency of individuals' working memory capacity, ranging from language tasks such as true/false sentence judgement and sentence completion to simple digit span tasks (e.g., Geva, 1995; Geva & Ryan, 1993; Gottardo, Stanovich, & Siegel, 1996; Waters & Caplan, 1996). Motivated by the findings of researchers such as Daneman and Carpenter (1980) indicating that there is a higher correlation
between reading comprehension and reading span measures or true/false sentence judgement tasks than between reading comprehension and the more traditional digit span tasks, L1 researchers have tended to prefer the use of language tasks in L1 reading research. However, such sentence judgement and sentence completion tasks were not used in the present study for two reasons. First, they were considered too complex to be used as memory tasks as they involve other less automatized processes such as semantic and syntactic processes that, while related to reading, are not necessarily specific to memory (Levy & Hinchley, 1990). The higher correlation shown to be holding between such measures and reading comprehension might be due to the comprehension-specific processes involved in doing such reading span tasks (Carr et al., 1990). Moreover, language-based memory tasks assume that participants are already competent in the language used in the tasks, as in the case of L1 readers. Thus, however appropriate they might be for L1 reading research, these tasks may be less appropriate for use with L2 readers. Therefore, in this study, a digit span task was instead used as a measure of working memory. The task was the forward and backward digit span section of the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981). While digit span tasks do not require complex comprehension-related processes (as may usually be involved in language-based memory tasks), they assess intake, maintenance, and retrieval of information (Carr et al., 1990). In addition, the backward digit span tasks involve not only a storage component but also a transformation component of the data, which is an important facet of working memory (Baddeley, 1986). The test used required the participants to recall a series of orally presented numbers that increase in set size. It starts with two and three digits for backward and forward recall respectively, increasing by one digit in every subsequent trial. A
standard administration procedure was used and the raw score, based on total correct, was employed in the analyses. The reliability of the digit forward and backward tasks (Cronbach's Alpha) for the people in this study is .80 and .68, respectively.

**Rapid Automatization Naming Test (RAN).** The speed with which individuals access the name of visual symbols has been considered part of the basic cognitive skills involved in accessing the lexicon; therefore, it has been considered important to reading (Denckla & Rudel, 1976; Jorm & Share, 1983; Bowers, Golden, Kennedy, & Young, 1995). To measure speed of lexical access, the letter naming section of Denckla and Rudel's (1976) Rapid Automatization Naming test (RAN) was used. This task is believed to tap basic lower-level cognitive processes by estimating the speed with which participants access the names of highly automatised printed symbols (Bowers, Golden, Kennedy, & Young, 1994; Wolf, Pfeil, Lotz, & Biddle, 1994). The task consists of a random presentation of 50 characters, which are a series of highly frequent letters of the English alphabet, i.e., o, a, s, d, p, each appearing altogether 10 times. The participants were instructed to continuously name the characters as quickly and accurately as possible. Accuracy and the amount of time to name all 50 letters were recorded. However, the number of errors on RAN was very small (The mean of accurate responses was 49.90 out of 50.); therefore, only the reaction time measure for RAN was used in the analyses.

**General Procedure**

The participants were tested individually in single sessions that lasted for approximately 2 hours. Each participant was paid $20 for participating in the study. Before
testing began, the participants were asked to fill out a background questionnaire in which information regarding their age, gender, educational background, and years of residence in English-speaking countries was collected. Then, they received the different experimental tasks in the following order. First they received the memory digit span task, followed by the RAN and word recognition tests. Then they received the five language component tasks, that is, phonological, orthographic, syntactic, sentence-semantic, and lexical-semantic tasks. The order of the language component measures was counter-balanced. That is, half of the participants performed the phonological task before the orthographic task and the syntactic task before the semantic tasks, and half did the reverse. Finally, they received the silent reading rate and the reading comprehension test. Standard procedures were followed for the standardised reading measures, according to their administration manuals.

Performance on the experimental tasks was measured in terms of scores for both accuracy and speed (time to carry out the task). Time was measured because simply knowing how to perform a task may not ensure that a reader is able to process the task components as rapidly and accurately as required during fluent reading (Eskey & Grabe, 1988). An index based on both speed and accuracy can provide a more accurate measurement of individual differences in reading than accuracy alone (Carr, Brown, Vavrus, & Evans, 1990; Haynes & Carr, 1990). I measured time by a stopwatch, measuring time to one hundredth of a second. The two indices of speed and accuracy were then combined to yield indices of the reader’s efficiency in processing the task.

Efficiency scores were computed based on a procedure used by Stanovich and West (1989). First, for each participant, the number of errors on each of the experimental tasks and
the time taken to perform the task were converted into their respective Z-scores. The two resulting Z-scores were then combined and averaged to yield a single composite efficiency score representing both speed and accuracy. For the standardized tests, the raw scores were used in the analyses rather than the standardized scores since the tests were normed with L1 readers and there was no intention to interpret the results of the tests according to L1 norms.
CHAPTER 4
DATA ANALYSIS AND RESULTS

Data were analyzed using two sets of scores for the experimental measures: accuracy scores calculated on the basis of the total correct responses on each task, and efficiency scores consisting of a composite of speed and accuracy. However, as just pointed out, since an index based on both speed and accuracy has been shown to provide a more accurate indication of skilled reading ability, the major interpretations drawn from this research are based on efficiency scores rather than an accuracy alone.

To explore the role of the component variables in the three criterion measures, different statistical procedures were employed. As a first step in analysing the data, two reader groups (of skilled and less skilled readers) were formed from the whole sample and their performance was compared on all the variables in the study (see the subsequent section). Subsequently, to determine the relative contributions of the variables to the reading measures, a series of correlational and multiple regression analyses were performed. Separate hierarchical multiple regressions were performed for each of the three dependent variables. Analyses were performed for accuracy as well as efficiency scores. The results of all these analyses are reported in the following section.

Results

Table 1 presents descriptive data on all the measures in the study. The Table includes the means, standard deviations, and the minimum and maximum scores on each measure.
Table 1

Descriptive Statistics of the Variables (N=60)

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RC(0-36)</td>
<td>19.15</td>
<td>5.64</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>2. Rate</td>
<td>179.20</td>
<td>25.28</td>
<td>120</td>
<td>232</td>
</tr>
<tr>
<td>3. Word (0-84)</td>
<td>63.40</td>
<td>5.61</td>
<td>50</td>
<td>76</td>
</tr>
<tr>
<td>4. RAN (0-50)</td>
<td>49.90</td>
<td>.30</td>
<td>49</td>
<td>50</td>
</tr>
<tr>
<td>5. RAN.t*</td>
<td>15.18</td>
<td>2.38</td>
<td>10.74</td>
<td>22.06</td>
</tr>
<tr>
<td>6. W. Memory (0-28)</td>
<td>15.72</td>
<td>2.73</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>7. Pho(0-30)</td>
<td>22.58</td>
<td>3.89</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>8. Pho.t*</td>
<td>97.42</td>
<td>26.70</td>
<td>59.93</td>
<td>170.18</td>
</tr>
<tr>
<td>9. Orth.(0-30)</td>
<td>25.78</td>
<td>2.77</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>10. Orth.t*</td>
<td>77.45</td>
<td>24.89</td>
<td>42.24</td>
<td>146.16</td>
</tr>
<tr>
<td>11. Syn. (0-30)</td>
<td>18.53</td>
<td>3.02</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td>12. Syn.t*</td>
<td>251.73</td>
<td>73.58</td>
<td>139.49</td>
<td>464.18</td>
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<tr>
<td>13. S-sem.(0-30)</td>
<td>21.63</td>
<td>2.50</td>
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<td>27</td>
</tr>
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<td>14. S-sem.t*</td>
<td>217.12</td>
<td>55.23</td>
<td>133.01</td>
<td>385.17</td>
</tr>
<tr>
<td>15. Lex-sem.(0-100)</td>
<td>37.28</td>
<td>10.21</td>
<td>17</td>
<td>60</td>
</tr>
</tbody>
</table>

Note. * time to carry out the tasks in seconds.
RC=reading comprehension; Rate=silent reading rate; Word=word recognition; RAN=Rapid Automatization Naming test; RAN.t= time carrying out the Rapid Automatization Naming test; W. Memory= working memory; Pho.=accuracy on phonological measure; Pho.t=time carrying out phonological task; Orth.=accuracy on orthographic task; Orth.t=time carrying out orthographic task; Syn.=accuracy on syntactic task; Syn.t=time carrying out syntactic task; S-sem.=accuracy on sentence-semantic task; S-sem.t=time carrying out sentence-semantic task; Lex-sem.=lexical-semantic measure (vocabulary).
Skilled Versus Less Skilled Readers

In order to obtain a general idea of the performance of the participants on all the variables, the sample was first divided into two groups of skilled and less skilled readers based on the median split of the readers' raw scores on the Nelson-Denny reading comprehension test. Those who performed above the median were classified as skilled readers and those who performed below the median were classified as less skilled readers. There were 27 readers in the skilled group and 33 in the less-skilled group. To determine whether the two groups differed significantly on any of the measures, individual t-tests were performed. Table 2 displays the results of this analysis.

As the Table shows, with the exception of RAN (Rapid Automatization Naming test), the two groups differed significantly on almost all the measures in the study. The less-skilled group performed relatively poorly on virtually all the component measures in comparison to the skilled group. Moreover, both groups had relatively similar standard deviations on all measures, indicating some degree of comparability in the range of scores within the groups.

