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**Literacy Acquisition:
A Developmental Study of Phonological
Awareness, Orthographic Knowledge and Working Memory**



© Afsaneh Amini-Baghdadorani

**A Dissertation Submitted to
the Graduate School and Research
in Partial Fulfilment of the Requirements for
the Degree of Doctor of Philosophy
in Linguistics**

University of Ottawa

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ABSTRACT

Literacy Acquisition: A Developmental Study of Phonological Awareness, Orthographic Knowledge and Working Memory

Afsaneh Amini-Baghbadorani

University of Ottawa

This study generally endeavoured to explore the development of literacy acquisition in Persian first language learners. To achieve this goal, the study did not focus on a narrow range of variables. There was a strong need for multivariate research taking into consideration phonological awareness, orthographic knowledge and working memory. The study comprised five phases. Phase One addressed the interrelation and development of two levels of phonological awareness: syllable awareness and phoneme awareness. Phase Two focused on the interrelation and development of various levels of orthographic knowledge including alphabetic knowledge, reading words, reading nonwords, spelling words, spelling nonwords, orthographic choice as well as the use of analogy and phonology in reading and spelling of nonwords. An attempt was made in Phase Three to examine the development of working memory. In Phase Four, the interrelation and contribution of phonological awareness, orthographic knowledge and working memory to reading and spelling achievement were surveyed jointly and individually. In the final phase, Phase Five, the factoring of all variables together and their functions in group distinction were determined.

The sample consisted of 156 Persian-speaking students: 21 kindergartners, 121 elementary students enrolled in Grades one to five, and 14 undergraduate university students.

Phonological awareness was examined through six tests including syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion. Measures of orthographic knowledge consisted of letter-name knowledge,

letter-sound knowledge, reading words, reading nonwords, spelling words, spelling nonwords and orthographic choice. Working memory was analysed through a set of three memory spans including word span, syllable span and letter span.

Series of statistical analyses performed on raw scores to provide answers to the research questions on which the study was based. Each phase was concluded with the following results.

The results of Phase One indicated that measures of phonological awareness were strongly correlated with one another giving evidence to the construct validity of these tests. Moreover, a developmental growth in phonological awareness was distinguished by statistically significant differences found between kindergarten and grade-one groups. The differences were more pronounced at the level of phoneme and deletion tasks possibly suggesting that these types of tasks require more cognitive demand.

The results of Phase Two revealed that different measures of orthographic knowledge had a nonsignificant to very strong relationship to one another. Additionally, the acquisition of various levels of orthographic knowledge followed a significant developmental pattern which was highly pronounced for reading words and orthographic choice. Importantly, the ratio of analogous and phonetic responses in reading and spelling of nonwords followed a converse relationship with each other. More phonetic responses were seen in lower grades than upper grades, possibly indicating that beginners were more willing to employ a phonological strategy than an orthographic strategy.

The results of Phase Three confirmed significant correlations among word span, syllable span and letter span. Furthermore, a developmental progression was recognized in working memory significant in between nonsubsequent grades. Incorporating the task and process oriented views of working memory and reading, I speculatively suggested that individual differences in working memory in Persian learners are due to two factors: a) the efficiency of language processing and, b) the general working memory capacity system of individuals.

The results of Phase Four demonstrated that phonological awareness, orthographic knowledge and working memory correlated with reading and spelling ranging from

nonsignificant to significant. The relationships found at the bivariate level were also confirmed at the multivariate level. Using all measures of phonological awareness, orthographic knowledge and working memory as predictors of reading and spelling achievement, a series of stepwise multiple regression analyses revealed interesting results. Reading nonwords was the only significant predictor of reading words. The best predictors of reading nonwords were phoneme deletion and syllable blending. The ability to spell words was predicted by five variables: word span, spelling nonwords, letter-name knowledge, reading nonwords and syllable blending. Similarly, spelling nonwords relied on four predictive variables including spelling words, letter-name knowledge, word span and syllable segmentation. All predictors accounted for a significant portion of the variance in the criterion variable in the order presented.

The results of Phase Five determined that orthographic choice and reading words significantly discriminated between groups. This indicated that membership in an advanced level of Persian literacy primarily require a good command of orthographic choice and reading words. Performing the principal components analysis on general variables, the results revealed five distinct but related factors on which all variables of phonological awareness, orthographic knowledge and working memory were loaded.

This study offers several suggestions for further research and important educational implications for teachers, material developers as well as test and curriculum designers working with Persian language learners.

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TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGEMENTS	vi
LIST OF TABLES	xv
LIST OF FIGURES	xviii
LIST OF APPENDICES	xix
CHAPTER ONE: INTRODUCTION	1
1.0 Orientation	1
1.1 General Purpose of the Study	4
CHAPTER TWO: REVIEW OF LITERATURE	6
2.1 Review of Theoretical Issues	6
2.1.1 Dual Route Theory of Reading and Spelling	6
2.1.2 Literacy Models	7
2.2 Review of Literacy Components	10
2.2.1 Phonological Awareness	10
2.2.1.1 Summary and Implications	22
2.2.2 Orthographic Knowledge	22
2.2.2.1 Summary and Implications	33
2.2.3 Working Memory	34
2.2.3.1 Summary and Implications	41
2.3 Persian Orthography	42
2.3.0 Background	42
2.3.1 Characteristics of Persian Orthography	43
2.3.1.1 Diacritic Vowels	43
2.3.1.2 Dots	46

2.3.1.3	Various Shapes of Letters	47
2.3.1.4	Homophones	47
2.3.1.5	Homographs	48
2.3.1.6	Silent Letters	49
2.3.1.7	Spoken and Written Persian	49
2.3.1.8	Summary and Implications	51
2.4	Educational Policy of Iran	52
2.4.0	Introduction	52
2.4.1	Primary Education	52
2.4.2	Educational Materials	53
CHAPTER THREE:	METHODOLOGY	54
3.0	Orientation	54
3.1	Phases of the Study	54
3.1.1	Phase I: Phonological Awareness	54
3.1.2	Phase II: Orthographic Knowledge	54
3.1.3	Phase III: Working Memory	55
3.1.4	Phase IV: Contribution of Phonological Awareness, Orthographic Knowledge and Working Memory to Reading and Spelling Achievement	55
3.1.5	Phase V: Discriminant Function and Number of Factors	55
3.2	Subjects	56
3.3	Development of Experimental Measures	56
3.3.1	Phonological Awareness Measures	58
3.3.1.1	Syllable Awareness Measures	58
a.	Syllable Blending Task	58
b.	Syllable Segmentation Task	58

c. Syllable Deletion Task	58
3.3.1.2 Phoneme Awareness Measures	59
a. Phoneme Blending Task	59
b. Phoneme Segmentation Task	59
c. Phoneme Deletion Task	60
3.3.2 Orthographic Knowledge Measures	60
3.3.2.1 Alphabetic Knowledge Measures	60
a. Letter-Name knowledge Task	60
b. Letter-Sound Knowledge Task	60
3.3.2.2 Orthographic Choice Measure	61
3.3.2.3 Reading Measures	61
a. Reading Words	61
b. Reading Nonwords	61
3.3.2.4 Spelling Measures	62
a. Spelling Words	62
b. Spelling Nonwords	62
3.3.3 Working Memory Measures	62
3.3.3.1 Word Span	62
3.3.3.2 Syllable Span	63
3.3.3.3 Letter Span	63
3.4 Procedure	63
3.5 Data Collection	63
3.6 Data Analysis	64
3.7 Scoring	66
CHAPTER FOUR: RESULTS	67
4.0 Orientation	67

4.1 Reliability of Experimental Tests	67
4.2 Phase I: Phonological Awareness	68
4.2.1 Concluding Remarks	72
4.2.1.1 Conclusion	72
4.2.1.2 Answers to Research Question 1-2	72
4.3 Phase II: Orthographic Knowledge	72
4.3.1 Concluding Remarks	84
4.3.1.1 Conclusion	84
4.3.1.2 Answers to Research Questions 3-4	84
4.4 Phase III: Working Memory	85
4.4.1 Concluding Remarks	90
4.4.1.1 Conclusion	90
4.4.1.2 Answers to Research Questions 5-6	90
4.5 Phase IV: Contribution of Phonological Awareness, Orthographic Knowledge and Working Memory to Reading and Spelling Achievement	91
4.5.1 Concluding Remarks	100
4.5.1.1 Conclusion	100
4.5.1.2 Answers to Research Questions 7-10	100
4.6 Phase V: Discriminant Function and Number of Factors	103
4.6.1 Concluding Remarks	109
4.6.1.1 Conclusion	109
4.6.1.2 Answers to Research Questions 11-12	109
CHAPTER FIVE: DISCUSSION	111
5.1 Phonological Awareness: Correlation, Development and Contribution to Reading and	

	Spelling Achievement	111
5.2	Orthographic Knowledge: Correlation, Development and Contribution to Reading and Spelling Achievement	115
5.3	Working Memory: Correlation, Development and Contribution to Reading and Spelling Achievement	122
5.4	Discriminant Function, Number of Factors and Contribution of all Variables to Reading and Spelling Achievement	126
CHAPTER SIX: SUMMARY AND CONCLUSIONS		129
6.0	Orientation	129
6.1	Phonological Awareness: Research Questions 1-2	130
6.2	Orthographic Knowledge: Research Questions 3-4	130
6.3	Working Memory: Research Questions 5-6	132
6.4	Interrelation and Contribution of all Variables to Reading and Spelling Achievement : Research Questions 7-10	132
6.5	Discriminant Function and Number of Factors: Research Questions 11-12 .	135
6.6	Answers to Research Questions	136
6.7	Educational Implications	141
6.8	Limitations of the Study	147
6.9	Suggestions for Further Research	147
APPENDICES		152
	Appendix A: Factor Analysis in Individual Constructs	152
	Appendix B: Phonological Awareness Measures	156
	Appendix C: Orthographic Knowledge Measures	163

Appendix D: Working Memory Measures 183

REFERENCES 187

LIST OF TABLES

Table 1: Number of Subjects at Each Grade Level	56
Table 2: Reliability of Experimental Tests	68
Table 3: Correlation Coefficients Among Phonological Awareness Measures for Kindergarten and Grade-One Groups Combined	69
Table 4: Means(%), Standard Deviations and T-Tests of Phonological Awareness Measures for Kindergarten and Grade-One Groups	71
Table 5: Correlation Coefficients Between Various Levels of Orthographic Knowledge for Grades 1-5 and University Combined	73
Table 6: Means(%) and Standard Deviations of Orthographic Knowledge Measures for Each Grade Level	76
Table 7: One-Way Analysis of Variance of Orthographic Knowledge Measures for Grades 1-5 and University Combined	77
Table 8: Scheffé Posthoc Test Results for Orthographic Knowledge Measures	78
Table 9: Means and Standard Deviations of Analogous and Phonetic Responses at Each Grade Level	81
Table 10: One-Way Analysis of Variance of Analogous and Phonetic Responses in Reading and Spelling of Nonwords for Grades 1-5 and University Combined	82
Table 11: Scheffé Post-hoc Test Results of Analogous and Phonetic Responses in Reading and Spelling of Nonwords for Grades 1-5 and University Combined	83
Table 12: Correlation Coefficients Among Working Memory Spans for Kindergarten, Grades 1-5 and University Combined	86
Table 13: Means(%) and Standard Deviations of Working Memory Spans for Kindergarten, Grades 1-5 and University	88
Table 14: One-Way Analysis of Variance of Working Memory for the General	

Sample, Kindergarten, Grades 1-5 and University Combined	89
Table 15: Scheffé Posthoc Test Results of Word Span, Syllable Span and Letter Span	89
Table 16: Correlation Coefficients Among Phonological Awareness Measures and Reading and Spelling Measures	92
Table 17: Results of the Stepwise Multiple Regression Analysis Using Phonological Awareness Tests as Predictors of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords	93
Table 18: Correlation Coefficients Among Orthographic Knowledge Measures	94
Table 19: Results of the Stepwise Multiple Regression Analysis Using Orthographic Knowledge Tests as Predictors of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords	94
Table 20: Correlation Coefficients Among Working Memory Spans and Reading and Spelling Measures	95
Table 21: Results of the Stepwise Multiple Regression Analysis Using Working Memory Spans as Predictors of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords	96
Table 22: Results of the Stepwise Multiple Regression Analysis Using Phonological Awareness, Orthographic Knowledge and Working Memory Tests as Predictors of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords	97
Table 23: Results of the Stepwise Multiple Regression Analysis Using Orthographic Knowledge and Working Memory Tests as Predictors of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords	99
Table 24: Pooled Within-Groups Correlations Among Discriminating Variables and Canonical Discriminant Functions for Grades 1-5 and University Combined	104