What is important to note here is that in addition to the syntactic and semantic measures, phonological and orthographic measures also significantly differentiated skilled from less skilled groups. The skilled readers performed both more accurately and more efficiently than the less skilled readers on the phonological measure (accuracy: $t (58) = 2.22, p < .05$; efficiency: $t (58) = -2.83, p < .01$). Similarly, there was a significant difference between the two groups on the orthographic measure. The skilled readers performed more accurately

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2 In all these and subsequent analyses, RAN consists of speed on Rapid Automatization Naming test.
and more efficiently on this measure as compared to the less skilled readers (accuracy: $t(58) = 1.98, p < .05$; efficiency: $t(58) = -3.12, p < .01$). In these analyses, the difference between the $t$-value of the accuracy and efficiency scores is important to note. Much higher $t$-values were obtained for the efficiency scores than for the accuracy scores, indicating that individual differences conceptualized in terms of a combination of speed and accuracy differentiated these skilled from less skilled comprehenders better than accuracy indices alone. Overall, this result suggests that to the extent that the participants are more proficient in reading comprehension, they are also more skilled at executing the various component processes of reading as well. In particular, those who are more skilled in reading comprehension are also more accurate and efficient at lower-level phonological and orthographic processing.
Table 2
Means and Standard Deviations of Variables for Skilled and Less Skilled Readers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Skilled ((n=27))</th>
<th>Less Skilled ((n=33))</th>
<th>(t)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M)</td>
<td>(SD)</td>
<td>(M)</td>
</tr>
<tr>
<td>1. RAN</td>
<td>15.04</td>
<td>2.42</td>
<td>15.29</td>
</tr>
<tr>
<td>2. W. Memory</td>
<td>16.62</td>
<td>2.76</td>
<td>15.06</td>
</tr>
<tr>
<td>3. Pho.</td>
<td>23.77</td>
<td>3.71</td>
<td>21.60</td>
</tr>
<tr>
<td>4. Pho.t</td>
<td>88.57</td>
<td>22.70</td>
<td>104.66</td>
</tr>
<tr>
<td>5. Orth.</td>
<td>26.62</td>
<td>1.98</td>
<td>25.24</td>
</tr>
<tr>
<td>6. Orth.t</td>
<td>68.96</td>
<td>18.83</td>
<td>84.39</td>
</tr>
<tr>
<td>7. Syn.</td>
<td>19.92</td>
<td>3.08</td>
<td>17.39</td>
</tr>
<tr>
<td>8. Syn.t</td>
<td>220.33</td>
<td>63.08</td>
<td>277.42</td>
</tr>
<tr>
<td>9. S-sem.</td>
<td>23.07</td>
<td>2.33</td>
<td>20.45</td>
</tr>
<tr>
<td>10. S-sem.t</td>
<td>194.67</td>
<td>43.92</td>
<td>235.49</td>
</tr>
<tr>
<td>11. Pho-effi</td>
<td>-0.31</td>
<td>0.75</td>
<td>0.26</td>
</tr>
<tr>
<td>12. Ortho-effi</td>
<td>-0.30</td>
<td>0.53</td>
<td>0.25</td>
</tr>
<tr>
<td>13. Syn-effi</td>
<td>-0.44</td>
<td>0.63</td>
<td>0.36</td>
</tr>
<tr>
<td>14. S-sem-effi</td>
<td>-0.49</td>
<td>0.57</td>
<td>0.40</td>
</tr>
<tr>
<td>15. Lex-sem</td>
<td>43.44</td>
<td>7.61</td>
<td>31.78</td>
</tr>
<tr>
<td>16. Word</td>
<td>66.48</td>
<td>5.01</td>
<td>60.87</td>
</tr>
<tr>
<td>17. Rate</td>
<td>200.48</td>
<td>17.72</td>
<td>161.78</td>
</tr>
<tr>
<td>18. RC</td>
<td>24.37</td>
<td>3.35</td>
<td>14.87</td>
</tr>
</tbody>
</table>

Note. RAN=Rapid Automatization Naming test (speed); W. Memory=working memory; Pho.=accuracy on phonological measure; Pho.t=time carrying out phonological task; Orth.=accuracy on orthographic task; Orth.t=time carrying out orthographic task; Syn.=accuracy on syntactic task; Syn.t=time carrying out syntactic task; S-sem.=accuracy on sentence-semantic task; S-sem.t=time carrying out sentence-semantic task; Pho.effi.=efficiency on phonological task; Orth.effi.=efficiency on orthographic task; Syn.effi.=efficiency on syntactic task; S-sem.effi.=efficiency on sentence-semantic task. Lex-sem.=lexical-semantic measure (vocabulary); Rate=silent reading rate; Word=word recognition; RC=reading comprehension. Times are in seconds. 
*= \(p<.05\); **= \(p<.01\); ***= \(p<.001\), all two-tailed.
Correlational Analyses

Correlations between variables can serve as another source of information on the performance of these people on the component processing measures. Table 3 displays the intercorrelations among all the variables in the study. Correlation coefficients of .25 and above are significant at $p < .05$ (two-tailed). Note that the negative signs next to the efficiency scores reflect the fact that efficiency scores were computed from the number of errors and the time taken to perform the task: better performance in reading is associated with fewer errors and less time to carry out the task (cf. Cunningham et al., 1990).

An examination of the pattern of correlations among the variables shows that, with the exception of age, virtually all the predictor variables correlated significantly with each other and with the criterion reading measures used. Not surprisingly, reading comprehension showed a strong correlation with lexical-semantic (vocabulary) knowledge ($r = .59, p < .0001$) and with accuracy as well as efficiency scores on syntactic and sentence-semantic measures (syntactic accuracy: $r = .44, p < .0001$; sentence-semantic accuracy: $r = .53, p < .0001$; syntactic efficiency: $r = -.51, p < .0001$; sentence-semantic efficiency: $r = -.65, p < .0001$). However, significant correlations were also observed between reading comprehension and both the accuracy and efficiency scores on the phonological and orthographic measures (phonological accuracy: $r = .30, p < .01$; phonological efficiency: $r = .42, p < .001$; orthographic accuracy: $r = .33, p < .01$, orthographic efficiency: $r = -.47, p < .0001$). As is evident, the correlations resulting from efficiency scores are more potent than those based on accuracy scores alone, indicating again that individual differences on efficiency indices of phonological and orthographic processing reflect more accurately individual differences in reading.
comprehension. Reading comprehension was significantly correlated with working memory 
\( r = .35, p < .01 \) as well. However, only a weak and non-significant correlation \( r = -.20 \) was observed between reading comprehension and speed of letter naming (RAN).

Silent reading rate also showed significant correlations with the predictor variables. Efficiency scores on syntactic, lexical-semantic (vocabulary), and sentence-semantic measures yielded moderate correlations with reading rate \( r = -.49, p < .0001, r = .53, p < .0001, \) and \( r = -.57, p < .0001 \), respectively). Significant correlations also appeared between silent reading rate and the phonological and orthographic accuracy and efficiency scores (phonological accuracy: \( r = .33, p < .01 \), phonological efficiency: \( r = -.35, p < .01 \); orthographic accuracy: \( r = .30, p < .01 \) orthographic efficiency: \( r = -.44, p < .0001 \)). RAN did not correlate significantly with silent reading rate \( r = -.17 \). However, working memory was significantly and positively correlated with this reading measure \( r = .34, p < .01 \).

The phonological and orthographic processing measures correlated significantly with word recognition as well. Note that this was true for both accuracy and efficiency scores (phonological accuracy: \( r = .33, p < .01 \); orthographic accuracy \( r = .31, p < .01 \); phonological efficiency: \( r = -.35, p < .01 \); orthographic efficiency \( r = -.44, p < .0001 \)). Moderate correlations also appeared between out-of-context word recognition and efficiency scores on the syntactic, lexical-semantic (vocabulary), and sentence-semantic measures \( r = -.44, r = .57, \) and \( r = -.58, p < .0001 \), respectively). These intercorrelations probably indicate a relation between the printed words, phonological and orthographic as well as syntactic and semantic attributes (see Vellutino, Scanlon, & Chen, 1995). Both working memory and RAN showed weak and non-significant correlations with word recognition (working memory, \( r = .21 \); RAN, \( r = -.18 \)).
To summarize, the correlational analyses reported in this section revealed that there was a positive and significant relationship between lower-level cognitive and linguistic variables and adult ESL reading. RAN did not correlate with the dependent measures in my sample of adult L2 readers. However, it correlated with efficiency scores on most of the component measures, such as phonological ($r=.35$), orthographic ($r=-.30$); syntactic ($r=.27$), and sentence-semantic measures ($r=.30$). These data seem to suggest that speed of lexical access as measured by RAN, while not related wholly to adult L2 reading comprehension, may be related to sub-components of L2 reading comprehension.
Table 3

*Intercorrelations of All the Variables*

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
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<th>3</th>
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<td>-.04</td>
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*Note.* RC = reading comprehension; Rate = silent reading rate; Word = word recognition; RAN = Rapid Automatization Naming test (speed); W. Memory = working memory; Pho. = accuracy on phonological measure; Pho.t = time carrying out phonological task; Orth. = accuracy on orthographic task; Orth.t = time carrying out orthographic task; S-sem. = accuracy on sentence-semantic task; S-sem.t = time carrying out sentence-semantic task; Syn. = accuracy on syntactic task; Syn.t = time carrying out syntactic task; Pho.effi. = efficiency on phonological task; Orth.effi. = efficiency on orthographic task; Syn.effi. = efficiency on syntactic task; S-sem.effi. = efficiency on sentence-semantic task. Lex-sem. = lexical-semantic measure (vocabulary).

Correlations above .25 significant at .05 (two-tailed); above .30 significant at .01 (two-tailed), and above .40 significant at .001 (two-tailed).
**Hierarchical Multiple Regression Analyses**

In order to determine the relative contribution of the predictor variables to the criterion variables, a series of forced-entry multiple regression analyses were performed. However, since in some cases relatively high correlations were observed among predictor variables, the data were first closely examined for the presence of multicollinearity. To check for this problem, the procedure suggested by Lomax (1992) was adopted. Several regression analyses involving only the predictor variables were performed. The regressions were conducted each time with one of the predictor variables as a criterion variable and the other variables as predictor variables. As suggested by Lomax (1992), if any of the resultant $R^2k$ (variance explained by all predictor variables) happens to be close to 1.0 (equal to or greater than 0.90), it might indicate a problem of multicollinearity. In the analyses conducted, the largest $R^2k$ obtained was 0.58, indicating little concern over the problem of multicollinearity among the measures.