Table 25: Eigenvalue, Percentage of Variance and Canonical Discriminant Functions for Grades 1-5 and University Combined	104
Table 26: Initial Factor Analysis: Factors, Eigenvalues and Percentage of Variance Accounted for by Orthographic Knowledge and Working Memory Measures	106
Table 27: Final Factor Analysis: Loadings of Orthographic Knowledge and Working Memory Measures on Factors after Equamax Rotation	106
Table 28: Initial Factor Analysis: Factors, Eigenvalues and Percentage of Variance Accounted for by Phonological Awareness, Orthographic Knowledge and Working Memory Measures	107
Table 29: Final Factor Analysis: Loadings of Phonological Awareness, Orthographic Knowledge and Working Memory Measures on Factors after Equamax Rotation	108

LIST OF FIGURES

Figure 1: Phonological Awareness Measures	
for Kindergarten and Grade-One Groups	70
Figure 2: Orthographic Knowledge Measures Across Grades 1-5 and University	75
Figure 3: Analogous and Phonetic Responses in Reading and Spelling of Nonwords	
Across Grades 1-5 and University	80
Figure 4: Working Memory Spans Across Kindergarten, Grades 1-5 and University . . .	87

LIST OF APPENDICES

APPENDIX A: FACTOR ANALYSIS IN INDIVIDUAL CONSTRUCTS	152
Table 1.	153
Table 2	153
Table 3	154
Table 4	154
Table 5	155
Table 6	155
APPENDIX B: PHONOLOGICAL AWARENESS MEASURES	156
Syllable Blending Task	157
Syllable Segmentation Task	158
Syllable Deletion Task	159
Phoneme Blending Task	160
Phoneme Segmentation Task	161
Phoneme Deletion Task	162
APPENDIX C: ORTHOGRAPHIC KNOWLEDGE MEASURES	163
Letter-Name Knowledge Task	164
Letter-Sound Knowledge Task	165
Reading Words	166
Reading Nonwords	172
Spelling Words	173
Grade-One-Spelling Test	173
Grade-Two-Spelling Test	174
Grade-Three-Spelling Test	175
Grade-Four-Spelling Test	176

Grade-Five(-and University)-Spelling Test	177
Spelling Nonwords	178
Orthographic Choice Measure	179
APPENDIX D: WORKING MEMORY MEASURES	183
Word Span	184
Syllable Span	185
Letter Span	186

CHAPTER ONE

INTRODUCTION

1.0 Orientation

There is widespread agreement that variety in spoken languages has given rise to a variety of orthographies including syllabary, logographic and alphabetic. Each orthography manifests a relationship unique to its structural characteristics (Katz and Frost 1992, Mattingly 1992). As Mattingly (1992) maintains, once a reader has learned a particular orthography the reader's linguistic awareness about his language is shaped by particularities of that orthography. A point of interest here is whether or not various orthographies require different cognitive and perceptual strategies for reading and spelling. Research findings indicate that various orthographies may activate different types of strategies in reading and/or spelling. For example, Frost and Bentin's study (1992) presented evidence that special types of flexible reading strategies exist for the reading process in Hebrew orthography. That is, skilled readers can read words without short vowels quite efficiently, determining the specific form of the word from the context. Nevertheless, despite this efficiency, when Hebrew readers read words in the pointed orthography (which include all vowel information), they adopt a different strategy that corresponds to phonological information available (Frost and Bentin 1992). Similarly, Simpson and Kang (1994) concluded that Korean readers are flexible in their use of phonological information when reading Hangeul words. This flexibility was attributed to the shallow nature of Hangeul orthography. Additionally, many researchers argue while readers of logographic systems normally have direct visual coding to lexical access (Glietman 1985, Satio 1981, Taylor and Taylor 1983), readers of shallow orthographies employ phonological coding that precedes semantic coding (Besner and Coltheart 1979, Brooks 1977, Coltheart 1981, 1984, Navon and Shimron 1984, Taft 1982, Turvey, Feldman and Lukatela 1984). On the basis of such studies, it has been hypothesized that script particularities affect reading strategies in different languages.

Within alphabetic systems, all orthographies can also be categorized as phonologically

shallow or deep depending on the degree of the correspondence between phonemes and graphemes. In shallow orthographies of Serbo-Croatian, Italian and Finnish, the relationship between phonemes of the spoken form and graphemes is almost one-to-one. Other languages such as Persian, Arabic and Turkish provide examples of shallow orthographies but in different degrees. In deep orthographies such as English and French the relationship between the sound and symbol is drastically opaque. In this regard, a number of researchers have reported that variations in the transparency of orthographies (i.e., phonetic regularity) not only impacts the processes involved in reading (e.g., Koda 1988), but also affects the patterns and prevalence of reading problems (often referred to under the general heading of 'dyslexia') in various languages (e.g., Stevenson et al. 1982). As a result of error analysis in reading different languages, some other researchers, in contrast, maintained that readers of different orthographies basically employ the same reading strategies (Barrera 1978, Goodman and Goodman 1978), and that patterns of dyslexia and its severity are not influenced by the orthographic complexity (Verhoven 1990). Between these two poles, it is worth referring to a number of other researchers in various areas of linguistics reporting that the higher levels of reading processes, that is, concept-driven processes (in opposition to data-driven processes) are not influenced by orthographic variations (e.g., Albert 1975, Barrera 1978, Bertelson and Tisserayre 1975, Biederman and Tsao 1979, Davelaar et al. 1978, Feldman and Turvey 1980, Kleiman 1975, Tzeng, Hung and Wang 1977). This indicates that at least lower levels of reading processes are subject to script variations. An interesting issue raised here is how different reading and spelling might be in Persian, which highly conforms to the spelling of the word, from English which weakly conforms to the spoken form. Following Frost, Katz and Bentin (1987) as well as Katz and Frost (1992), it may be predicted that in Persian, a shallow orthography, phonology should be more easily assembled because the letter-phoneme/phoneme-letter association is more consistent than in a deep orthography like English.

Regardless of the degree of opacity across alphabetic orthographies, it is generally believed that unlike learning to speak that almost all children accomplish automatically at an

early age, learning to read and spell is not achieved very easily since these skills require a number of subskills such as phonological awareness and orthographic knowledge that speaking and understanding do not (see Adams 1990). These skills together with such cognitive constructs as working memory have been postulated to play a basic role in literacy acquisition.

Phonological awareness is a metalinguistic ability (Hakes 1982, Tunmer, Herriman and Nesdale 1988) requiring the recognition and manipulation of segments of spoken language (Bentin 1992, Hakes 1982, Liberman 1973, Liberman et al. 1974, Mattingly 1972, Morais, Alegria and Content 1987, Morais et al. 1979, Tunmer and Hoover 1992). There is a great deal of research in the literature showing that phonological awareness is a primary predictor of future literacy (e.g., Bradely and Bryant, 1978, 1983, 1985, Fox and Routh 1980, Goldstein 1976, Juel 1988, Kamhi and Catts 1989, Liberman 1982, 1989, Share et al. 1984, Snowling 1980, 1981, Treiman and Baron 1981, Tunmer and Nesdale 1985, Wallach and Wallach 1976, Yopp 1988), and that deficits in phonological awareness is a critical factor underlying severe word decoding problems in reading disabled individuals (e.g., Bruck 1990, 1992, Galaburda 1988, Høien et al. 1989, Katz 1986, Liberman and Shankweiler 1991, Lundberg and Høien 1989, Manis, Custodio and Szezulski 1993, Olson et al. 1990, Pennington et al. 1990, Rack, Snowling and Olson 1992, Siegel 1988, 1989).

Orthographic knowledge basically is the awareness of sound-symbol/symbol-sound association. This ability has different levels indicating that reading and spelling change throughout their course of acquisition. Skilled word decoding and encoding constitute the highest levels of orthographic knowledge. To read and spell the child needs to internalize the abstract association of graphemes with phonemes and phonemes with graphemes (Ehri 1986, 1989, Gentry 1982, Gough and Juel 1991, Frith 1985, Juel 1994). This knowledge increases with schooling age among normal readers (Juel 1994, Snowling 1980). However, as the child progresses through the stages of reading and spelling, the sound-symbol/symbol-sound principle gradually becomes less significant (Beers and Henderson 1977, Ehri 1986, 1989, Gentry 1982, Frith 1985). That is, skilled readers/spellers do not work with individual letters

but with the automatic¹ recognition and spelling of words.

Working memory is a processing resource of limited capacity which plays a central role in normal cognitive functioning (Siegal and Linder 1984). Information received is recorded into a phonological code or sound-based representational system for short periods of time but long enough to be processed (Baddeley, 1966, 1979, 1982, 1986, Baddeley and Hitch 1974, Hitch and Baddeley 1976). Numerous studies indicate that poor readers recall less information from working memory tasks than good readers (e.g., Liberman and Shankweiler 1985, Share et al. 1984, Stanovich 1982, Torgesen and Houck 1980, Wagner and Torgesen 1987), and that poor readers do show specific deficits concerning the phonological code in working memory tasks (Brady, Shankweiler and Mann 1983, Bryan 1972, Koppitz 1975, 1977, Stanovich 1982).

Overall, the shift from phonological, bottom-up coding to visually automatic, top-down coding requires the mastery of different levels of phonological and orthographic knowledge, in the first place. These constructs together with working memory constitute the base for reading fluency.²

1.1 General Purpose of the Study

The present study is an endeavour to investigate literacy acquisition in Persian when the interrelation and contribution of three important components including phonological awareness, orthographic knowledge and working memory are involved. Though there is a considerable

¹Here the automatization phase of word recognition refers “to the establishment of an automatic process characterized by a high level of speed and accuracy. It is carried out unconsciously; makes minimal demands on attention; and is difficult to suppress, ignore or influence” (Gersons-Wolfensberger and Ruijssenaars 1997:209).

²Although reading certainly entails more than being able to recognize words, word recognition or word decoding is considered basic to higher level ordering (Adams 1990, Ehri 1987, Juel, Griffith and Gough 1986). Moreover, in elementary grades and even among adults, word recognition efficiency accounts for a considerable portion of the variance in reading ability (Bertelson 1986, Gough and Tunmer 1986, Morrison 1984, 1987, Perfetti 1985, Vellutino 1979). Importantly, word recognition is the primary locus of reading difficulty for individuals with developmental dyslexia (Jorm and Share 1983, Perfetti 1985, Stanovich 1988).

body of research on the aforementioned components in English (e.g., Badian 1998, Boden and Darlene 1999, Bradley and Bryant 1983, Curtis 1980, East 1993, Ehri 1987, Gerber and Hall 1987, Layton et al. 1996, Liberman et al. 1980, Mann 1993, Stanovich 1986, Torgesen 1989, Treiman and Tincoff 1997, Wagner 1988, Zifcak 1981, Zuck 1991), to the extent that can be ascertained, there is no research in Persian analysing the development of phonological awareness, orthographic knowledge and working memory, on the one hand, and synthesizing their relation to reading and spelling achievement, on the other hand. Thus, the need for research in this area is worth investigating. From a pedagogical point of view, without empirical studies which explore the role and development of different components in literacy acquisition, very little can be done to help those Persian students who have problems in learning to read and write Persian. From a theoretical point of view, cross-linguistic studies fill theoretical gaps and help highlight the scientific path toward universality or particularity.

What follows begins with a review of related literature in Chapter Two which is divided into four parts. The first part reviews the dual route theory and stages of literacy development to provide a theoretical framework. This is followed by literacy components including phonological awareness, orthographic knowledge and working memory. The main purpose of this section is to see what has been done in English and what is worth measuring in Persian. A description of the characteristics of Persian orthography is given in the third part. This part aims to introduce those aspects of Persian orthography which may pose problems for Persian children. A brief report on the educational system in Iran where the research questions were carried out is provided in the last part of Chapter Two. In Chapter Three, the research questions and methodology are presented. Chapter Four contains the results of statistical analyses which is followed by a general discussion in Chapter Five. Summary, conclusions and suggestions for further research are reported in Chapter Six.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Review of Theoretical Issues

2.1.1 Dual Route Theory of Reading and Spelling

The dual route theory³ of reading and spelling (e.g., see Barry 1992, Barry and Seymour 1988, Ellis 1982, Morton 1969, 1979, 1980, Sterling and Seed 1992) is widely accepted as a theoretical framework for understanding how English readers and spellers read and spell regular and irregular words. The theory proposes that there exist two separable processing systems or routes: a) the phonological route and, b) the lexical route. The phonological route breaks up the word into its constituent phonemes (e.g., bag = b, a, g) and then uses the knowledge of sound-spelling (e.g., /b/ = b, /a/ = a, /g/ = g) correspondences to assemble an appropriate spelling. This route is usually referred to as: the phonological route, phonological skill, phonological coding, phonological strategy or phonological assembly. Regardless of different names given to it, its major feature is that it can produce correct readings and spellings only for regular words. Irregular words will be incorrectly read or spelled because they break the rules and regularities of English. If an irregular word is attempted, the reading/spelling, though wrong, will be phonetically plausible (e.g., 'laf' in place of 'laugh').

The lexical route,⁴ on the other hand, copes with the irregularities of English orthography. The critical feature of this route is that it uses word-specific knowledge stored in the mental lexicon. Irregular words could not be read or spelled correctly by any purely phonological spelling-to-sound/sound-to-spelling conversion and so some lexical knowledge must be functional. Note also that all known words can be read or spelled by the lexical route

³The dual route theory has been justified from regular and irregular words in English. The neuropsychological and empirical evidence shows the association of the two routes in adult speakers, and their dissociation in patients with phonological and lexical dysgraphia (Barry and Seymour 1988, Campbell 1983, Shallice 1981).

⁴As well, different names are given to the lexical route including the word-specific route, visual route, visual coding, visual skill, orthographic coding and orthographic skill.

because all known words are assumed to have representations in the mental lexicon. However, it is entirely possible that the reading and spelling of very familiar words are stored and that low-frequency words may need to be read or spelled using the phonological route. Therefore, a complete reliance on a phonological recognition strategy may not be an effective approach while learning to read and spell English.

Some researchers (e.g., Carr and Pollatsek 1985) postulate that lexical and phonological routes of lexical activation are cooperative in that they both contribute to the process of word recognition. However, some other researchers (e.g., Coltheart 1978, Coltheart et al. 1977, Davelaar et al. 1978, Norris and Brown 1985, Seidenberg 1985, Seidenberg et al. 1984, Stanovich and Bauer 1978) argue that both phonological and lexical routes of lexical activation work in parallel, with the lexical activation being a faster process. What is common in the two versions of the dual-access theory is that the process of word recognition includes both phonological and orthographic sources of activation.

Adopting the dual-route model of reading and spelling, we may predict that word decoding and encoding in Persian depend on linguistic characteristics of the stimuli. High frequency words are assumed to be identified through lexical route since phonological, semantic and orthographic representations of these words are stored in the output lexicon. On the other hand, low frequency words and unfamiliar words are assumed to be identified through the phonological route since these words have no lexical entries in the lexicon. Based on these assumptions, the correct pronunciation and spelling of exception words must be achieved lexically. Thus, the variables of frequency, regularity, familiarity and exceptionality would underlie the selection of the lexical or phonological route when reading and spelling Persian.

2.1.2 Literacy Models

Regardless of different types of orthographies that might impact different cognitive and perceptual strategies in reading and spelling, there is a consensus that reading and spelling are not the same acts for a beginning reader/speller as it is for a fluent reader/speller. Though the

stages of literacy development in English have been named differently (e.g., see Beers 1974, Beers and Beers 1981, Ehri 1987, 1991, 1992, Ehri and Wilce 1983, Frith 1985, Gentry 1982, Graham and Miller 1979, Harris and Coltheart 1986, Marsh et al. 1977, 1980, 1981), the general framework shares common features moving from simple to complex indicating that the concept of developmental reading and/or spelling improves along a continuum. To compare literacy acquisition in English and Persian, we very briefly review two established models of literacy development in English and one tentative model in Persian.

Frith's (1985) reading and writing model based on the acquisition of English literacy postulates three stages in the development: Logographic, Alphabetic and Orthographic. In the Logographic stage, the child reads and spells based on the relationship between a visual representation and its meaning. Salient graphic features and contextual clues may have a role in this process. In the Alphabetic stage of development, the child acquires the knowledge and use of the relationship between phonemes and graphemes. This stage enables the child to connect sounds of speech to graphemes and graphemes to phonemes for spelling and reading. In the third stage of development, the Orthographic stage, the child learns regularities or word-based patterns during his/her exposure to language.⁵

Based on invented spellings of children, a number of researchers (e.g., Beers and Henderson 1977, Ehri 1986, 1989, Gentry 1982, Henderson 1981, Read 1971) distinguish four stages in spelling development: Prephonetic (Precommunicative), Semiphonetic, Phonetic and Morphemic. In the Prephonetic stage, the child strings together the randomly selected letters to express words and sentences. In the Semiphonetic stage, the child realizes that letters stand

⁵Stuart and Coltheart (1988) disputed the sequencing proposed in the Frith's model. They argued that a child might skip the logographic stage and launch directly into the alphabetic stage. To them, this can happen if the child understands the sounds of speech and the way these segmental units are represented by graphemes when s/he begins to read words. While incorporating Stuart and Coltheart's point of view, Treiman (1993) tried to preserve the view that there is just a single route to skilled reading by proposing the notion of 'default option'. She argued that phoneme awareness is essential for the progress to the alphabetic stage. However, if the child does not possess knowledge of the alphabetic principle, then s/he will read logographically at first (i.e., the default option), otherwise alphabetically.

for segments in the spoken form. Here detecting of sounds into letters is incomplete and usually the initial and final sounds of words are detected. The Phonetic stage enables the child to segment words into sounds and select a letter for every sound. In the final stage of spelling development, the morphemic stage, knowledge of the writing system is firmly established. The speller makes use of within-word patterns for spelling of words.

One can see that Frith's logographic, alphabetic and orthographic stages correspond to semiphonetic, phonetic and morphemic stages, respectively. Overall, both frameworks move from simple to complex indicating a steady developmental sequence in the course of reading and spelling acquisition.

Adopting these models and building on the case study, Amini (1997) proposes a model of literacy development for Persian consisting of five stages: Prealphabetic, Semialphabetic, Alphabetic, Semi-postalphabetic and Postalphabetic. First, the *Prealphabetic Stage* refers to any combination of simplified alphabetic letters, drawings, etc. used by the child to express an idea. Here the concepts of syllable, word, reading and writing may be understood by the child; however, no alphabet has been introduced to him/her yet. While English-speaking children usually have some alphabetic knowledge at this stage (i.e., the prephonetic stage), Persian children have no knowledge of the alphabetic principle. Therefore, this stage is purely nonalphabetic in Persian and may be represented by some drawings at least or some simplified alphabetic letters at most (refer to Amini 1997). Secondly, the *Semialphabetic Stage* refers to the stage where the child focuses on the salient features of alphabetic letters, the visual appearance of words and situational context. Here the child has been exposed to alphabetic letters; however, s/he has not yet internalized the perceptual abstraction of phonemes and their relations to graphemes. Ambiguous words and mirror inversion of words may characterize spelling. In reading, semantic and visual types of errors may be in evidence. The *Alphabetic Stage* refers to the stage where the child has figured out that every grapheme indicates a sound in the spoken language. S/he tends to read and spell linearly, representing each letter with a sound segment and each sound segment with a letter. To the extent that the child assumes a

one-to-one relation from phonemes to graphemes, exception words and homophones will be sources of difficulty. Knowledge of dots and letter shapes may not be established at the beginning of this stage; consequently, errors related to dots and letter shapes may be frequent initially. The *Semi-postalphabetic Stage* which is absent in English enables a child to read and spell without the help of diacritics. Although the child's reading performance falls back and serious phonetic errors appear, through this stage and the following, s/he would acquire phonological and orthographic skills needed for fluent reading and spelling. Exception words and homophones would still be sources of difficulty since the semi-postalphabetic child would not move beyond the phoneme-grapheme/grapheme-phoneme correspondence rule. Finally, the *Postalphabetic Stage* which parallels the orthographic stage in English enables the child to become a competent reader and speller in Persian. Though the child relies more on orthography than phonology, homophones could still be a source of difficulty in spelling.

2.2 Review of Literacy Components

Literacy acquisition is not a unitary phenomenon (Adams 1990, Adams and Bruck 1993, Ehri 1987, Siegel and Ryan 1988). It involves the integration of basic components such as phonological awareness, orthographic knowledge and working memory, in the first place. These individual components are developed in relation with one another and all together make up an interwoven system (see Adams 1990). Though higher levels of reading certainly involve other skills such as syntactic and semantic knowledge, the review here focuses on those components which are vital to word reading and spelling.

2.2.1 Phonological Awareness

Children all over the world begin to use words and to arrange them sequentially to form sentences in much the same way and much the same time (Bloom 1970, Brown 1973, Gibson and Levin 1975, Gleitman and Gleitman 1981, Lennberg 1967, Slobin 1973). However, learning to read and write depends in large part on special language-related skills that go

beyond the primary abilities required in the production and perception of speech (Fox and Routh 1984, Liberman and Shankweiler 1985). The child does not need to be aware of the sublexical structure of individual words in order to speak and understand speech because the speech apparatus processes them automatically (see Adams 1990). However, alphabetic letters are manmade; therefore, their learning is not accomplished automatically and easily. The learner needs to discover and develop certain types of language awareness in order to be able to read and write (Adams 1990, Treiman 1993). One type of such knowledge is phonological awareness. Phonological awareness refers to a conscious awareness of the sound structure of the language (Liberman 1973, Tunmer and Hoover 1992).⁶ It is an awareness of words in terms of their linguistic characteristics rather than their meanings (East 1993). For example, given the word 'bag', one would say it consists of three phonemes, or is one syllable and rhymes with 'rag'. Phonological awareness tasks generally require the analysis or synthesis of word units. While an analysis task, for instance, requires a child to segment a word into its respective speech units, i.e., syllables and phonemes, a synthesis task requires a child to blend speech units to form a word (Lewkowicz 1980, Liberman 1973, Treiman 1993). However, there are some levels of knowledge that comprise phonological awareness. Adams (1990) describes five levels of phonological awareness ranging from an awareness of rhyme to being able to deliberately remove the initial and final sounds in a word. Blachman (1989) as well as Ball and Blachman (1991) associate phonological awareness with a two-fold competence: an awareness of sound segments in a word and the ability to manipulate those sound segments. In a similar line, Swank (1991) concludes that phonological awareness consists of two distinct but related levels, i.e., the syllable and phoneme levels.

There have been numerous studies asking children to isolate particular linguistic units such as words and syllables (e.g., Bruce 1964, Ehri 1975, Ehri and Wilce 1979, Ferreiro 1978, Fox and Routh 1975, Høien et al. 1995, Wimmer, Landerl and Schneider 1994) because such

⁶Phonological awareness is also called linguistic awareness (Mattingly 1972) and phoneme awareness (Golinkoff 1978, Lewkowicz 1980).

linguistic awareness appears to be linked to literacy outcomes (Bradley and Bryant 1985, Ehri 1987, Jorm and Share 1983, Liberman 1973, Liberman et al. 1977, Treiman 1985).

Bruce (1964) examined children's awareness of sounds at different levels of mental ability. His purpose was to support the conjecture that at some stage of reading it is important for children to possess some understanding of the sound structure of words. A phoneme deletion task including 26 monosyllables, 3 bisyllables and 1 trisyllable was given to sixty-seven children ranging in age from five to seven and a half. The task was presented orally and individually. Each subject was asked to say what word would be left if a particular letter sound is deleted from the test item. In this task children had to remove only part of the onset.⁷ These children found this task quite difficult, and Bruce concluded that children below the mental age of seven cannot analyse words into individual speech sounds.

Bruce's findings were supported by Liberman et al. (1974). Working with 46 nursery school, 49 kindergarten and 40 first grade subjects, Liberman et al. (1974) tested the ability of children to identify syllable and phoneme segments in a series of spoken words. Subjects were required to repeat a word spoken by the examiner and tap it out by a small wooden dowel on the table. While nearly half of four-year olds (46%) could tap out the number of syllables, none of these youngest children could tap out the number of phonemes. The researchers concluded that explicit analysis of spoken words and syllables into phonemes is significantly more difficult for young children than analysis into syllables, and this type of awareness develops later.

Fox and Routh (1975) asked 50 children aged three to seven years to repeat a number of spoken sentences and then divide up these sentences into words, the words into syllables and the syllables into speech sounds. There was a clear developmental progression with increasing age level in the ability of children to divide larger units into smaller units. Even three-year-old children were able to segment over half of the sentences into words, nearly one third of the words into syllables, and one-fourth of the syllables into individual phonemes. There were no

⁷The onset is the initial consonant or consonant cluster of the syllable, and the rime is the vowel and any following consonants.

significant effects for sex and the interaction of age and sex. However, the effects of age were significant on the four dependent variables including sentence segmentation, word segmentation, use of conventional syllable boundaries and segmentation of syllables into individual sounds. The results of Fox and Routh's study contradicted Bruce's finding since in their study children with mental ages below four years got half of the syllables segmented correctly. The authors concluded that children have the ability to segment spoken utterances into smaller units at younger ages than had previously been thought.