Regressions were performed using both accuracy as well as efficiency scores on the predictor variables. Only those predictor variables that significantly correlated with the criterion variables were entered into the regression models. Age was not significantly correlated with any of the criterion variables; therefore, it was not included in the regression equations. RAN was not significantly correlated with the criterion variables either. However, RAN was correlated with some of the predictor variables. Therefore, I included RAN in the regression analyses as a covariate to partial out the variance related to speed of letter naming.

In forced-entry hierarchical regressions, the order whereby each predictor variable is entered into the equation is determined in advance. In this study, the predictor variables were
entered into the regression models in two different orders. Initially, a theory-based sequence of data entry was adopted, in which lower-level processing measures were entered into the equations before higher-level processing measures. First RAN was entered followed, on the second step, by working memory. Then the phonological and orthographic measures were entered, respectively. Finally, the syntactic, lexical semantic (vocabulary), and sentence semantic measures were entered, respectively. This ordering was maintained in all the regressions (six in total) including those regressions on accuracy as well as regressions on efficiency scores. This initial ordering of the predictor variables, in which lower-level processing measures were entered before higher-level processing measures, was based on the theoretical assumption that the execution of lower-level cognitive and language processing components—such as speed of lexical access, working memory, phonological and orthographic processing—takes place prior to that of higher-level semantic and syntactic processing. In other words, higher-level processes depend upon the information supplied by lower-level visual and word identification processes (Haynes & Carr, 1990).

However, one of the main questions addressed in this study was whether lower-level phonological and orthographic processing skills make any contribution to ESL reading over and above the contribution made by syntactic and semantic measures. Therefore an additional series of multiple regressions was performed in which the entry order of variables was reversed and phonological and orthographic measures were entered after the syntactic and semantic measures. These analyses examined whether the lower-level processing measures could explain any significant proportion of variance after the variance attributable to syntactic and semantic measures has been partialled out. Therefore, any variance remaining for the last
variable in the equation would be the unique variance of that variable, not being accounted for by the variables already in the equation (Kerlinger & Pedhazur, 1973). The following section presents the results of all the regression analyses. First, the results of the hierarchical regressions conducted on accuracy scores are presented.

Hierarchical Multiple Regressions Using Accuracy Scores

Table 4, 5, and 6 display the results of six hierarchical multiple regression analyses where the predictor variables are accuracy scores on the component measures and the criterion variables are reading comprehension, silent reading rate, and out-of-context word recognition, respectively. Each table includes the results of the two sets of regression analyses just mentioned. The first half of the table (marked A) displays the results of the regressions where phonological and orthographic measures were entered into the regression equation before syntactic and semantic measures were. The second half (marked B) displays the results where phonological and orthographic measures were entered after the syntactic and semantic measures. The column labeled $R^2$ change in each table gives the magnitude of the contribution of each variable at the point where the variable was entered into the analysis.

As the tables display, when entered on the first step, RAN did not contribute significantly to any of the reading skill measures: reading comprehension, silent reading rate, or word recognition. Entered on the second step, working memory accounted for a significant proportion of the variance in reading comprehension and silent reading rate (9%, $p < .01$; and 9%, $p < .01$, respectively) (Tables 4 and 5). Working memory accounted for some variance in word recognition (3%); however, it did not reach significance (Table 6). Entered on the third
step, accuracy on the phonological measure explained 7% ($p < .05$), 10% ($p < .01$), and 9% ($p < .01$) of the variance in reading comprehension, silent reading rate, and word recognition, respectively. Entered on the fourth step, accuracy on the orthographic measure accounted for an additional amount of variance in reading comprehension, silent reading rate and word recognition (7%, 5%, 5%, respectively). However, while the contribution of the orthographic measure to reading comprehension was statistically significant ($p < .05$), it did not reach significance for silent reading rate and word recognition ($p < .06$, <.07, respectively). Finally the three syntactic, vocabulary, and semantic measures were entered into the regression model and each contributed some additional variance to the three criterion measures. Among all the predictor variables, vocabulary accounted for the largest proportion of the variance on each of the three reading measures (14%, 13%, and 13%, $p < .001$), suggesting a strong relationship between vocabulary knowledge and ESL reading performance.

The second portion in each of the tables (Marked B) shows the contribution of the phonological and orthographic measures when they were entered into the equation after the syntactic and semantic measures. As can be seen, when entered after the syntactic and semantic measures, phonological and orthographic accuracy failed to contribute significant additional variance to the three reading measures. This suggests that accuracy of phonological and orthographic knowledge did not contribute to the reading performance of these advanced adult ESL readers independently of that of syntactic and semantic knowledge.
Table 4

Hierarchical Multiple Regression Using Accuracy Scores on Component Measures as Predictor Variables and Reading Comprehension as the Criterion Variable

<table>
<thead>
<tr>
<th>Predictor</th>
<th>final $\beta$</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
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<td></td>
</tr>
<tr>
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<td>.04</td>
</tr>
<tr>
<td>2. W. Memory</td>
<td>.31</td>
<td>.13</td>
<td>.09**</td>
</tr>
<tr>
<td>3. Phonological</td>
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<td>.07*</td>
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<td>7. Sentence-Semantic</td>
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<td>.04*</td>
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* = $p < .05$; ** = $p < .01$; *** = $p < .001$
Table 5

Hierarchical Multiple Regression Using Accuracy Scores on Component Measures as Predictor Variables and Silent Reading Rate as the Criterion Variable

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* = $p < .05$; ** = $p < .01$; *** = $p < .001$
Table 6

Hierarchical Multiple Regression Using Accuracy Scores on Component Measures as Predictor Variables and Out-of-Context Word Recognition as the Criterion Variable

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* = $p < .05$; ** = $p < .01$; *** = $p < .001$
Hierarchical Multiple Regressions Using Efficiency Scores

As mentioned earlier, efficiency scores based on a combination of speed and accuracy were assumed to be a more accurate indicator of individual differences in reading than just simple accuracy scores. Therefore, a second series of multiple regressions was performed for each of the three criterion variables using efficiency indices (composite of speed and accuracy) on each of the predictor variables. The following section presents the results of these hierarchical multiple regressions.

Reading Comprehension. Table 7 displays the results of the hierarchical multiple regressions with reading comprehension as the criterion variable. The top part of the Table (marked A) presents the regression results when phonological and orthographic efficiency measures have been entered into the equation prior to the higher-level syntactic and semantic efficiency measures. As displayed in the Table, RAN was not a significant predictor. Entered on the second step, working memory accounted for 9% of the variance. The phonological measure, entered on the second step, explained 14% of the variance, and the orthographic measure, entered on the fourth step, explained an additional 10% of the variance. Syntactic, lexical-semantic (vocabulary), and sentence-semantic measures, which were entered next, each accounted for an additional 5%, 7%, and 7% of the variance, respectively. What is important to note here is the contribution of phonological and orthographic measures, which jointly explained 23% of the variance in reading comprehension when entered into the regression equation prior to the syntactic and semantic measures.

The second half of Table 7 (section B) displays the results of the regression analysis when the phonological and orthographic efficiency measures were entered into the equation
after the syntactic and semantic efficiency measures. As The table shows, the phonological measure did not emerge as predictive of reading comprehension when entered after the syntactic and semantic measures. However, the orthographic measure continued to explain significantly an additional 4% of the variance, even after the variance associated with the semantic and syntactic measures was accounted for.

Table 7

*Hierarchical Multiple Regression Using Efficiency Scores on Component Measures as Predictor Variables and Reading Comprehension as the Criterion Variable*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>final $\beta$</th>
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<th>$R^2$ change</th>
</tr>
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<td>3. Syntactic</td>
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<td>.04*</td>
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</table>

* = $p < .05$; ** = $p < .01$; *** = $p < .001$
Silent Reading Rate. Table 8 displays the results of the hierarchical multiple regressions with silent reading rate as the criterion variable. The entry order of the predictor variables was identical to the one described in the regression analyses for reading comprehension. Basically, results pertaining to reading rate mimic those reported for reading comprehension. As the first half of the Table (section A) shows, RAN, when entered first, was not a significant predictor. However, working memory, entered on the second step, explained 9% of the variance. Entered next, the phonological and orthographic efficiency measures explained an additional 10% and 11% of the variance, respectively. Entered next, the syntactic, lexical-semantic (vocabulary), and sentence-semantic efficiency measures each accounted for an additional 5%, 5%, and 4% of the variance, respectively. What is important to note again is the substantial proportion of variance accounted for by the phonological and orthographic efficiency measures, which collectively explained 19% of the variance when entered prior to the syntactic and semantic measures. As displayed in the second half of Table 8 (section B), when entered after the syntactic and semantic measures, the phonological measure failed to explain any variance in silent reading rate. However, the orthographic measure continued to explain significantly an additional 4% of the variance.
Table 8

*Hierarchical Multiple Regression Using Efficiency Scores on Component Measures as Predictor Variables and Silent Reading Rate as the Criterion Variable*

<table>
<thead>
<tr>
<th>Predictor</th>
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<th>$R^2$ change</th>
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</tr>
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</tr>
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<td>4. Orthographic</td>
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<td>5. Syntactic</td>
<td>-.29</td>
<td>.38</td>
<td>.05*</td>
</tr>
<tr>
<td>6. Lexical-semantic</td>
<td>.31</td>
<td>.43</td>
<td>.05*</td>
</tr>
<tr>
<td>7. Sentence-semantic</td>
<td>.32</td>
<td>.47</td>
<td>.04*</td>
</tr>
<tr>
<td><strong>B:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Syntactic</td>
<td>-.45</td>
<td>.31</td>
<td>.19***</td>
</tr>
<tr>
<td>4. Lexical-semantic</td>
<td>.37</td>
<td>.38</td>
<td>.07**</td>
</tr>
<tr>
<td>5. Sentence-semantic</td>
<td>-.31</td>
<td>.42</td>
<td>.04*</td>
</tr>
<tr>
<td>6. Phonological</td>
<td>-.03</td>
<td>.43</td>
<td>.01</td>
</tr>
<tr>
<td>7. Orthographic</td>
<td>-.29</td>
<td>.47</td>
<td>.04*</td>
</tr>
</tbody>
</table>