The fact that children achieve an awareness of syllables before they achieve an awareness of phonemes continued to be supported by Liberman et al. (1974) and Treiman and Baron (1981). Treiman and Baron gave children syllable and phoneme blending tapping tests and found similar results to those of Liberman et al. (1974). An additional level of awareness (i.e., intrasyllable awareness) that intermediates between syllables and phonemes was further reported by Treiman (1987).

Phonological awareness does not emerge all at once. Awareness of words precedes awareness of syllables, awareness of syllables precedes awareness of intra syllables (onset and rime), and awareness of intra syllables develops earlier than awareness of phonemes (see Adams 1990, Fox and Routh 1975, Goswami and Bryant 1990, Kirtley et al. 1989, Leong and Haines 1978, Liberman et al. 1974, Liberman 1987, Treiman 1985, 1988, 1991, 1992, Treiman and Baron 1981).

Several studies have addressed the relationship of phoneme awareness to reading (e.g., Calfee, Lindamood and Lindamood 1973, Cardoso-Martins 1995, Foorman and Francis 1994, Lenchner, Gerber and Routh 1990, Muter et al. 1997, Vellutino and Scanlon 1987). In a test developed to measure auditory perception and conceptualization of speech, Calfee, Lindamood and Lindamood (1973) looked at children's phoneme awareness. The Lindamood Auditory Conceptualization Test (LAC Test) (1971) required the manipulation of phonemes and the findings of Calfee, Lindamood and Lindamood (1973) supported the idea that performance improved with age. Calfee et al. claimed that there was a relationship between children's ability

to judge how many phonemes a word contains and their reading skills. They tested 660 school children, ages 6-18, on the LAC Test, concluding that children's tests scores were directly related to their reading and spelling ability.

Vellutino and Scanlon (1987) reported two studies providing correlational and experimental evidence that deficiencies in phonological coding and phoneme segmentation results in deficiencies in word identification. In Experiment 1, Vellutino and Scanlon conducted a longitudinal study to develop a screening battery to identify kindergarten students who might have difficulty in reading acquisition. The screening battery was administered initially in the fall semester to 295 randomly selected kindergartners. All children were given the Gilmore Oral Reading Test (Gilmore and Gilmore 1968), and Bryant's (1963) pseudoword decoding test at the end of first grade and also at the end of second grade. A second cohort of kindergarten students (N= 135) was tested in the fall semester of the following year, and a third cohort (N= 135) was tested in the spring. These children were also assigned to the oral reading and pseudoword decoding tests. The reading readiness battery consisted of several subtests: a) rhyming, b) letter names, c) sound letter, consonants, d) letter sound, consonants, e) initial consonant substitution, f) letter sound, vowels and, h) identification of sight words. In addition to above measures, the study also included measures of semantic development, measures of syntactic development and standard measures of intelligence (Slosson 1963, Wechsler 1967). The results of the study indicated: a) the high and most reliable correlations between the test of oral reading and those tests which relied heavily on phoneme segmentation ability and; b) strong support for the theoretical position that phoneme segmentation, phonetic decoding and word identification are intrinsically related skills and; c) strong support for the assumption that phoneme segmentation tasks generally have valid predictive power than do the intelligence measures. Vellutino and Scanlon's (1987) second experiment involving second- and sixth-graders demonstrated that training in phoneme segmentation and alphabetic mapping had a salutary effect on the dependent tasks of word identification and code acquisition.

In a longitudinal study, Cardoso-Martins (1995) investigated the relationship between

different levels of phonological awareness and progress in reading and spelling acquisition in Portuguese. The phonological awareness and/or reading and spelling ability of 105 kindergartners (51 boys, 54 girls) were assessed at five different sessions over a period of approximately 20-24 months. To determine knowledge about print and measure sensitivity to rhymes, syllables and phonemes, four tasks of phonological awareness (i.e., a rhyme detection task, a syllable detection task, a phoneme detection task and a phoneme segmentation task) and three tests of knowledge about print (letter knowledge, word reading and word spelling) were administered. Analyses of the results showed that sensitivity to phoneme segmentation significantly predicts reading and spelling ability, whereas sensitivity to global phonological similarity plays a relatively minor role in learning to read and spell in Portuguese.

Lenchner, Gerber and Routh's (1990) study addressed the relationship among various measures of phonological awareness and between these measures and phonetic decoding. Subjects were 38 male third- and fourth-grade students, of whom 19 disabled/poor decoders and 19 above-average readers/good decoders. The placement of students into one of the groups was based on two criterion tests: the California Test of Basic Skills and the measure of phonetic decoding of pseudowords. Good decoders scored at the 70th percentile or above on at least three of the four language tests of the school-administered California Test of Basic Skills and achieved 85% or more on the timed measure of phonetic decoding test. Children with learning disabilities/poor decoding met California disability placement and also scored below 60% on the timed measure of phonetic decoding. Materials included a series of phonological awareness measures: the phonetic decoding measure of Share et al. (1984), phoneme segmentation tasks, a phoneme deletion task (a modified version of Bruce's 1964 and Rosner and Simon's 1971), the consonant substitution task of Rosner's (1975) auditory training program, a vowel substitution task, and the phoneme blending task of Kirk, McCarthy and Kirk's (1968) Illinois Test of Psycholinguistic abilities. Subjects were first administered the test of phonetic decoding of pseudowords in order to place subjects in one of the decoding groups. The subjects who were qualified for the study were then assessed on four of the five tasks

involving segmentation. The results indicated various intercorrelations (from nonsignificant to .76) among the measures of phonological awareness. The deletion of a consonant correlated most highly with phonological awareness tasks and with phonetic decoding. Poor readers' performance on both the deletion and substitution tasks was significantly intercorrelated with their scores on the two criterion tests.

Using exploratory data analysis, Foorman and Francis (1994) examined grade-one students to find: if growth in phonological awareness affects progress in first-grade reading and spelling; if knowledge of how to read a word has some relation with how to spell the same word during first grade; and if instruction impacts the progression from errors to correct responses in grade-one reading and spelling. Subjects were two groups of students. The first group included 40 first-grade students receiving an average of 45 minutes of letter-sound instruction per day. The second group consisted of 40 first graders receiving an average of 15 minutes letter-sound instruction per day. Materials included sixty one-syllable words for the reading and spelling measures. Of the 60 words, 40 had regular and 20 had exceptional spelling patterns. Subjects were administered the MacGinitie's reading test (MacGinitie 1978) consisting of 4 subtests of letter sounds, vocabulary, letter recognition and comprehension. The Peabody Picture Vocabulary Test (Dunn and Dunn 1981) was given to students in October only. Spelling and reading tests and the phoneme segmentation test were administered over three time points: October, February and May. Since the authors were interested in the progression of reading and spelling across the first grade year on an individual base and item by item, they examined the patterns of correct and incorrect responses using exploratory data analysis techniques. The examination of February scores in phoneme segmentation skill on reading and spelling responses revealed that 38% of the students with October scores of 10 scored at ceiling in February. In other words, the subjects with good scores in segmentation skill moved faster through the sequence of nonphonetic errors to correct responses in reading and spelling as compared to the students with low growth. Thus, letter-sound instruction appeared to improve the rate at which segmentation skill changes during first grade. In answering the second

question, the authors found that knowledge of a word's reading is linked to knowledge of a word's spelling in that correct spellings were almost always accompanied by correct readings. Regardless of instruction, the two groups of subjects moved through a developmental pattern of nonphonetic errors to phonetic errors to correct responses.

Some researchers found a causal relationship between phonological awareness and reading (e.g., Lundberg, Olofsson and Wall 1980, Treiman and Baron 1983). Treiman and Baron (1983) attempted to demonstrate that phoneme analysis training promotes the spelling-sound-rule use and helps children in learning to read. In two experiments, 8 preschoolers and 20 kindergarten prereaders participated in an analysis condition and a control condition on each of 4 test days. Each condition had two phases. In the analysis condition, children were trained to segment (and in Experiment 2, also to blend) four syllables into their initial consonants and remaining portions. In the control condition, the children were exposed to four different syllables, but no training was provided. Simply, children were required to repeat syllables. The second phase of each condition involved a reading task. Children were introduced to printed items that corresponded to the spoken syllables with which they had worked. It was predicted that the pronunciation of the 'related' item could be deduced from those of other printed items in the set, whereas the pronunciation of the 'unrelated' item could not be so deduced. Treiman and Baron found their prediction to be true. Both experiments revealed a significant interaction between the two conditions (i.e., analysis vs. control) and the type of item (i.e., related vs. unrelated). In the control condition, children made more errors on the related item than on the unrelated item, whereas in the analysis condition, children made fewer errors on the related items than on the unrelated item. Based on the results of the study, the researchers suggested the existence of a causal link between the ability to analyse spoken syllables and the ability to benefit from spelling-sound association in reading.

Several researchers concluded or suggested that the relationship between phonological awareness and learning to read is interactive (e.g., Ehri 1976, Perfetti et al. 1987, Sultman et al. 1983, Tunmer and Rohl 1991, Valtin 1984). Perfetti et al.'s (1987) research strategy was

to examine the performance of children learning to read on tasks that tap the abilities of phoneme synthesis and analysis. Subjects were three groups of first graders (N= 82), of which two groups were taught by a basal reader series, and one group by systematic direct code instruction. The results of their study indicated that phoneme awareness and learning to read develop in mutual support.

Tunmer and Rohl (1991) conducted a two-year study of 76 initially prereading Australian children to examine the relationships among phonological awareness, working memory and the development of reading and spelling. Their findings support the theoretical view that phonological awareness and working memory contribute to the early stages of literacy development. Tunmer and Rohl suggested that phonological awareness and reading may have an interactive relationship with each other. According to them, this might explain why some readers in a nonalphabetic script are unable to perform the more complex phonological awareness tasks of phoneme reversal and deletion. This is evident in the studies of Mann (1986) and Read et al. (1986), as discussed below.

Mann (1986) examined the development of syllable awareness and phoneme awareness in Japanese and American children. Children were given syllable and phoneme counting tests as well as syllable and phoneme deletion tests. Mann found that most of American first graders were aware of syllables and phonemes. This contrasted with Japanese first graders, of whom almost all were aware of mora. Mann attributed this contrast to the fact that Japanese first graders learn to read a syllabary orthography, whereas American first graders learn to read an alphabetic orthography. Similarly, Read et al. (1986) compared two groups of adult Chinese readers on the tasks of syllable and phoneme awareness. The first group was literate in the traditional logographic writing system and an alphabetic writing system, whereas the second group was literate only in the traditional writing system. In education and experience the two groups were similar; however, they differed in age and familiarity with an alphabetic writing system. The researchers found that users of the nonalphabetic written language system were unable to segment words beyond syllables. This finding lent support to the view that training

in an alphabetic written language system contributes to emergence of phoneme awareness.

Some investigators have attempted to determine the factorial structure underlying phonological awareness by using a variety of phonological awareness tasks (e.g., Høien et al. 1995, Stanovich, Cunningham and Cramer 1984, Yopp 1988). Høien et al. (1995) examined different levels of phonological awareness in two successive studies in order to investigate the factorial structure underlying different types of phonological awareness tasks. In their first study, a total of 128 Norwegian preschoolers (64 girls and 64 boys) were included. Six types of phonological awareness tests including rhyme recognition, syllable counting, initial-phoneme matching, initial phoneme deletion, phoneme blending and phoneme counting were administered. In the rhyme recognition task, children were presented a set of pictures, of which one was used as a target picture. They were to select the picture depicting a word which rhymed with the word on the target picture. The syllable counting task consisted of 16 items. Children were presented a picture for each item in the test and were asked to count the number of syllables in the word and mark each syllable by a pencil stroke. In the initial-phoneme matching, children were presented with a row of three pictures. They were asked to select the picture in the row which has the same initial sound with the one pronounced by the experimenter. The task of deletion of initial phoneme required children to select a picture among three alternatives and to match it with the word pronounced by the experimenter when the first sound of this word was deleted. In the phoneme blending task, children were asked to select a picture in the row of three pictures that concorded with the word that the experimenter pronounced in the form of a sequence of isolated phonemes. The phoneme-counting test required children to segment words into phonemes. Each word was presented with an unambiguous picture. The results of Høien et al.'s study were quite interesting. The maximum score and mean belonged to the task of syllable counting whereas the minimum score and mean belonged to phoneme counting. Furthermore, the results of a principal components analysis using Varimax rotation yielded three factors on which different constructs of phonological awareness were loaded. In their conclusion, they recognized a phoneme factor occupying

38.6% of the variance, a syllable factor occupying 17.6% of the variance, and a rhyme factor occupying a small portion of the variance (0.94). Relatedly, in their second successive study, Høien et al. (1995) examined the differential validity of different levels of phonological awareness as predictors of early word recognition. A total of 1509 Norwegian first graders (799 girls and 710 boys) were included in the study. With the exceptions of some modifications and additions, the tests used for this group of children were the same as the tests used for preschoolers in their first study. Additionally, two tests of word reading, i.e., word-picture matching and picture-word matching, were given to first-school children. As in the first study, the highest correlations were observed among phoneme awareness tests. The rotated loadings revealed exactly three factors on which the six tests of phonological awareness were loaded. A principal components analysis of the two word reading tests indicated that both tests were included in a common component. The results of multiple regression further demonstrated that the three components of phonological awareness (i.e., rhymes, syllables and phonemes) were separate predictors of early word decoding ability.

Yopp (1988) examined the factorial structure, reliability and predictive validity of tests that have been used to operationalize phoneme awareness. Subjects, ninety-six kindergarten children, were administered 10 tests of phoneme awareness. These tests were: a) the auditory discrimination test of Wepman (1973), b) the phoneme blending test of Rosewell-Chall (1959), c) phoneme counting tests of Liberman et al. (1974), d) the phoneme deletion test of Bruce (1964), e) the phoneme deletion test of Rosner (1975), f) the phoneme segmentation of Goldstein (1974), g) a phoneme segmentation test (Yopp-Singer), h) a rhyming test (Yopp), i) a sound isolation test (Yopp modification of Wallach and Wallach's 1976) and, j) a word-to-word matching test (Yopp modification of Wallach and Wallach's 1976). A learning test was also added to phoneme awareness measures which assessed children's ability to use sound-symbol association to decode printed words. The tests of phoneme awareness were given to each child in no predetermined order. The learning test was given after other tests were completed. Reliability of the tests varied from .58 for the Yopp modification of Wallach and

Wallach's (1976) word-to-word matching test, to .96 for the Rosewell-Chall's (1959) phoneme blending test. A principal factor analysis with Oblique rotation revealed three factors, of which the first had an eigenvalue above 1 and the two others below 1. Since the second factor predicted 9.5% of the variance, Yopp adopted a two-factor solution suggested by Cattell (1966). A stepwise regression analysis was further conducted with the scores on the learning test as the criterion variable and the 10 tests of phoneme awareness as predictors. The results revealed that two tests (i.e., the Yopp modification of the sound isolation test and the phoneme deletion test) significantly explained a total of 62% of the variance.

Although there is substantial agreement regarding the importance of phonological awareness, there are conflicting views as to what the relationship is likely to be between phonological awareness and reading. Whereas some studies (Morais et al. 1979, Perfetti 1985, Perfetti et al 1987, Read et al. 1986, Yopp 1988, 1992) indicate that it is reading that causes phonological awareness, others hold the view that phonological awareness precedes and causes reading (Bradley and Bryant 1983, Bryant et al. 1989, Fox and Routh 1975, Lundberg, Olofsson and Wall 1980). Still others advocate a reciprocal relationship between phonological awareness and reading (Ehri 1976, Perfetti et al. 1987, Valtin 1984).

Lack of any generalization concerning what the relationship is like between phonological awareness and reading is related to methodological problems with the studies to date. One cause for this lack of consistency may be due to the differences in the age of subjects. Another possibility may be that phonological awareness and reading measures used in different studies have widely varied in cognitive demands (Backman 1983). This makes comparisons of findings difficult (Yopp 1988) and brings about contradictory results. However, whether phonological awareness is consequential, causal or reciprocal, the fact remains is that it plays a critical role in learning to read (Ball and Blachman 1991, Goswami and Bryant 1990, Lundberg, Olofsson and Wall 1980, Olofsson and Lundberg 1983, Stanovich 1986, Tunmer and Rohl 1991, Wagner and Torgesen 1987) and to spell (Foorman and Francis 1994, Muter et al. 1997).

2.2.1.1 Summary and Implications

Following Swank (1991), it is assumed that there are two distinct but related levels in the theoretical constructs of phonological awareness: syllable awareness and phoneme awareness. Syllable awareness is knowing that words are made up of syllables. Phoneme awareness is knowing that words and syllables are made up of phonemes. A developmental progression according to age is observed across both types of awareness (e.g., Fox and Routh 1975). However, phoneme awareness is considered to be more cognitively demanding (e.g., Lundberg et al. 1984) and more predictive of later literacy achievement (e.g., Treiman 1985) than syllable awareness.

Tasks suggested in the literature to measure syllable and phoneme awareness are synthesis types of tasks (e.g., see Dreyer 1989, Rosewell-Chall 1959), analysis types of tasks (e.g., see Bruce 1964, Fox and Routh 1975, Goldstein 1974, Liberman et al. 1974, Tunmer and Nesdale 1985) and deletion types of tasks (e.g., see Bruce 1964, Catts 1991, Rosner 1975). A synthesis type of task assesses the child's ability to blend a sequence of syllables or phonemes to form a word. An analysis type of task examines the child's ability to identify the number of syllables or phonemes in a word. A deletion type of task assesses the child's ability to delete a specific syllable or phoneme from the word.

Since little has been reported in the literature about the role of phonological awareness in literacy acquisition of Persian, many questions answered in English have been left unexplored in Persian. Thus, there is an increasing need to evaluate empirically various levels of phonological awareness in the context of Persian.

2.2.2 Orthographic Knowledge

Orthographic knowledge also contributes to the ability of children to become literate (Stanovich and West 1989, Stanovich, West and Cunningham 1989). However, just as phonological awareness consists of various levels of knowledge, so does orthographic knowledge. In general, orthographic knowledge refers to the reader's primitive knowledge

about reading and spelling, e.g., what constitutes a word, a sentence and a paragraph. In particular, it refers to knowledge about letters, their sounds and spelling patterns (Henderson 1984). This knowledge can be organized hierarchically into: print awareness, alphabetic knowledge (i.e., letter-phoneme and phoneme-letter knowledge), word-specific knowledge and skilled word decoding and encoding.⁸

Print awareness is the most primitive kind of orthographic knowledge. It refers to children's awareness of rudimentary conventions of written language (Downing 1984). For example, beginning readers must acquire the understanding that words, not pictures, are what is read on a page. They must, for example, recognize that words are comprised of letters, and that words constitute sentences.⁹ In a study, Johns (1980) investigated first graders' concepts about print, as measured by Clay's (1972) Concepts About Print Test (Sand). Subjects were 60 first-grade children, evenly divided into three groups: above average readers, average readers and below average readers. Each subject was given the Sand test, a 24-item test designed to measure differences among the three groups of readers in the expected direction. A two-way factorial Anova yielded a significant main effect for type of reader. The results of the Scheffé procedure further revealed a significant difference between means at the .05 level for each of the three groups. There were no significant sex differences or interactions between type of reader and sex of subject. Further analyses of individual items on the Sand test revealed that above average readers were superior to below-average readers in print-direction concepts, letter-word concepts and advanced-print concepts.

In another study, Day et al. (1981) used the Concepts About Print test (Clay 1972) to predict later word reading ability. The test of print awareness and two measures of oral

⁸I considered skilled word decoding and encoding as the highest levels of orthographic knowledge. My rationale is that according to the present investigation the tests of reading words and orthographic choice have a high intercorrelation and discriminatory power (see 4.6). Moreover, when we talk about the act of word reading and spelling, we talk about reading and spelling of all types of words (i.e., regular, semi-regular and exceptional), which indeed includes the lower levels of orthographic knowledge.

⁹This knowledge is generally acquired by most children before they begin to attend school (Chall 1983, Clay 1979).

language were given at two different times in the year to a class of first-grade children. Knowledge about print awareness measured at the beginning of first grade appeared to greatly affect later word reading ability. A measure of oral language also had an effect. This study suggested a direct link between print awareness and subsequent word reading skill.

A second type of orthographic knowledge is letter-name and letter-sound knowledge. After basic concepts about print are acquired, children come to know the names of letters. Gaining this knowledge allows elementary decoding and encoding. It is indeed the babbling stage in reading and writing. There is partial mapping between phonemes and graphemes. For example, a single consonant may represent the whole word.¹⁰ Later on, the child begins to conceptualize the alphabetic principle that letters are used to represent sounds in words. Ultimately, the child masters enough letter-sound/sound-letter relationships to be able to decode and encode all words correctly or at least plausibly, a stage of reading called Phonetic (Gentry 1982) or Ciphering (Gough and Hillinger 1980, Juel 1994). Phonological coding is of extreme importance since it enables the reader and speller to decode and encode all words correctly or at least plausibly, even those which are not in the current lexicon (Adams 1990, Chall 1983, Gough and Hillinger 1980, Juel 1994, Treiman 1993).

Mason (1980) investigated knowledge of letters and printed words to determine if preschool children (four-year-old children) begin reading, and if so how. Two classrooms of children were observed for nine months while they attended a university operated preschool. The children's parents filled out questionnaires in which they described: a) their child's interest in, and knowledge about letters and words and, b) what role they played in helping their child learn to read. Several tests and tasks were devised to measure children's conceptual knowledge of letters and printed words and the kinds of strategies they used to learn, remember and spell words. Mason found several predictors of word reading ability at the end of the year: names letters in play, recites alphabet, prints letters and makes letters on pictures. The results

¹⁰Some children master the use of phonetic cue reading before coming to school. However, as Perfetti (1984) maintains, full mastery of the alphabetic principle requires direct instruction.

suggested a natural hierarchy of knowledge development in learning to read words.

Bradley and Bryant (1983) examined the letter-sound correspondence rule in a longitudinal study. Initially they tested 118 four-year olds and 285 five-year-old children on categorizing sounds. None of the children were able to read any word in the Schonell and Schonell reading test. Three years later, the authors gave children the standardized tests of reading and spelling. The students who were able to recognize the initial sound categorization were achieving at a higher level in reading and spelling. The design of Bradley and Bryant's project also included special training over a two year period. Sixty five students were selected from the sample and divided into four groups closely matched for age, verbal intelligence and their scores on sound categorization. Starting in the second year of the project, Groups I and II received intensive training (40 individual sessions) in categorizing sounds. Group II also received training on alphabetic letters. Group III was taught over the same period on conceptual categorization only. Group IV received no training at all. The experimental groups, Groups I and II, were ahead of the control groups, Groups III and IV, on reading and spelling. This suggested a causal relationship between sound categorization as well as reading and spelling. Additionally, Group II revealed a better performance than that of Group I in reading and spelling. On the basis of these results, Bradley and Bryant (1983) suggested that training in sound categorization is more effective when it is connected with explicit instruction in alphabet.

Results of Ehri and Wilse's (1985) study indicated that beginning readers benefit from letter-sound knowledge. They examined children's use of visual and phonetic cues when they first begin learning to read words. 50 kindergartners and 6 preschoolers from middle class were divided into three groups according to their ability to read words: 1) prereaders who could not read any words, 2) novices who could read a few words and, 3) veterans who could read several words. They were taught to read two kinds of spellings: a) simplified phonetic spellings whose letters corresponded to sounds (e.g., JRF for giraffe) and, b) visual spellings whose letters had no correspondence to sounds but were more distinctive visually (e.g., XGST

for balloon). The experimenters aimed to detect whether the three groups of subjects would find the phonetic spellings or the visual spellings easier to learn. Materials included letter-name/letter-sound knowledge, the Gray Oral Reading test (Gray 1967), word identification and memory for spellings. Subjects were shown a sheet displaying all 26 uppercase letters randomly mixed. They were to go through the set twice, naming each letter the first time and giving the sound made by each letter the second time. Subjects were also to read up to three of the easiest passages on the Gray test. They were told to read each story quickly but accurately and to remember what they read. Concerning word identification, subjects were shown 17 cards, each displaying three or four printed words and one object drawing. Two kinds of words were included: 40 preprimer and primer level words to measure subjects' word reading ability, and 12 target words to determine whether subjects could already read the words to be taught in the experiment. A paired-associate learning task was used for training and as a measure of the speed at which the letter combinations were learned. Series of one-way Anovas indicated significant differences in all analyses. Posthoc comparisons revealed that veterans and novices scored equivalently and significantly higher than prereaders on the measures of age, letter-name and letter-sound knowledge. The results of Ehri and Wilse's study supported the conclusion that novice as well as veteran beginning readers differed substantially from prereaders in the cues they attended to in learning to read words. Among prereaders, visually distinctive spellings were easier to learn. However, among beginning readers, spellings where letters correspond to sounds were easier. Ehri and Wilse's interpretation of their findings is that movement into effective word readings requires a shift from the visual stage to the phonetic stage and that this shift enables children to begin decoding their first words reliably.