*$=p < .05; **=p < .01; ***=p < .001$
Out-of-Context Word Recognition. Finally, two regressions were performed with out-of-context word recognition as the criterion variable, using the same logic described above. The results are summarized in Table 9. Note that speed of lexical access (RAN) and working memory did not account for any significant proportion of variance (3% and 3%, respectively). However, entered on the third step, the phonological efficiency measure explained 9%, and the orthographic efficiency measure explained an additional 10% of the variance. Entered on the next step, the syntactic efficiency measure failed to explain any additional significant proportion of variance in out-of-context word recognition. However, the lexical-semantic (vocabulary) and sentence-semantic efficiency measures explained an additional 11%, and 5% of the variance, respectively. As section B of Table 9 shows, when entered after the syntactic and the two semantic measures, both phonological and orthographic measures failed to add significantly to the variance in out-of-context word recognition. Although the orthographic measure accounted for an additional 3% of the variance, it was not statistically significant when syntactic and semantic measures were already in the equation. This weaker contribution of orthographic processing to out-of-context word recognition versus reading connected text replicates the findings of Barker et al. (1992), in which less contribution was found for orthographic processing when L1 readers were reading isolated words as opposed to reading connected text.
Table 9

Hierarchical Multiple Regression Using Efficiency Scores on Component Measures as Predictor Variables and Out-of-Context Word Recognition as the Criterion Variable

<table>
<thead>
<tr>
<th>Predictor</th>
<th>final $\beta$</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. RAN</td>
<td>-.16</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>2. W. Memory</td>
<td>.18</td>
<td>.06</td>
<td>.03</td>
</tr>
<tr>
<td>3. Phonological</td>
<td>-.33</td>
<td>.15</td>
<td>.09**</td>
</tr>
<tr>
<td>4. Orthographic</td>
<td>-.38</td>
<td>.25</td>
<td>.10**</td>
</tr>
<tr>
<td>5. Syntactic</td>
<td>-.24</td>
<td>.29</td>
<td>.04</td>
</tr>
<tr>
<td>6. Lexical-semantic</td>
<td>.47</td>
<td>.40</td>
<td>.11***</td>
</tr>
<tr>
<td>7. Sentence-semantic</td>
<td>-.36</td>
<td>.45</td>
<td>.05*</td>
</tr>
<tr>
<td>B:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Syntactic</td>
<td>-.41</td>
<td>.21</td>
<td>.15***</td>
</tr>
<tr>
<td>4. Lexical-semantic</td>
<td>.51</td>
<td>.36</td>
<td>.15***</td>
</tr>
<tr>
<td>5. Sentence-semantic</td>
<td>-.35</td>
<td>.41</td>
<td>.05**</td>
</tr>
<tr>
<td>6. Phonological</td>
<td>-.01</td>
<td>.41</td>
<td>.00</td>
</tr>
<tr>
<td>7. Orthographic</td>
<td>-.25</td>
<td>.44</td>
<td>.03</td>
</tr>
</tbody>
</table>

*=p < .05; **=p < .01; ***=p < .001.
The Contribution of Phonological and Orthographic Processing Skills to Syntactic and Semantic Processing Skills

The results of the multiple regressions reported so far reveal that when entered before syntactic and semantic measures, efficiency on phonological and orthographic measures accounted for a significant proportion of the variance in the three reading measures. When entered last, the orthographic measure still explained a significant proportion of the variance, but the phonological measure did not. On the other hand, syntactic and semantic measures accounted for a substantial proportion of the variance when entered either first or last into the regression equations. While the more robust contribution of syntactic and semantic measures was to be expected, I wondered why the phonological measure, which accounted for a significant proportion of variance when entered prior to syntactic and semantic measures, lost its significance when entered last into the regression equation.

One possibility was that because the participants were advanced ESL readers and that they had already a good knowledge of higher-level syntactic and semantic structures at their disposal, they did not rely on lower-level phonological processing to any significant degree. Instead, they may have mainly drawn on higher-level knowledge sources to process the text. Alternatively, however, given the evidence from L1 research that phonological processing contributes to reading even among highly proficient adult readers (Bell & Perfetti, 1994; Cunningham et al., 1990), and given the evidence from both the L1 and L2 literature that a strong relationship holds between phonological processing skill and syntactic and semantic knowledge (e.g., Cassidy & Kelly, 1991; Cheung, 1996; Papagno, Valentine, & Baddeley, 1991), it was possible that phonological processing skill contributed to the ESL reading
among these adult ESL learners via contributions to other higher-level syntactic and semantic processes.

In an attempt to tease apart the relative contribution of phonological and orthographic processes to semantic and syntactic processes, an additional series of hierarchical regression analyses was carried out, in which the syntactic, lexical-semantic (vocabulary), and sentence-semantic measures served as criterion variables, and phonological and orthographic efficiency measures served as predictor variables, entered into the analysis in two different orders. Due to the significant correlation observed between RAN and some of the predictor variables, RAN was also included in these analyses. Table 10 summarizes the results of these regression analyses.

These analyses showed that efficiency of phonological and orthographic processing contributed significantly to the efficiency of syntactic and semantic processing. When the phonological efficiency measure was entered into the equation followed by the orthographic efficiency measure, the phonological efficiency measure accounted for 19%, 25%, and 16% of the variance, and the orthographic efficiency measure accounted for 6%, 5%, and 2% of the variance in syntactic, lexical-semantic, and sentence-semantic efficiency measures, respectively. When entered into the equation after RAN and the orthographic efficiency measure, phonological efficiency measure still accounted for 7%, 11%, and 8% of the variance on syntactic, lexical-semantic, and sentence-semantic efficiency measures, respectively. Even though phonological and orthographic processing shared 30% of the variance, each also explained some unique variance in efficient syntactic and semantic processing. These two lower-level processes jointly accounted for 25%, 30%, and 18% of the
variance in the syntactic, lexical-semantic, and sentence-semantic measures, respectively. It is noteworthy that RAN also explained a significant proportion of the variance on the efficiency scores of the syntactic and sentence-semantic measures (8% and 10%, respectively), suggesting that individual differences in the speed with which individuals access highly automatized aspects of the lexicon (i.e., letter names) may also have played a significant role in how efficiently these readers processed more demanding higher-level syntactic and semantic tasks. Overall, the results of this section indicate that among these adult L2 readers efficient lower-level cognitive and graphophonic processes contributed importantly to the processing of more complex linguistic processes involving syntactic and semantic processes.
Table 10

Contribution of Efficiency of Phonological and Orthographic Processing to Efficiency of Syntactic and Semantic Processing

<table>
<thead>
<tr>
<th>Variables</th>
<th>final $\beta$</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I) Syntactic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. RAN</td>
<td>.27</td>
<td>.08</td>
<td>.08**</td>
</tr>
<tr>
<td>2. Phonological</td>
<td>.47</td>
<td>.27</td>
<td>.19***</td>
</tr>
<tr>
<td>3. Orthographic</td>
<td>.30</td>
<td>.33</td>
<td>.06*</td>
</tr>
<tr>
<td>B:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Orthographic</td>
<td>.46</td>
<td>.26</td>
<td>.18***</td>
</tr>
<tr>
<td>3. Phonological</td>
<td>.31</td>
<td>.33</td>
<td>.07*</td>
</tr>
<tr>
<td><strong>II) Lexical-semantic(vocabulary)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. RAN</td>
<td>-.17</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>2. Phonological</td>
<td>-.54</td>
<td>.28</td>
<td>.25***</td>
</tr>
<tr>
<td>3. Orthographic</td>
<td>-.26</td>
<td>.33</td>
<td>.05*</td>
</tr>
<tr>
<td>B:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Orthographic</td>
<td>-.46</td>
<td>.22</td>
<td>.19***</td>
</tr>
<tr>
<td>3. Phonological</td>
<td>-.41</td>
<td>.33</td>
<td>.11**</td>
</tr>
<tr>
<td><strong>III) Sentence-semantic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. RAN</td>
<td>.31</td>
<td>.10</td>
<td>.10**</td>
</tr>
<tr>
<td>2. Phonological</td>
<td>.43</td>
<td>.26</td>
<td>.16***</td>
</tr>
<tr>
<td>3. Orthographic</td>
<td>.18</td>
<td>.28</td>
<td>.02</td>
</tr>
<tr>
<td>B:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Orthographic</td>
<td>.35</td>
<td>.20</td>
<td>.10**</td>
</tr>
<tr>
<td>3. Phonological</td>
<td>.33</td>
<td>.28</td>
<td>.08*</td>
</tr>
</tbody>
</table>

* = $p < .05$; ** = $p < .01$; *** = $p < .001$
Further, in order to get a better picture of the interaction and the interrelationship among the different component processes involved in L2 reading comprehension, additional analyses were performed. In these analyses, instead of calculating the increments of variance using hierarchical regressions, the shared variance between the component processes and the total variance that each contributed to reading was computed. For this purpose, single regressions, that is, regressions that contained only one predictor variable, were carried out. Then the squared \( R \) (coefficient of determination) in the equation was used as an index of the total variance explained by each predictor variable in each criterion variable. The results are presented schematically in Figure 3.

In this figure, the basic lower-level processes appear in the top ovals, and the intermediate general language processes appear in round-cornered rectangles in the middle. Reading comprehension appears in the rectangle at the bottom part of the figure. The percentage of variance shared by each pair of variables is shown on the lines connecting the different variables in the Figure.