The next complex type of orthographic knowledge is word-specific knowledge, referring to the understanding of spelling patterns (see Stanovich and West 1989). For example, pronouncing the word 'laugh' requires knowledge that the letter L correspond to the sound /l/, AU to /a/ and GH to /f/. Word-specific knowledge is generally measured with three types of tasks: orthographic choice tasks, homophonic choice tasks and spelling tasks (see Stanovich

and West 1989).

Orthographic choice tasks require the learner to compare two different spelling patterns which are phonetically similar, but orthographically just one of them is correct (e.g., given the words *san* and *sun*, only the latter is correct). Homophonic choice tasks tap the learner's ability to determine which of two similar sounding real words fits a clue sentence; for example, the question might be 'which one do you travel with *sheep* or *ship*?' The third type of task is spelling. The student is asked to spell words and/or nonwords. An analysis of errors not only gives insight into the reader's knowledge of rules but also generally reveals what type of strategy the learner has employed.

Several experimental studies have demonstrated that beginning readers take advantage of this type of orthographic information (e.g., see Ehri and Wilce 1987, Goswami 1988). In her study, Goswami (1988) examined three important developmental issues: a) whether beginning readers can make orthographic analogies; b) how the consistency of spelling-sound relations affects this ability and; c) whether orthographic analogies have an important role to play in reading prose. To examine whether children at the beginning stages of reading can use analogies, Experiment 1 used a word game in which children were given a 'clue' word (e.g., *beak*) as a basis for analogy, and were then given a series of new test words to try to read. The test words were either analogous to the clue word (*peak*), nonanalogous to the clue word (*rain*), or could be read by using grapheme-phoneme correspondences from the clue word (*bask*). The results of this experiment indicated that children can use analogies from the earliest stages of learning to read. This, as Goswami suggested, raises the possibility that instead of being a sophisticated strategy of skilled readers, analogy is a relatively primitive strategy most frequently used in the early stages of reading and spelling development. Experiment 2 was further designed to examine whether children could avoid making inappropriate analogies if they are given a choice of models. Children were taught to read a pair of words that varied in consistency, e.g., *peak-leak* (consistent), *peak-steak* (inconsistent), *peak-loan* (unconnected). And then analogies to new words such as *beak*, *weak* and *break* were examined. The results

indicated that children make more analogies in reading when spelling-sound relations are consistent across words, and they make fewer inappropriate analogies if given a choice of models. Goswami suggested that the results are compatible with the idea that children are aware that analogy will not always be a useful strategy to use for reading new words. In Experiment 3, a series of short stories was designed around the words used in Experiment 1 to assess children's use of analogy. According to Goswami, the rationale was that if a child comes across new words when reading a story, performance on these words will partly demonstrate the effects of context on decoding skill. However, if the child comes across the same words in a story after first being taught to read an analogous 'clue' word, performance will show the effects of both context and analogy on decoding skill. Two conditions were used in the experiment. In one, the child was given the stories to read without first being taught to read a related clue word from which analogies could be made. In the other, the child read the stories after first learning to read a clue word. The aim was to find out whether a child who learns a new word when reading a story will subsequently use knowledge of this word to decode other similar new words encountered later in the story. It was concluded that: a) analogies are used to read new words in normal prose reading; b) the effect of analogy is independent of the effect of context and; c) analogy enhances performance above the levels achieved by using context alone. Overall, Goswami's (1988) three experiments revealed that analogy is a very important developmental strategy in decoding new words and is not simply characteristics of skilled readers.

Correlational studies using invented spelling have demonstrated some support for a direct influence of spelling-pattern knowledge on word reading development (e.g., Mann, Tobin and Wilson 1987, Morris and Perney 1984). In a study, Morris and Perney (1984) investigated whether spelling predicts later reading achievement. Subjects were seventy-five first graders from four classrooms in two elementary schools. They were tested at three points during the school year: September, January and May. In September, subjects were administered an 18-word spelling test. In January, the same spelling test was again administered to all

subjects. May testing consisted of two reading achievement tests, one an informal word recognition test provided by the authors, and one the Metropolitan Achievement test (Durost et al. 1970). The results indicated reliable correlations between invented spelling performance at the beginning of first grade and reading achievement at the end of the year in all the classrooms that the researchers studied. Similarly, Mann, Tobin and Wilson (1987) reported significant correlations between kindergartners' invented spelling performance and first grade reading performance on word identification and word attack. However, some other researchers (e.g., Frith 1980, 1985) argued for a dissociation between reading and spelling and suggested that predicting one's spelling on the basis of reading is not very accurate. Frith (1980) reasoned that readers tend to read either 'by eye' or 'by ear'. Those who read 'by ear' use partial cues for reading since they sample minimal cues by a visual-spatial approach. For example, they may attend to the first letter of the word and its general length. To Frith (1980), though reading 'by eye' is economical, it would provide less opportunity for acquiring knowledge of potential orthographic information. On the other hand, individuals who read 'by ear' use full cues and employ a redundant strategy. That is, they make use of many elements in a word which are not essential to the recognition of the word. Frith's (1980) study indicated that poor spellers do not utilize a full cue strategy and; consequently, they deprive themselves of knowledge of the underlying spelling system.

A number of researchers have studied the development of reading and spelling (e.g., Knight and Fischer 1992, Sprenger-Charolles and Casalis 1995, Stage and Wagner 1992). Sprenger-Charolles and Casalis (1995) investigated the development of reading and spelling in French first graders. 40 first graders were tested twice in their first year of primary school, in February and in June. In Experiment 1, a list of 60 words was chosen from three categories: simple regular words, complex regular words and irregular words. Each child was asked to read each word in the list aloud when it appeared on the computer monitor. An analysis of variance was conducted on three factors: session (i.e., first and second), frequency (i.e., high or low) and regularity (i.e., simple regular words, complex regular words and irregular words).

Under the assumption that alphabetic processing is letter by letter, a complexity effect was predicted. The results indicated that: a) simple and complex words were read more accurately than irregular ones; b) high-frequent words were read more accurately than low-frequent ones; c) complex words were read less well than simplexes and; d) first graders' lexical skill was doubled in the space of four months. In Experiment 2, the mode of processing used for complex graphemes and irregular words was reexamined. The word list used in Experiment 2 contained 24 items from three categories: simple regular words, complex regular words and irregular words. This word list was simpler than the one used in Experiment 1 since it included simpler graphemes and irregularities affecting the final consonant were dropped. The same children participated in the second experiment and they were tested in February and June. The results of Experiment 2 indicated that regular words were read more accurately than irregular words, and that high-frequent words were read more accurately than low-frequent ones. Similarly, spelling was examined in two experiments, each was administered in February and June. In Experiment 1, the spelling list contained 24 selected words used in the first experiment. The results indicated a significant progression in spelling from February to June. In Experiment 2, the spelling list was identical to the reading list used in the second experiment. A sharp development was observed in spelling between February and June. As was the case in the two reading experiments, there was a regularity effect for the two spelling experiments. Simple regular words and complex regular words were spelled more accurately than irregular ones. The hypothesis of strict reliance on alphabetic strategy was not confirmed since a frequency effect was observed in both reading and spelling. Error analysis further revealed a high correlation between correct responses in reading and in spelling in the February session as well as in the June session.

Stage and Wagner (1992) attempted to investigate the development of young children's phonological and orthographic knowledge as revealed by their spellings. Subjects were 187 children, 45 each from kindergarten, Grade one and Grade two, and 52 from Grade three. Materials included a spelling task, the sound categorization task of Bradley and Bryant (1985),

the letter span task of Shankweiler et al. (1979), word-level decoding tasks of Woodcock (1973), and the general cognitive ability of Wechsler (1974). The spelling task consisted of 22 pronounceable nonwords that contained 37 different phonemes of the English language. The Bradley and Bryant's sound categorization task involved listening to sets of three and four words, of which all but one of the words in each set had a sound in common. Liberman et al.'s letter span task involved recalling orally presented strings of phonological nonconfusable letters. The word decoding tasks included word identification and word attack. To assess general cognitive ability, the vocabulary and block designs of the Wechsler Intelligence Scale test were used. In these tests, children were required to provide definitions for vocabulary words and to arrange blocks so as to match a target design. All subjects were also assigned to the spelling task. A subsample of 30 first-grade, 29 second-grade and 31 third-grade children randomly selected and were administered individually the word decoding, general cognitive ability, sound categorization and letter span tasks. The results of statistical analyses indicated: a) satisfactory internal consistency for all tasks for all grades; b) young children's nonword spelling reflects developmentally orthographic and phonological knowledge as well as working memory limitations; c) for younger children, individual differences in phonological awareness and working memory explained almost all of the shared variance between spelling and decoding and; d) for older children, spelling was less linked with efficiency of coding in working memory.

Whether groups of normal and below average readers employ different developmental sequences of skills in reading single words is evident in the study of Knight and Fischer (1992). The authors employed a total of 120 first-, second- and third-grade students, 30 of whom (8 first graders, 13 second graders and 9 third graders) were low-level readers whose reading levels were below average in comparison to others in the same grade. Tasks included word definition, letter identification, rhyme recognition, rhyme production, reading recognition and reading production. In word definition, the child was to produce a verbal definition for a word or indicate its meaning. If the child failed in the task of verbal definition, s/he was given picture definition in which the picture of an object was presented and the child was asked to name the

object and define it. The letter identification task required the child to name the composing letters of the word when it was presented visually. While in the rhyme recognition task the child was to select from four orally presented words the one that rhymed with the stimulus word, in the rhyme production task the child was to verbally produce a word that rhymed with the stimulus. Similarly, in reading recognition the child matched a printed word to an appropriate picture, whereas in reading production the child orally read a word without prompting. All children were assigned individually to the six tasks. The results indicated three different developmental sequences in the acquisition of reading skills: a) the normal sequence in which the visual-graphic and phonological domains are integrated in the course of reading acquisition; b) the read and rhyme independent sequence in which sound-analysis skills are independent of reading and; c) the read, rhyme and letter identification independent sequence in which the greatest lack of integration of skills existed in different domains. The normal sequence was associated with good readers. However, the last sequence characterized poor readers since they showed general deficiencies in rhyming and letter-identification skills with lack of integration of rhyming, reading and letter identification.

At the top of the hierarchy of orthographic knowledge is skilled word decoding and encoding. Attainment of automaticity and efficiency is vital in the processes of reading and spelling (see Jorm and Share 1983, Perfetti 1985). An important step to attain automaticity is to reduce the attentional demands made by preliminary processes (Curtis 1980). Using a variety of tasks involving single-grapheme and multiple-grapheme stimuli, Doehring (1976) found a consistent decrease by grade level in matching and oral-reading latencies.

Speed of naming pseudowords¹¹ is a reliable task that differentiates good from poor readers (Baron and Strawson 1976, Perfetti and Hogaboam 1975, Seidenberg et al. 1984), and beginning from skilled readers (Curtis 1980). In a study, Curtis (1980) assessed the speed of

¹¹Pseudowords are nonsense words which conform to sound patterns of the language. The use of the pseudowords technique has been widely employed by investigators in the area of reading (Manis 1985, Siegel 1985, 1986). Pseudowords are particularly informative because they are basically pronounced by recording the letter string into a phonological form.

vocalization in skilled and less skilled readers. She compared five groups of students: second-, third- and fifth-grade skilled readers and third- and fifth-grade less skilled readers in the tasks of reading and listening comprehension, memory span, matching and vocalization. Among other results, the study indicated that: a) fifth graders were significantly faster at letter naming than other groups; b) skilled fifth-grade readers recalled more than other groups in the memory span; c) for word and pseudoword naming, skilled fifth graders performed significantly better than all other groups and; d) the speed in processing printed stimuli increased at successive grade levels.

2.2.2.1 Summary and Implications

Orthographic knowledge is a multi-level competence. It is an awareness of the orthographic structure of one's language (Henderson 1984) starting with primitive literacy knowledge and ending with skilled word decoding and encoding. More specifically, orthographic knowledge consists of print awareness, alphabetic knowledge (letter-phoneme/phoneme-letter knowledge), word-specific knowledge as well as skilled word reading and spelling. Results of different studies (e.g., see Day, Spicola and Griffen 1981, Mason 1980, Mann, Tabin and Wilson 1987) indicate that lower levels of orthographic knowledge intercorrelated with higher levels.

Different measures are used to examine various levels of orthographic knowledge. They include the print awareness task (e.g., see Clay 1972), the alphabetic knowledge task (e.g., see Woodcock 1987, Clay 1985), orthographic choice and homophonic choice tasks (e.g., see Stanovich and West 1989) as well as word spelling, word recognition and word attack tasks (e.g., see Calfee and Calfee 1981, Schonell and Schonell 1950, Wimmer, Landerl and Schneider 1994, Woodcock 1987).

Since "an orthography is not a theory of language but a theory of a language" (Veltman 1992), one cannot generalize all aspects of literacy from one language to the other. Therefore, it might be the case that every language has its own particularities that may affect the development and acquisition of orthographic knowledge. Since Persian has its own particular

characteristics (see Section 2.3), it is worth investigating whether there exists a developmental pattern in the acquisition of orthographic knowledge and whether lower levels of orthographic knowledge are linked to reading and spelling ability.

2.2.3 Working Memory

Working memory is one of the primary skills involved in literacy acquisition¹² (see Perfetti 1985, Wagner and Torgesen 1987). Its role in reading is primarily to hold phonological information for short-term periods of time¹³ while performing other mental tasks (Baddeley 1986, 1990).¹⁴ Essentially, a reader engaged in decoding and/or encoding words must maintain the phonological code¹⁵ or sound-based representation of phonemes or syllables in memory

¹²Working memory is also critical in the higher-level processes of reasoning, problem solving and language understanding (e.g., Baddeley 1986, Baddeley and Hitch 1974, Just and Carpenter 1992).

¹³One of the important features of working memory is its limited capacity in the amount of information and the period on which information is held (e.g., Atkinson and Shiffrin 1968, Baddeley 1986, Broadbent 1958, Just and Carpenter 1992, Waugh and Norman 1965, Turner and Engle 1989). But this limited capacity of working memory seems to be vast enough to allow us to carry out cognitive tasks (Baddeley 1986, 1990, Jorm 1983). For example, we are able to retain an unfamiliar telephone number in memory long enough to dial it. But if the number include more than 8 digits the task would become very difficult.

¹⁴According to Baddeley and colleagues (e.g., Baddeley 1979, 1986, 1992, Baddeley and Lieberman 1980, Hitch and Baddeley 1976, also see Brainerd and Kingma 1987, Glenberg 1997) working memory consists of three major interrelated components: a) a central executive, b) a visuo-spatial sketch and, c) a phonological articulatory loop system. The central executive controls attentional system and the visuo-spatial sketch maintains visuo-spatial materials. The phonological articulatory loop known as phonological store hold information in a phonological code. Consequently, it is prone to phonological confusions, i.e., confusions resulting from similar-sound items. For instance, if a Persian child attempts the sequence of the phonemes /r/, /l/, /b/, /č/ and /k/, s/he might recall it as /r/, /l/, /p/, /j/ and /k/, since voicing is the only feature that distinguishes /b/ from /p/ and /č/ from /j/. However, as the inputs decay so rapidly, the 'articulatory rehearsal loop' is used to recycle the material back into the phonological store. This process ('rehearsal'), if repeated continually, supplies the materials to be stored permanently in long-term memory.

¹⁵To explain the concept of a code in working memory, Jorm (1983) compares the human memory system to a tape recorder since both share one broad similarity. He explains that what a tape recorder does when recording speech is converting vibrations in the air (which are speech sounds) into a form of magnetic code on the tape. When the tape is played back, these magnetic codes are converted to speech sounds. Similarly, the human memory system does not store actual sounds, but uses codes which are internal representations of sounds (Jorm 1983).

long enough to process the whole word. Liberman, Mattingly and Turvey (1972) suggested that the processing of either spoken or written language would demand an ability to store verbal material efficiently in working memory. Following the same line of research, Shankweiler et al. (1979) hypothesized that children who learn to read with facility differ from those who read with difficulty in the extent to which they rely on sound-based processes in working memory.

At present, the degree to which phonological awareness, decoding and encoding relies on working memory is not so clear. As a matter of fact, the empirical evidence is presently inconclusive and even contradictory. One sort of contradiction relates to the possible relationship between working memory and reading skills. While some studies (e.g., Johnston 1982, Mann 1984, Mann and Liberman 1994, Share et al. 1984, Wagner et al. 1987) report significant correlations between working memory and some components of reading ability, others claim a minimal/no significant correlation (e.g., Bradley and Bryant 1983, 1985, Rack 1985). Another sort of contradiction concerns the sources of poor memory in reading disabled individuals. Some investigators (e.g., Bauer 1987, Bauer and Emhert 1984, Dallego and Moely 1980, Torgesen, Murphy and Ivey 1979, Wong, Wong and Foth 1977, also see Daneman and Carpenter 1980) attribute the memory problems of readers with reading disabilities to a failure to use effective coding strategies. On the other hand, other investigators attribute such deficits to attention, concentration, organization, task persistence and/or retrieval (e.g., Freidman, Cancelli and Yoshida 1988, Keogh and Margolois 1976, Torgesen 1977, Worden 1986). Still others argue that poor memory of readers with reading disabilities reflects difficulties in storage and coding of verbal information (e.g., Baker, Ceci and Herrmann 1987, Brainerd, Kingma and Howe 1986, Swanson 1984, 1986, also see Just and Carpenter 1992). These two sorts of contradiction may have some relation to the fact that phonological recording in working memory does not have a wide literature addressing its impact on reading skills (see Wagner and Torgesen 1987).

Saunders (1931) was among the first to investigate the link between working memory

and reading. Reporting on four students with normal intelligence but poor spans, Saunders (1931) argued that an inadequate auditory memory span resulted in difficulty with reading and spelling. She then stated that the child with a short auditory span disability found it difficult to meet the requirements of his first grade. Although Saunders (1931) did not conclude that the short auditory span was responsible for many of the reading and spelling difficulties found among children, she did state that "all poor memory spans are allied with difficulty in reading and spelling" (p. 64).

Rizzo (1939) examined the interrelationships between the auditory span and visual span as well as the relationships between these constructs and reading ability (i.e., comprehension and speed in silent reading). Subjects were 310 students from Grades two, three, four, five, six and eight. The students were classified by chronological age, by mental age and by grade placement. Memory was measured by three types of memory span: the Auditory span, Temporal visual span and Tachistoscopic visual span. Rizzo found that: a) the correlation between the Auditory and Temporal visual tests revealed the highest coefficient; b) all tests of memory span were reliable; c) the highest scores in memory span belonged to the Temporal visual span test; d) the lowest memory span scores occurred consistently with the Tachistoscopic visual test; e) growth in memory span was observed throughout the mental age of 21 years; f) the maximum in memory span development seemed to reach at the 18th years of chronological age; g) the intercorrelations between scores on memory span tests and reading measures were low but significant; h) the intercorrelations between memory span scores and reading ability were not sufficiently large to allow a prediction of reading achievement on the basis of memory span scores and; i) in extreme cases of serious retardation in reading achievement, limited memory span ability might be an important contributing factor, especially with younger subjects.

In a study, Spring (1976) tested the hypothesis that memory impairment in dyslexic children is due to slow speech-motor encoding. Subjects were two groups of dyslexic and normal readers ranging in age from 6 to 12 years. Tasks included digit naming, colour naming,

picture naming and digit span. In the first three tasks, subjects were required to name 50 randomly selected digits, 30 colour patches and 25 tinted-line drawings. In digit span, subjects were asked to repeat a series of orally presented digits as fast as possible. Subjects were tested individually on identical tasks in a fixed order. The results indicated that: a) dyslexic children were significantly slower than normal children conflicting the major hypothesis; b) younger children were significantly slower than older children; c) performance on concrete stimuli (i.e., colours and pictures) was significantly slower than performance on verbal stimuli (i.e., digit span); d) digit naming speed and digit span commonly accounted for a large portion of the variance in reading ability and; e) each of the independent variables unequally explained a small but significant portion of the variance in reading ability.

Gathercole and Adams (1993) investigated the nature of working memory skills in children below 4 years of age. Initially a total of 111 children took part in the study. However, only 54 children, ranging in age between 2 years 10 months and 3 years 1 month, completed all tasks. The researcher assigned each child to a battery of tests in order to tap the range of intellectual skills that may influence their performance on phonological working memory tests. Measures of phonological memory included tests of digit span, nonword repetition and word repetition. The tasks tapped out the child's cognitive skills were articulation rate, vocabulary, number identification and nonverbal skills. To measure articulation rate, the researchers asked the child to repeat as quickly as possible the words *cat* and *nose*. Vocabulary was measured by giving each child the Short Form of the British Vocabulary Scale (Dunn and Dunn 1981). The child was asked to point to the picture (of a set of four) which corresponded to a word spoken by the examiner. A series of cards numbered from 1-10 were randomly presented to the child to name the number. Each child was also required to assemble a series of six puzzles to form pictures of familiar objects such as animals. The results indicated that: a) measures of digit span, nonword repetition and word repetition were significantly intercorrelated with one another; b) a common phonological memory factor underpinned measures of digit span, nonword repetition and word repetition and; c) word and nonword measures appeared to have

additional links with other cognitive skills. The researchers concluded that phonological memory skills can reliably and readily be assessed in children as young as 2 years of age.

Wagner et al. (1987) described that phonological awareness is related to working memory because it requires the use of an efficient code in memory. They administered five phonological awareness tasks, three working memory tasks, four phonological retrieval tasks, five cognitive ability tasks and a standard decoding task to 184 kindergartners and second-grade students. Their results revealed that efficiency in working memory affects performance on word recognition and phonological awareness tasks. Some other researchers (e.g., Mann and Liberman 1984) also obtained a moderate correlation between a simple phonological awareness measure (syllable counting) and a memory span test for rhyming and nonrhyming word lists.

Mishra and Sahu (1992) examined the relationship between working memory capacity and reading proficiency of fluent oral Oriya readers. Oriya is a shallow orthography in which grapheme-phoneme correspondences are highly consistent. It contains 47 characters and several symbolic markers that slightly change the phonetic representation of basic consonants. Subjects (70 grade-five children) were administered verbal and nonverbal tests of working memory. They also completed oral reading and cloze tests to measure reading comprehension. There was a high correlation between working memory and reading comprehension measures. The group with high working memory performed significantly higher than the low working memory group on the oral reading task as well as the cloze task. The findings revealed that working memory capacity facilitates decoding and comprehension with the alphabetic-syllabic type of phonetic orthography found in Oriya.

In their study, Swanson and Ramalgia (1992) attempted to determine whether children with and without reading disabilities vary in their degree of dependency on phonological information in memory and spelling performance. The extent of the correlation between phonological information required for memory and spelling performance was investigated with 31 thirteen-year-old subjects with reading disabilities and 32 younger average readers. The

memory tasks included two word lists of 12 words constructed for each type of encoding condition: a) phonetically dissimilar, consonant similar and, b) rhyme. One word list from each encoding condition was randomly assigned to the auditory or visual presentation. Within each word list, words in the same category or word family were organized sequentially. After the presentation of each recall task, subjects were presented a word recognition task in which the words from the recall task and distractor words were combined and subjects were to identify words presented for the recall task. Error analysis was employed to examine spelling performance. Errors were categorized into semiphonetic (letter names represent sounds in a word, e.g., 'lidl' for 'little'), phonetic (sound that is represented by a letter, e.g., 'lessen' for 'lesson'), and morphemic (a spelling rule related to a morpheme, e.g., 'sead' for 'seed'). The results indicated that children with reading disabilities (who were comparable in reading and spelling to normal younger children) exhibit normal recall effects concerning phonological similarity. Moreover, both groups of children rely on phonological processing during spelling, but the degree of reliance is associated with their spelling ability.

In a two-year longitudinal study, Rohl and Pratt (1995) examined the relationship between phonological awareness, verbal working memory and the development of reading and spelling. The initial sample consisted of 83 children (46 boys and 37 girls) from five classes in three schools in lower-middle-class areas of Perth, Western Australia. (The number of subjects decreased to 79 students at the second testing time at the end of Grade one.) At the start of testing, children had a chronological age of 5 years and 8 months. They were not able to read words recognized by the Ready-to-Read Word Test (Clay 1985). Experimental tests included: a) 3 verbal working memory tests (memory for letter test, memory for word test, memory for sentence test), b) 3 phonological awareness tests (a sound categorization test, a phoneme segmentation test and a phoneme deletion test), c) 5 tests of reading and spelling (Neale 1988), the real word decoding test (a subtest of Calfee and Calfee 1981), a pseudoword decoding test, the real word spelling test of Schonell and Schonell (1950), a pseudoword spelling test and, d) the Peabody Picture Vocabulary Test of Dunn and Dunn (1981). The researchers administered

the first phase of testing in the first 5 weeks of school year before the effects of reading instruction could confound the results. Children were tested individually. The tests administered in this phase were: the Peabody Picture Vocabulary Test, the letter, word and sentence memory tests as well as the sound categorization and phoneme segmentation tests. The second phase was readministered 9 months later, at the end of Grade one. Subjects were given the tests of letter, word and sentence memory, the tests of sound categorization, phoneme segmentation and phoneme deletion, and the tests of reading and spelling. After another 9 months, the final testing time took place at the beginning of the second semester of Grade two. Subjects were assigned to all three verbal working memory tests and reading and spelling measures. The results of the factor analyses from the three testing times consistently loaded the three working memory tests on two distinct but highly related factors. Multiple regression analyses further revealed that phonological awareness predicted composite reading and spelling. However, with 4 individual reading measures and 2 individual spelling measures as dependent variables, it was demonstrated that phonological awareness was not quite a consistent predictor of reading and spelling. While it was highly related to reading pseudowords and spelling real words, it was not highly related to spelling pseudowords. Given the importance of verbal working memory for the completion of phonological awareness, reading and spelling tasks (particularly spelling pseudowords), Rohl and Pratt (1995) concluded that their findings lent support to two theoretical views: the view that both phonological awareness and working memory contribute to the early stages of literacy acquisition, and the view that as children progress in reading and writing, the constructs of verbal working memory and phonological awareness become more differentiated.