Figure 3 depicts the complex and highly intercorrelated nature of the cognitive and linguistic component processes involved in L2 reading comprehension. It highlights the fact that L2 reading comprehension is an interactive, multivariate process with each of the component processes contributing both to each other and to reading comprehension overall. In this context, however, it is important to note the significant contribution of the lower-level phonological and orthographic processing skills to the more global syntactic and semantic processing skills and then the total contribution of these lower-level processing skills to L2 reading comprehension. As Figure 3 illustrates, about half of the variance contributed by
syntactic, sentence-semantic, and lexical-semantic measures to reading comprehension is mediated via the variance contributed by phonological and orthographic measures. As such, the lower-level phonological and orthographic processing skills had both a direct as well as an indirect contributions through higher-level syntactic and semantic processing skills to L2 reading comprehension among these adult L2 readers.
Figure 3. A Schematic Representation of the Relationship Between Lower-Level and Higher-Level Language Processing Skills in ESL Reading Comprehension by Native Speakers of Farsi

Note. * $R^2$=6% and above significant at $p < .05$; $R^2$=9% and above significant at $p < .01$; $R^2$ =16% and above significant at $p < .001$. 
Another way of demonstrating the complex relationship between the component variables and ESL reading comprehension is through commonality analysis. Commonality analysis is a statistical procedure that partitions the total variance in the criterion variable into common and unique variances explained by predictor variables. Unique variance is the variance explained by a predictor variable when the variance explained by other variables has been partialled out. Common variance is the variance shared by two or more variables when the effects of other variables have been controlled.

In commonality analysis, the number of commonalities produced depends on the number of predictor variables and always equals $2^K - 1$, where $K$ is the number of predictor variables in the analysis (Mood, 1971). As can be seen, as one adds to the number of predictor variables in the analysis, the number of commonalities will increase exponentially. Therefore, doing commonality analyses with many variables becomes very cumbersome. Moreover, the interpretation of the higher-order commonalities produced in these analyses is very hard (Mood, 1971). For this reason, in such cases, it is usually recommended that the variables be grouped and the analysis be done on grouped variables (Mood, 1971; Seibold & McPhee, 1979).

In the analyses conducted for this section, the predictor variables were grouped into three sets of variables: higher-level syntactic/semantic, lower-level graphophonetic, and basic cognitive variables. The higher-level syntactic/semantic variable consisted of a composite score of syntactic, lexical-semantic, and sentence-semantic measures. The lower-level graphophonetic variable consisted of a composite score of phonological and orthographic measures, and the basic cognitive variable consisted of a composite score of speed of letter
naming (RAN) and working memory measures. The composite scores were computed as before, that is, by adding and averaging the Z-scores of the individual variables.

Table 11 presents the results of the commonality analyses using the above-mentioned grouped variables as predictor variables and ESL reading comprehension as the criterion variable. The table shows the total variance explained by each set of variables, and its decomposition into common and unique variances.

Each of the variables explained both unique and common variances in L2 reading comprehension. The higher-level syntactic/semantic variable explained 40% of the total variance, which was further decomposed into 2% shared with the basic cognitive variable (composite score of RAN and working memory measures), 14.4% shared with lower-level graphophonic variable (composite score of phonological and orthographic measures), and 5.7% shared with both the lower-level graphophonic variable and the basic cognitive variable. The basic cognitive variable (composite score of RAN and working memory measures) jointly accounted for 11.7% of the variance, out of which 2.5% was unique and the remainder was the variance it had in common with higher-level syntactic/semantic and lower-level graphophonic variables.

As the Table displays, lower-level graphophonic variable accounted for 25.7% of the total variance. Of this, 1.5% was shared with the basic cognitive variable, 14.4% with the higher-level syntactic/semantic, and 5.7% with both the higher-level syntactic/semantic variable and the basic cognitive variable. Most notably, in addition to common variance with the higher-level syntactic/semantic and the basic cognitive variables, the lower-level graphophonic variable contributed 4.1% unique variance to L2 reading comprehension.
Overall, the results of the commonality analyses indicated that each set of the component variables contributed both common and unique variance to the prediction of L2 reading comprehension. Not surprisingly, these findings converge with those of multiple regression reported before. Among the component variables, the most predictive one was the higher-level syntactic/semantic one, which accounted uniquely for about 18% of the variance in reading comprehension. However, what is important to note is the contribution of lower-level graphophonic variable, which explained a substantial proportion of the variance (about 26%) to L2 reading comprehension. Out of this proportion, 4.1% was unique, that is, it was variance which was not shared with other sets of component variables.

Table 11

*Commonality Analysis Using Component Variables as Predictor Variables and L2 Reading Comprehension as the Criterion Variable*

<table>
<thead>
<tr>
<th>Variables*</th>
<th>1 Cognitive</th>
<th>2 Syntactic/semantic</th>
<th>3 Graphophonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Unique</td>
<td>.025</td>
<td>.179</td>
<td>.041</td>
</tr>
<tr>
<td>2 Common to 1 &amp; 2</td>
<td>.020</td>
<td>.020</td>
<td></td>
</tr>
<tr>
<td>3. Common to 1 &amp; 3</td>
<td>.015</td>
<td>.020</td>
<td>.015</td>
</tr>
<tr>
<td>4. Common to 2 &amp; 3</td>
<td>.144</td>
<td>.144</td>
<td></td>
</tr>
<tr>
<td>5. Common to 1 &amp; 2 &amp; 3</td>
<td>.057</td>
<td>.057</td>
<td>.057</td>
</tr>
<tr>
<td>Total $R^2$ of the variables</td>
<td>.117</td>
<td>.400</td>
<td>.257</td>
</tr>
</tbody>
</table>

*Note.* *Cognitive* = composite score of RAN and working memory measures; *Syntactic/semantic* = composite score of syntactic, lexical-semantic, and sentence-semantic measures; *Graphophonic* = composite score of phonological and orthographic measures.
CHAPTER 5
GENERAL DISCUSSION

The present study set out to examine the relative contribution of basic language processing components to ESL reading. In particular, the study explored the extent to which phonological and orthographic processing abilities contribute to advanced ESL reading by native speakers of Farsi. The study demonstrated that, contrary to the views prevailing in many publications about L2 reading, individual differences in the efficiency with which these ESL readers processed phonological and orthographic information contributed to the prediction of individual differences in skilled ESL reading. The data from the comparison between skilled and less skilled readers revealed that not only higher-level syntactic and semantic processing skills, but also lower-level phonological and orthographic ones, significantly differentiated skilled from less skilled ESL readers. The results suggest that it is possible to distinguish among even relatively proficient adult L2 readers based on their ability at basic linguistic processing components and that individuals who are relatively more effective comprehenders differ from their less skilled counterparts not only on syntactic and semantic processing skills but also on phonological and orthographic processing skills.

Correlational analyses revealed that both speed and accuracy on L2 phonological, orthographic, syntactic, and semantic measures correlated significantly with each other and with various indices of L2 reading proficiency. In particular, there was a positive and significant correlation between efficiency on phonological and orthographic measures and reading comprehension, silent reading rate, and the ability to read accurately individual words.
out of context. These results suggest that there is an important relationship between the skills involved in processing L2 phonological and orthographic information and ESL reading ability.

Finally, hierarchical regressions revealed that efficiency in phonological and orthographic processing skills contributed significantly to the prediction of individual differences in reading comprehension, silent reading rate, and reading words out of context. Furthermore, multiple regression analyses revealed that individual differences in phonological and orthographic processing skills made a significant predictive contribution to syntactic and semantic processing skills as well, suggesting that efficient lower-level decoding processes may be essential for the execution of higher-level and more complex cognitive and linguistic processes involved in processing semantic and syntactic information (cf. Geva & Ryan, 1993). These results then converged with those of commonality analyses which indicated that graphophonic processing (i.e., a combination of phonological and orthographic processing) contributed both shared and unique variances to ESL reading comprehension.

A principal finding of the study was the unique contribution made by lower-level processing skills to ESL reading. While phonological processing skill emerged as a significant predictor of the reading measures only when it was entered into the regression models before syntactic and semantic measures, orthographic processing skill was found to make an independent contribution to reading comprehension and silent reading rate beyond the contribution made by higher-level syntactic and semantic processing. In the case of out-of-context word recognition, however, this contribution failed to reach statistical significance. The weaker contribution of orthographic processing to isolated, out-of-context word recognition versus reading connected text indicates that there is a relationship between
reading task types and lower-level orthographic processes. The difference can be understood in terms of the complexity of reading connected text as opposed to reading isolated words. The more complex nature of reading connected text places a premium on lower-level visual and word identification processes; therefore, those who have developed more efficient, automatized orthographic processing skills are more privileged when reading connected text than when reading isolated words (Barker et al., 1992). Moreover, the connected text may provide more orthographic information for the reader to utilize. This additional orthographic information is provided through parafoveal processing of connected text, which "involves extracting orthographic information to the right of fixation: word and letter information, and word length information that is used to determine where to look next" (Rayner & Pollatsek, 1989, p. 472). This region, according to Rayner and Pollatsek (1989), extends from where fixation begins to about 15 characters to the right of fixation among native English readers.

Another finding of the present study relates to the evidence it provides for the role of working memory in adult ESL reading. This finding adds to the growing body of L2 studies where working memory was found to play an important role in L2 reading comprehension and word recognition (e.g., Geva & Ryan, 1993; Geva & Siegel, in press; Geva & Wade-Woolley, in press; Gholamian, & Geva, 1997; Harrington & Sawyer, 1992). Geva and Ryan (1993) found that working memory plays even a more important role in the L2 reading of upper-elementary school children than in their L1 reading. According to these researchers, this is mainly due to the heavier demands posed on working memory by the lack of automaticity in executing lower-level component processes in L2 relative to L1 reading. The relatively weaker correlation between working memory and reading decontextualized words in
the present study can then be understood in terms of the differential cognitive processing demands made on adults who are involved in comprehending connected text and reading words out of context. Readers appear to make heavier demands on their working memory to process connected text, which requires them to integrate information at different levels to comprehend the text, than when reading isolated words.

The role of speed of letter naming (RAN) and the way in which this variable contributed to L2 reading in this study is also important to note. L1-based studies have shown that speed of letter naming is a good predictor of individual differences in early reading (Bowers et al., 1994; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wolf, 1984). For the present sample of advanced adult ESL readers, however, RAN was weakly correlated with their performance on reading measures. This finding is consistent with several L1 studies with adult readers in which low correlations have been reported between RAN and L1 reading tasks (e.g., Cunningham et al., 1990; Palmer, MacLeod, Hunt, & Davidson, 1985). However, RAN was found to contribute to the efficiency of syntactic, semantic, and phonological processing. This latter result suggests that while speed of letter naming is not wholly associated with reading comprehension among experienced adult L2 readers, it appears to be related to some of the subcomponents of L2 reading. In particular, it suggests that a link may exist between the speed of recognizing and naming letters and efficient phonological processing in ESL reading, at least among native, literate readers of languages such as Farsi.

Although the nature of such a link between reading and speed of letter naming is not clear, individual differences in highly automatized written symbols such as single letters may be related to a "precise timing mechanism" that is essential for the amalgamation of phonological
and visual orthographic information that underlies fluent word recognition in reading (Bowers & Wolf, 1993, p. 70).

The difference between accuracy-based results and efficiency-based results is also important to note in the present study. Efficiency scores (a composite of time and accuracy) accounted for much more variance on the reading measures than the accuracy scores did alone. This finding suggests that the role of lower-level processing in advanced L2 reading might not depend simply on knowing the relevant linguistic rules but rather on how efficiently these processes operate and how quickly they supply information to higher-level processing. If these operations are slow and inefficient, they might hamper L2 reading comprehension by setting limits on the availability of resources for efficient higher-order processing such as assigning meaning to clauses, and the generation of expectations about upcoming information on the basis of semantic and grammatical knowledge (Geva & Ryan, 1993; Perfetti, 1985; Perfetti & McCutchen, 1987; Van Dijk & Kintsch, 1983).

Given the above results, one might argue that what is responsible for the contribution of basic component processing might be a more general speed factor rather than efficient phonological and orthographic processing skills. This possibility, however, was examined by taking the conservative step of entering the predictor variables into the regressions. In all the regressions, RAN was entered into the equation prior to all the other predictor variables. It was expected that this procedure would extract the variance attributable to the speed of retrieving sequentially the name of individual alphabetic letters implicated in the processing of phonological and orthographic measures. However, there still remained unexplained variance in the efficient processing of phonological and orthographic processing even after the variance
due to letter naming speed was partialled out. These results indicate that difference in efficient graphophonic processing skills in L2 reading, while related to naming speed, does not merely reflect letter naming speed. Rather, it may reflect in part an efficient processing mechanism specific to the processing of phonological and orthographic information (see Chiappe, 1997; Cunningham et al., 1990). This interpretation is consistent with Segalowitz and Segalowitz's (1993) study which showed that automaticity in ESL word recognition is not simply a matter of speed but is the result of a qualitative change in the reader's behavior.

Another important observation in this study was the difference between the unique contribution of phonological and orthographic processing skill. While in most of L1-based studies the lion's share of the variance has been reported to be for phonological processing, in the present study, the unique contribution of orthographic processing skill was found to be more pronounced than that of phonological processing skill. The following factors might help to explain this difference.

First, the participants in the study were well educated, advanced L2 readers. As advanced readers with university educations, they may have relied more on orthographic strategies in reading than on phonological mediation. This interpretation is consistent with the idea that while beginning readers depend more on phonological codes, expert readers may rely more on orthographic representations of words (Ehri, 1992; Perfetti, 1992), and on efficient use of orthographic visual codes during word recognition processes (Doctor and Coltheart, 1980; Frith, 1993; Stanovich, 1993). This interpretation is also consistent with Frith's (1985) model of reading acquisition. Frith considered three developmental stages for reading acquisition: logographic, alphabetic, and orthographic stages. According to Frith, the very
early stages of reading can be characterized as logographic: the learner has not yet developed a full analytic strategy for recognizing words through applying sound-letter correspondence rules. At this stage, learning readers rely for the most part on salient visual features and read words on the basis of their generic images. The second stage is alphabetic. At this stage, the learners have developed an analytic strategy and recognize words by applying their knowledge of phoneme-grapheme correspondence rules. Here phonological ability plays a critical role.

The third stage in Frith’s model is the orthographic stage. This stage, which results from extensive exposure to print and practice (Stanovich, 1993), involves the use of orthographic knowledge and characterizes more fluent adult reading. At this stage, the reader "uses familiar orthographic sequences to aid in accessing" (Stanovich, 1993, p. 122).

There are several L1 studies that are consistent with the above explanation. While the L1 research concerned with beginning readers shows a more important role for phonological processing than for orthographic processing, the research with skilled adult readers suggests a more important role for orthographic processing. Several L1-based studies have shown that the contribution of phonological and orthographic knowledge to reading processes changes as readers become more proficient in their reading. For example, Olson, Wise, Conners, Rack, and Fulker (1989) found that while the independent contribution to word reading of phonological and orthographic skills for poor readers was 30% and 18% respectively, it was 8% and 10% for normal readers. Comparing the reading ability of first and second graders, Juel et al., (1986) found that while orthographic knowledge accounted for 3% of the variance in reading words for first graders, it increased to 20% for second graders.
Another factor that might help to account for the difference in the contribution of phonological and orthographic processing skills in the present study concerns its being conducted with L2 readers. It is possible that there is a difference between L1 and L2 reading processes as far as the contribution of phonological and orthographic processing skills are concerned. After all, L2 readers are different from L1 readers. They already know, and may be literate in, a different language with a different writing system. They also lack the oral competency in L2 that a normal native reader usually possesses, so they may rely on orthographic cues more than on phonological ones. Moreover, native readers begin to learn to read their L1 when they have already developed a good oral competency in the language. Therefore, L1 readers have already a strong phonologically accessible lexicon at the time they start to read (Luo, 1996). This link may not be so strong in L2 reading, or it may be mediated by diverse L1 phonological influences. This may then cause L2 readers to rely more on orthographic information when processing text in L2 as compared to reading a text in L1, or to confuse phonological information among their two languages.

One more factor that could have been responsible for the difference between the contribution of phonological and orthographic processing skills to reading in this sample of ESL readers may have to do with the difference between the participants' L1 orthography and that of English. This explanation rests on the assumption that there may be different information-processing mechanisms involved in L2 reading by proficient L1 readers coming from different background orthographies and that L2 readers may transfer their L1 reading strategies when they read L2 (Koda, 1991, 1995). As mentioned earlier, although alphabetic, Farsi has an orthography completely different from that of English orthography. The alphabets
of the two languages vary considerably in terms of physical shape, the manner they combine to make a word, the direction in which they are written and read, and also in terms of the grapheme-phoneme regularity. The orthographic properties of Farsi have been found to have significant influence on the way Farsi readers read Farsi as their L1. In an experiment addressing the issue of what route-phonological or orthographic-Farsi readers use when reading in Farsi, Baluch and Besner (1991) found that Farsi readers were more orthographically-oriented than phonologically-oriented when reading in their L1. When reading transparent words, that is, words that can be read through applying sound-spelling correspondence rules, Farsi readers used primarily a phonological route. When reading opaque words, that is, words that cannot be read simply by applying sound-spelling correspondence rules, they employed an orthographic route. However, when reading both transparent and opaque words, the dominant route was found to be an orthographic route. According to Baluch and Besner (1991), this is mainly due to the orthographic characteristics of Farsi, particularly the manner in which vowels are represented in print. Short vowels are not typically represented in Farsi scripts.

Moreover, in Farsi, many of the alphabetic letters look visually identical, and they can be distinguished from one another only by two or three dots that are placed above or below the letters. These tiny graphic features play distinctive roles in distinguishing one word from another in Farsi (Mahmoudi, 1967), and Farsi readers learn to be very sensitive to these small visual cues when reading their L1. It is possible that Farsi readers rely on their L1 orthographic processing strategies and that they may specially be sensitive to orthographic cues when they read in L2. That L2 learners may transfer their L1 processing strategies onto
L2 has been shown in other areas of second language learning research. Bates and MacWhinney (1981), for example, found that adult German and Italian bilinguals of English used their L1 word-order processing strategies to comprehend English sentences. If that is the case, it is possible that L2 readers use their L1 orthographic strategies when reading an L2. Therefore, the contribution of orthographic processing skills to reading in this sample of ESL readers may be partly explainable in terms of transferring L1 orthographic strategies onto L2 when Farsi native readers read to comprehend English texts.

Overall, the results of the present study demonstrated that the ability to use lower-level graphophonetic information was closely related to ESL reading performance, even when the readers were advanced L2 readers. It showed that information about syntactic and semantic linguistic skills alone was not sufficient to fully understand how and why adult ESL advanced readers vary from each other on reading.

These results have strong theoretical implications. They weaken the common assumptions in many L2 publications claiming that the availability of higher-level processes in reading comprehension reduces significantly the contribution of lower-level processes. They also challenge the idea articulated by researchers such as Coady (1979) that as L2 readers become more proficient, that is, as they increase their command of L2 vocabulary, syntax and discourse markers, they move away from using lower-level skills and rely instead on higher-level semantic and syntactic skills. Rather, consistent with many L1 studies and some recent L2 studies (e.g., Koda, 1992; Haynes & Carr, 1990; Wade-Woolley, 1996), the present research provides evidence for the value of a multivariate information-processing mode in ESL reading. That is, higher-level syntactic and semantic skills should not be taken as the only
skills that underlie fluent L2 reading. Special allowance must be made for the role of cognitive and stimulus-driven processes in developing and enhancing ESL reading fluency. These processes should not be overlooked even when the readers are highly proficient adult L2 readers.

The present research also provides important insights into the implications of interactive models in L2 reading. Interactive models emphasize the contribution of both lower-level and higher-level processes in reading. However, there has not yet been a complete appreciation of the implications of these models for L2 reading research. As mentioned earlier, L2 research in this area has mostly focused on the interaction between the reader and the text, rather than on interactions among various component processes of L2 reading. The present research, however, showed that there is a complex interrelationship among cognitive and linguistic component processes and ESL reading. The study has made it clear that various language component processes in ESL reading correlate with one another and with underlying cognitive processes such as working memory and speed of processing sequentially orthographic information, while at the same time each correlates with reading comprehension. One way of interpreting these intercorrelations is that there is a high degree of interaction among the component processes in L2 reading and that L2 reading comprehension is an interactive, multivariate process with each of the component processes contributing both to each other and to reading comprehension overall. Any comprehensive model of L2 reading, therefore, must take account of the various component processes involved in the L2 reading process and their complex interactions with one another.
Pedagogical Implications of the Study

Any pedagogical approach to teaching reading is based on some underlying assumptions and views about the nature of reading processes and the way reading is learned. It is these assumptions that feed into, and provide justification for, any decision a teacher makes as to how to teach reading. So far the dominant theoretical framework in the field of L2 reading pedagogy has been the psycholinguistic views. These views have permeated most recent L2 reading methodology books, training courses, and teaching materials (Paran, 1996). Instruction within this framework emphasizes prediction and guessing strategies as an important means to train fluent readers. Strategy training procedures have come to be regarded as an indispensable aspect of second language instruction. Clarke and Silberstein (1979), for example, recommended that: "[P]roviding students with practice in these skills and helping them to develop consistent `attack strategies' should be the focus of any reading program" (p. 49). Given this emphasis on strategy training, it is not surprising that less attention has been paid to the development of lower-level word recognition processes in L2 instruction (Coady, 1993).

Although an empirical understanding of the role of different component processes may not be directly translatable into teaching practice and may not ensure any easy-to-do solutions for practical pedagogical problems (Stanovich, 1993), it may have certain implications for reading pedagogy (see below). Moreover, it is important that L2 reading educators develop an empirically-based understanding of the nature of the L2 reading process and the role of different component processes in L2 reading. Several L2 researchers have recently written about the important role of lower-level identification skills in L2 reading instruction (e.g.,
Coady, 1993; Grabe, 1991; Haynes, 1993; Bernhardt, 1991). However, their observations have been essentially based on research from L1 reading. This is partly because little research has been done on the role of lower-level component processes in L2 reading, despite the growing number of empirical studies in other areas of L2 research in the past couple of years (Koda, 1997). The present study, thus, can provide ESL reading professionals with more than mere reliance on L1 reading research as to the nature of ESL reading process and the contribution of different reading component processes to ESL reading comprehension and word recognition.

The results of the present study show that efficiency in lower-level graphophonemic processes contributes importantly to the prediction of ESL reading even among adult ESL readers who are fairly skilled L2 readers. This suggests that ESL reading practitioners should pay more attention to the role of these word-level processes in ESL reading, considering ways to incorporate this important aspect of reading development into their pedagogical practices even when they are teaching adult L2 readers. In particular, findings of this study suggest that ESL reading instruction should consider the development of efficiency, including both accuracy and speed of component processes in L2 reading practices, rather than the development of accuracy alone.

One way of encouraging the development of efficient component-processing skills involves instructional exercises that aim specifically at fostering efficient word recognition skill and any of its sub-skills, i.e., phonological and orthographic skills (see Stoller, 1986). Training L2 students in such skills may enhance fluent ESL reading comprehension. Alternatively, however, exercises can be used that enhance the development of L2 reading subcomponents in
an integrative fashion. This suggests the value of extensive reading in L2 and having L2 readers read L2 print as much as possible (see Elley, 1994). Extensive exposure to written text may not only offer good conditions for the development of various subcomponents of L2 reading but also provide a context in which L2 readers can internalize them and make themselves capable of employing these subcomponents simultaneously as is entailed in fluent reading comprehension.

However, it is important to note that the development of lower-level graphophonic processing skills may not just be a by-product of general language proficiency. The present study showed that while vocabulary knowledge and the ability to judge the grammaticality of written sentences was highly related to L2 reading comprehension by these adult ESL readers, efficiency in processing orthographic information made an independent contribution to the reading comprehension, over and above the contribution made by semantic and syntactic knowledge. This finding indicates that the development of semantic and syntactic knowledge may not lead automatically to adequately developed lower-level processing skills. Therefore, ESL reading practitioners need to pay special attention to these areas in L2 instructional contexts. In particular, these areas should receive more attention in situations where the target language uses an orthography different from the readers' L1 orthography. Therefore, I would suggest that L2 instruction for Farsi native readers should aim at increasing the sensitivity of these readers to the orthographic conventions of English. Intervention studies in these areas would be revealing.

The present study also demonstrated that ESL reading efficiency is related to the extent to which the readers were able to process information within their working memory
limits. This finding strengthens the idea that to become fluent, ESL readers need to be efficient at executing lower-level phonological and orthographic processes. Reading educators should be cognizant that the comprehension of reading materials is linked to readers’ working memory capacities. Thus, there may be value in attempting to tailor the difficulty level of L2 reading materials to learners’ cognitive capacity levels to help them gain optimal benefit from L2 reading exercises (Koda, 1992).

**Limitations of the Study and Directions for Future Research**

It should be noted that the syntactic and semantic tasks used in this study were written tasks. This choice was made under the assumption that written tasks provide L2 readers with a better opportunity to demonstrate their semantic and syntactic processing skills, for they are self-paced and free from the problems associated with auditory tasks (Johnson, 1992). Indeed, auditory tasks have been found to have a detrimental effect on L2 learners’ judgements, causing them to be both less accurate and slower in judgement as compared to when they do written tasks (Murphy, 1997). However, written tasks may be confounded with other aspects of reading skill that include phonological and orthographic processing. This potential confounding was addressed in the present research by using the logic of regression analysis, whereby the effects of other relevant variables were partialled out by entering them first into the regression equations. However, future research should be conducted using both oral and written versions of these tasks. This approach could at least allow researchers to examine the extent to which the contributions of lower-level graphophonic processes are sensitive to the type of modality in which higher-level processing tasks are presented to L2 readers.
This study did not look into the effects of L1 reading components and the extent to which lower-level graphophonic processes in L2 reading may be related to parallel processes in L1 reading. The focus of the present study was rather on components in L2 reading. However, future research should be conducted in which the role of these processes in L2 could be examined with respect to their L1 reading counterparts.

Further, in this study, although the participants were assumed to be highly proficient readers in their L1, for they were graduate students who received the major part of their education in their home country (having all completed Bachelor's degrees in Iran), L1 reading proficiency was not controlled in any systematic manner. Therefore, future research should be carried out to examine the extent to which the role of lower-level graphophonic processes in L2 reading varies as a function of L1 reading proficiency. This issue might best be explored by selecting participants with varying degrees of L1 reading proficiency.

The present study used relatively few measures to test each particular component skill. This decision was mainly made due to the number of component skills measured. It was felt that adding to the number of tests might create fatigue on the part of the participants who were being tested in single sessions. However, if possible, future studies could include more measures for each skill and a larger number of items in each measure. This might increase the reliability and validity of the measures used as well as enable a more subtle examination of tasks varying in their demands. Future research, for example, can use pseudoword naming as a possible measure for phonological processing in L2. Although in the present research, pseudoword naming was not used because of the reasons mentioned before, pseudoword naming has been shown to be a more pronounced measure for phonological processing in L1
reading (e.g., Stanovich & Siegel, 1994). Therefore, it is possible that if pseudoword naming is used in future research, a greater contribution will be obtained for phonological processing than what was obtained in the present study.

It is important to caution against a simplistic and injudicious application of these findings to any theory of L2 reading. As shown earlier, there is a growing body of research on adult L2 learners suggesting that specific aspects of L2 phonology and orthography may be negatively or positively affected due to transfer from various L1s (e.g., Akamatsu, 1996; Chitiri et al. 1992; Haynes & Carr, 1990; Koda, 1991; Wade-Woolley, 1996). Therefore, further studies are needed to examine the generalizability of the results from the present study to readers of various L1 language backgrounds in various L2s.

Finally, the present study was carried out with relatively proficient adult ESL readers. Additional studies should be conducted with readers with different levels of L2 reading proficiency, though it is expected that with less skilled readers, more contribution will be obtained for lower-level graphophonic processes than with more skilled readers. Such studies could examine the contribution of different cognitive and language component processes in light of their relationship with reading proficiency level. Such studies would not only help further our understanding of the L2 reading process in general, but they would contribute to a fine-tuned understanding of the L2 reading process from a developmental perspective as well.
REFERENCES


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Appendix A
Phonological Matching Task

ID. No:
Instructions:
In the following, you will see pairs of non-words. Please read each pair silently and as quickly as possible and decide whether the members of the pair sound the same or different. If they sound the same, mark S( ), and if they sound different, mark D( ).

Example: tat - toot S( ) D( )

<table>
<thead>
<tr>
<th></th>
<th>SAME</th>
<th>DIFFERENT</th>
<th></th>
<th>SAME</th>
<th>DIFFERENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pague - paig</td>
<td>S( )</td>
<td>D( )</td>
<td>16.</td>
<td>thake - thack</td>
</tr>
<tr>
<td>2</td>
<td>plemb - plem</td>
<td>S( )</td>
<td>D( )</td>
<td>17.</td>
<td>mought - muft</td>
</tr>
<tr>
<td>3</td>
<td>nert - nirt</td>
<td>S( )</td>
<td>D( )</td>
<td>18.</td>
<td>koe - kue</td>
</tr>
<tr>
<td>4</td>
<td>munk - mank</td>
<td>S( )</td>
<td>D( )</td>
<td>19.</td>
<td>cern - sern</td>
</tr>
<tr>
<td>5</td>
<td>nalk - nack</td>
<td>S( )</td>
<td>D( )</td>
<td>20.</td>
<td>creat - crite</td>
</tr>
<tr>
<td>6</td>
<td>boe - bew</td>
<td>S( )</td>
<td>D( )</td>
<td>21.</td>
<td>thun - thone</td>
</tr>
<tr>
<td>7</td>
<td>wrax - rax</td>
<td>S( )</td>
<td>D( )</td>
<td>22.</td>
<td>zign - zine</td>
</tr>
<tr>
<td>8</td>
<td>rept - repped</td>
<td>S( )</td>
<td>D( )</td>
<td>23.</td>
<td>taum - tume</td>
</tr>
<tr>
<td>9</td>
<td>nij- nidge</td>
<td>S( )</td>
<td>D( )</td>
<td>24.</td>
<td>wust - wussed</td>
</tr>
<tr>
<td>10</td>
<td>kight - keet</td>
<td>S( )</td>
<td>D( )</td>
<td>25.</td>
<td>cirk - cerc</td>
</tr>
<tr>
<td>11</td>
<td>naid - nade</td>
<td>S( )</td>
<td>D( )</td>
<td>26.</td>
<td>gnole - nole</td>
</tr>
<tr>
<td>12</td>
<td>fype - fip</td>
<td>S( )</td>
<td>D( )</td>
<td>27.</td>
<td>micked - mict</td>
</tr>
<tr>
<td>13</td>
<td>sert - surt</td>
<td>S( )</td>
<td>D( )</td>
<td>28.</td>
<td>jot - jote</td>
</tr>
<tr>
<td>14</td>
<td>pilk - pilque</td>
<td>S( )</td>
<td>D( )</td>
<td>29.</td>
<td>voam - vum</td>
</tr>
<tr>
<td>15</td>
<td>darge - darg</td>
<td>S( )</td>
<td>D( )</td>
<td>30.</td>
<td>lought- loat</td>
</tr>
</tbody>
</table>

*Note. This task has been modeled after one by Manis et al. (1990).*
Appendix B

Orthographic Non-word Decision Task

Instructions:
In what follows, you will see pairs of non-words. Please look at each pair carefully and circle as quickly as possible the item from each pair which looks more like an English word.

Example: leet - liit

1. filv - filve
2. bolz - bolk
3. powl - lowp
4. qoust - quost
5. fant - tanf
6. miln - milg
7. wolg - wolt
8. vigh - vegh
9. hift - hifl
10. gmup - gnup
11. nitl - nilt
12. sckap - skap
13. tridth - tribth
14. dlun - lund
15. fenth - femth
16. clid - cklid
17. vrine - wrine
18. poat - paot
19. dayke - dake
20. fyeth - fieth
21. frength - frenkth
22. fague - fageu
23. tamb - tabm
24. tirtt - tirth
25. kmort - knort
26. pihgt - pight
27. bleam - blaem
28. netch - neetch
29. tign - tagn
30. trenths - trenthz

Note. Some of the items in this task have been taken from Siegel et al. (1995).
Appendix C
Syntactic Judgement Task

ID. No:
Instructions:
In what follows, you will see a list of sentences. Some of them are grammatically correct and some are grammatically incorrect. You are asked to read each sentence at a normal pace and indicate whether the sentence is grammatically correct or incorrect. Mark correct ( ) if the sentence is grammatically correct and mark incorrect ( ) if the sentence is grammatically incorrect.

Example:
| This is a book. | correct ( ) | incorrect ( ) |
| This a book is. | correct ( ) | incorrect ( ) |

<p>| 1. He answered the ringing telephone. | correct ( ) | incorrect ( ) |
| 2. The child wrote his friend a letter. | correct ( ) | incorrect ( ) |
| 3. The lion and the tiger live in jungle. | correct ( ) | incorrect ( ) |
| 4. The children's mother work very hard. | correct ( ) | incorrect ( ) |
| 5. He did not understand you unless you had spoken slowly. | correct ( ) | incorrect ( ) |
| 6. A group of brightly coloured fish swam past the boat. | correct ( ) | incorrect ( ) |
| 7. Birds have to learn using their wings. | correct ( ) | incorrect ( ) |
| 8. It was so dark we could hardly see the road signs. | correct ( ) | incorrect ( ) |
| 9. The book writing about nature is rather interesting. | correct ( ) | incorrect ( ) |
| 10. It is important that he come on time. | correct ( ) | incorrect ( ) |
| 11. He ran fast for winning the race. | correct ( ) | incorrect ( ) |
| 12. The number of students who fail are increasing. | correct ( ) | incorrect ( ) |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13. I took so a long test that I felt like going to bed.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>14. I wish I could read the book next week.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>15. We objected to visit our friends.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>16. This is an interesting book I have ever read.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>17. It is time we went to bed.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>18. Driving home in my car, I had a bad accident.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>19. I was reading the paper while it had rained</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>20. I suggested him to sleep before the exam.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>21. She wanted to have her car fixed.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>22. Had he tried hard, he might have won the prize.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>23. The house seems very new although it is built two hundred years ago.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>24. Ten miles is not far to go for a good lunch.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>25. I seem to have left my key in the car last night.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>26. The doctor appeared nervously when he talked to the patient.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>27. He is waiting in the hall for half an hour.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>28. He decided to go to the university rather than to get a job.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>29. He asked me what countries I had visited.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
<tr>
<td>30. The cat climbed up the wall.</td>
<td>correct ( ) incorrect ( )</td>
</tr>
</tbody>
</table>
Appendix D
Semantic Judgement Task

ID. No:
Instructions:
In what follows, you will see a list of sentences. Some of them are meaningful sentences (i.e., they make sense.) and some are meaningless sentences (i.e., they don't make sense.). You are asked to read each sentence at a normal pace and indicate whether the sentence is meaningful or meaningless. Mark Yes ( ) if it is meaningful, and mark No ( ) if it is meaningless.

Example
The man ate the cheese. Yes ( ) No ( )
The cheese ate the man. Yes ( ) No ( )

1. The angry teacher punished the rude student. Yes ( ) No ( )
2. The small plane enjoyed the lucky guess. Yes ( ) No ( )
3. The young maid prepared a simple dish. Yes ( ) No ( )
4. The prevalent judge sentenced the guilty man. Yes ( ) No ( )
5. The strange noise disturbed his efficient sleep. Yes ( ) No ( )
6. The notorious director impeded the fabulous merchandise. Yes ( ) No ( )
7. The desperate prisoner chanted a lively song. Yes ( ) No ( )
8. The pompous official revered his immense virtue. Yes ( ) No ( )
9. A timid accident devastated a huge crop. Yes ( ) No ( )
10. The tiny tablet soothed my irritable feelings. Yes ( ) No ( )
11. The smart detective aroused the restful tribe. Yes ( ) No ( )
12. The hostile crowd alienated a reasonable price. Yes ( ) No ( )
13. The stable policy benefited the poor people. Yes ( ) No ( )
14. The decisive prisoner escaped the novice attack. Yes ( ) No ( )
<table>
<thead>
<tr>
<th>No.</th>
<th>Sentence</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>The single light illuminated the whole room.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>The major hoax disgusted the decent client.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>The wasteful habit resorted to an official denial.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>The strict director disliked the generous turmoil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>An incredible joy scrutinized the stern solicitor.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>The conscientious manager stunned a courteous behaviour.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>The expert trader recommended the convenient pair.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>The serious boss eliminated the typical errors.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>The purple pill assigned the new scheme.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>A casual encounter disturbed his joyful mood.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>A robust director dismissed the tabular client.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>A popular adventurer inspected the perilous gadget.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>A prudent mayor notified a deficient document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>The awkward posture offended the tasty bone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>The agitated mob horrified the cowardly inmate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>The impulsive bachelor repudiated the elaborate ceremony.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Personal Background Questionnaire

1. Name: ______________________________

2. Sex: Male ( ) Female ( )

3. Age: 20-25 ( ) 26-30 ( ) 31-35 ( ) 36-40 ( )
        45-50 ( ) 50-over ( )

4. In what country were you born? _________

5. How long have you been in English speaking countries? _________

6. How long have you been staying in Canada? _________

7. What is your current program? Ph.D. ( ) M.A. ( ) Undergraduate ( )
   Department: _____
   Field: ______

8. If you are currently doing a PhD, please identify your previous undergraduate and graduate fields and the country where you studied.

   Bachelor in the field of ______________ Country _______
   Masters in the field of ______________ Country _______

The following section concerns your language learning experience.

1. My first language is ______

2. I started to learn English at the age of ______

3. I have studied English for ________ years.

4. Do you know other languages besides English and your first language?
   Yes ( ) No ( )

If yes, please identify.
5. How do you evaluate your proficiency in English and other language(s) you know in comparison with native speakers (Please check one category for each language.).

<table>
<thead>
<tr>
<th>Languages</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td></td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

6. How do you evaluate your following four language skills in English and other language(s) you know (Please check one category for each skill.).

a. English

<table>
<thead>
<tr>
<th>Skills</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Writing</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Listening</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Speaking</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

b. (other)_____

<table>
<thead>
<tr>
<th>Skills</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Writing</td>
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<td>Listening</td>
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<td>_____</td>
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<td>_____</td>
</tr>
<tr>
<td>Speaking</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

c. (other)_____

<table>
<thead>
<tr>
<th>Skills</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Writing</td>
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<td>_____</td>
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</tr>
<tr>
<td>Speaking</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

Thank you for your cooperation.