In contrast to these findings, Mann (1984) examined the relationship between phoneme reversal and word string memory tasks. The tasks were found to be minimally correlated. Similarly, Share et al. (1984) failed to find a significant interaction between phoneme segmentation tests and sentence memory.

Assessment of these conflicting results is not a simple task. A possible approach for

examining the sources of differences in the relationship between working memory and literacy components could consist of examining the experimental characteristics of the related studies. Johnston (1982) has suggested that the discrepancy among studies may be due to differences in the age of subjects. Another explanation related to varying views may be that researchers have used different tasks for examining working memory, reading and spelling. Alternatively, the variety of tasks reflects varying cognitive demands, possibly bringing about contradictory results.

2.2.3.1 Summary and Implications

Working memory is also considered to be particularly vital in the beginning stages of literacy when the child has not reached an automatic level of word recognition (Perfetti 1985). The role of working memory in reading primarily is to retain phonological information long enough to be able to process language units (Baddeley 1966, 1979, 1982, 1986, Hitch and Baddeley 1976). Basically, there are numerous ways addressed in the literature to measure working memory. The most common measure is simple memory span (see Baddeley and Lewis 1981, Brady, Shankweiler, and Mann 1983, Mann and Liberman 1984, Siegel and Ryan 1989). Memory span measures “the ability of an individual to reproduce immediately, after presentation, a series of discrete stimuli in their original order. Practically any sort of material may be presented, such as digits, letters, words and sounds . . .” (Blankenship 1939:13). Memory span is measured by different tests using various linguistic and nonlinguistic units. Among other types, these tests include digit span (e.g., see Koppitz 1975, 1977, Spring 1976), letter span (e.g., see Rizzo 1939, Brady, Mann and Schmidt 1987, Rohl and Pratt 1995), syllable span (e.g., see Dreyer 1989) and word span (e.g., see Brady, Shankweiler and Mann 1983, Bryan 1972, Rohl and Pratt 1995).

It has been found that poor memory spans are allied with difficulty in reading and spelling (Saunders 1931, Shankweiler et al. 1979), and that poor readers recall less information from memory tasks than good readers (Share et al. 1984, Wagner and Torgesen 1987).

However, because of the inconsistencies in the literature, the possible relation between these components remains unclear. While some studies (e.g., Wagner et al. 1987, Mann and Liberman 1984) report a significant correlation between working memory and some components of reading ability, others claim minimal or no significant correlation (e.g., Rack 1985, Share et al. 1984). Thus, due to lack of agreement in the role of working memory in literacy acquisition, it seems that a study involving a language which has not been widely studied, e.g., Persian, could yield interesting results.

2.3 Persian Orthography

2.3.0 Background

A crucial factor in reading and spelling of various orthographies is the extent to which the graphemic/spoken form can be systematically converted into the spoken/graphemic representation. In Persian, the mapping of phonemes to graphemes is almost complete. In a slightly different state of affairs is Serbo-Croatian. The relation between phonemes and graphemes is isomorphically complete. Each grapheme represents only one phoneme and each phoneme is represented by only one grapheme. Moreover, all phonemes in the spoken word are reflected in the spelled word. A totally different situation exists in English, a language which is highly opaque in the correspondence between phonemes and graphemes.¹⁶ According to the Orthographic Depth Hypothesis (Frost, Katz and Bentin 1987, Katz and Frost 1992), both phonological and orthographic codings are available in all orthographies, but phonological coding makes more of a contribution to word recognition in reading shallow orthographies than in reading deep orthographies. In contrast, orthographic (visual) coding is probably more important in deep orthographies (Lyytinen et al. 1995). The core idea is that deep orthographies contain a large number of irregular words. To read such words readers must use a direct access strategy, using knowledge directly from the lexicon since there is no way to

¹⁶Many people (e.g., Chomsky and Halle 1968, Veltman 1992) argue that in addition to phonemes, English orthography represents morphemes, words and phonetic features.

correctly pronounce such words using the grapheme to phoneme correspondence rule (Olson et al. 1985).

Although Persian does not show the multi-linguistic function and the quasi-regular system as English does (see Veltman 1992, Seidenberg and McClelland 1989), it reflects some degree of irregularities. The Persian script is not always consistent as Balouch and Shahidi (1991) as well as Balouch and Besner (1991) suggest. It reflects some degree of inconsistency in terms of homophones, homographs, silent letters, the length symbol and the relationship between spoken and written language. Relatedly, the possible relations between phonemes and graphemes in Persian are of either the one-to-one (e.g., /b/ is represented by the only grapheme ب, one to two (e.g., /n/ plausibly can be shown as ن and [ـن]), or one-to-many (e.g., /s/ is graphemically shown as س, ص and ث). It may then be followed that reliance on phonological skills may not always result in correct reading and spelling in Persian. Instead, some lexical knowledge may be functional. In what follows we look more closely at the characteristics of Persian orthography.

2.3.1 Characteristics of Persian Orthography

2.3.1.1 Diacritic Vowels

Like Arabic, the Persian script is substantially consonantal. All thirty-two letters of the alphabet are primarily used as consonants though three of them have secondary roles as long vowels.¹⁷ There are three diacritic marks¹⁸ which also stand for short vowels. Vowel indication in Persian is therefore accomplished by six vowels falling into two subsets: a) short vowels /a/, /e/, /o/

¹⁷As in the case of Hebrew readers (see Shimron 1993), it is sometimes difficult for readers in Persian to determine whether the dual-function graphemes represent a vowel or a consonant.

¹⁸Of course, diacritics also include the grammatical sign, Tanvin [ـ], and the length symbol, Tasdid [ـ:]. The length symbol stands above a letter and indicates that the letter is read twice (e.g., نجتار /nadjâr/). Tanvin which is the result of the interference of Arabic to Persian is usually placed above some nouns and changes them into adverbs. It is read as /n/ but never written by the conventional grapheme 'ن'. For example, روحاً /rouhan/ consists of the noun /rouh/ and Tanvin /-an/.

and, b) long vowels /â/, /î/, /u/. Two of the short vowels, /a/ and /o/, are superscribed and the other one is subscribed (i.e., inserted below the letter). It should be noted that except for the purposes of teaching and learning at the beginning stages of learning literacy, Persian writers do not ordinarily provide the reader with any short vowels at all.¹⁹

Because they are not part of the script, short vowels are omitted in writing. Omission of short vowels might seem strange since, in Persian, as in other languages, many words consist of similar sequences of letters with different meanings. In such cases where contrasts are not recorded orthographically, context to a very large extent provides necessary cues for the reader to differentiate between words. However, as Kavanagh and Venezky (1980) argue, for Semitic languages, the consonant writing system probably does not pose as many problems as it does for various Indo-European languages which have adopted the consonant system from the purely Semitic languages. This is certainly true because Semitic language roots are characterized by their consonant schemes and vowels serve mostly as grammatical markers. In other words, the linguistic contrasts made by vowels are, to a large degree, grammatical rather than lexical. Cases where distinct lexical items differ only in vowels are by no means absent. In particular, many nouns are formed independently of consonants and possess intrinsic short vowels, that is, vowels which are not reflected in the written form. Thus we can find sets of Persian words which are identical orthographically but different phonologically. For instance, the string گرد <grd> can be read in three different ways (i.e., گرد /gard/ 'dust', گرد /gerd/ 'round', گرد /gord/ 'champion') depending on the vowel assignment the reader makes.

So Persian is an orthography in which all diacritic vowels are omitted.²⁰ These diacritics represent half of the vowels and also disambiguate the strings of consonants. Nevertheless, writing without diacritics is often sufficient to indicate the exact intended meaning if it is supported by context. A question of interest is how vowel marks are processed by skilled and

¹⁹All schools in Iran adopt a method of teaching where vowel signs are used at the initial stages of reading and spelling acquisition. Indeed the basic benefit from this is to enhance children's phoneme awareness.

²⁰Indeed, the omission of short vowels makes Persian somehow a deep orthography.

unskilled readers in Persian.²¹ Here we may refer to Koriat (1984), Aburabia (1997) as well as Balouch and Shahidi (1999). Koriat (1984) examined lexical decision latencies for pointed and unpointed letter strings. He used Hebrew words that had only one meaningful pronunciation in their pointed form, and found almost identical lexical decision latencies for pointed and unpointed words. The results revealed that the presentation of vowel marks positively affected lexical decisions. The advantage of pointed print was larger for low-frequency words than for high-frequency words, suggesting that the use of phonology is more prevalent for infrequent words. Similarly, Aburabia (1997) investigated the effect of vowels and context on the reading accuracy of poor and skilled native Arabic readers in reading words, sentences and paragraphs. Subjects were 77 Arabic speakers, of whom 34 poor readers and 44 normal/skilled readers. They were to read in Arabic 210 words, 60 sentences and 15 paragraphs in three conditions: fully vowelized, partially vowelized and unvowelized. The results indicated that vowels and context facilitate word recognition in poor and normal/skilled readers. Relatedly, in their experiment, Balouch and Shahidi (1991) selected 30 transparent words (i.e., words that contained long vowels), and 30 opaque words, i.e., words of which diacritics were omitted (also see Khanlari 1979). These words were given to 10 Iranian beginning readers with a mean age of 8.4 years to read aloud. The experiment revealed that beginners in Persian performed more accurately on reading transparent words than reading opaque words. They suggested that beginners engage more in phonological coding for word recognition.

Presumably, without the aid of diacritics, beginners in Persian would have to rely on either the holistic identification of consonant clusters and their correspondence to spoken words or on the contextual clues as Hebrew readers would (see Ben-dror, Bentin and Frost 1995). The reader who uses contextual clues would recognize the ambiguity of unvowelized words more rapidly. However, note that the use of contextual clues requires some level of proficiency, in the first place. If the reader's skill does not reach that threshold, s/he cannot

²¹At this point it should be mentioned that from the end of first grade children are exposed to unvowelized print and by the third grade they encounter unvowelized print almost exclusively.

benefit from contextual cues.

2.3.1.2 Dots

In the writing system of Persian, dots are used to differentiate letters which have similar shapes.²² So all letters are distinguished from one another by the number and positions of dots, or their absence. Additionally, phonemic similarities, i.e., the manner of articulation, the place of articulation and/or voicing are highly significant among similar-shape letters. In (1a) and (1b), voicing is the only distinctive feature between /b/ and /p/. Similarly, /č/ and /j/, are identical in the place and manner of articulation but not in voicing. Thus if we change the feature specification for voicing in /b/ or /p/ (and similarly, in /č/ or /j/), a different sound segment results.

- (1) a. ب /b/: voiced, bilabial, stop
 b. پ /p/: voiceless, bilabial, stop
 c. چ /č/: voiceless, alveoplatal, affricate
 d. ج /j/: voiced, alveoplatal, affricate

In (2a) and (2b), the primary distinction between /s/ and /š/ is the place of articulation. By assigning three dots, the place of articulation is changed from alveolar to alveoplatal. Similarly, /h/ and /x/ are identical in all features except for the place of articulation.

- (2) a. س /s/: voiceless, alveolar, fricative.
 b. ش /š/: voiceless, alveoplatal, fricative.
 c. ح /h/: voiceless, glottal, fricative
 d. خ /x/: voiceless, post-velar, fricative

The distinctive features due to the assignment of dots signal a difference in phoneme

²²Comparing Persian and Roman letters, one can see that Persian alphabetic letters are much less redundant than Roman's. Indeed Persian has only sixteen shapes to represent thirty-two letters. Thus only the presence or absence of a single dot above or below a standard character shape distinguishes among the letters.

as well as in meaning (e.g., حک /hak/ 'engraving', جک /jak/ 'jack' and چک /čak/ 'slap'. This means that although the system of dots is primarily used to create visual differences among identical letters, the significance of the outcome is visually weak but semantically very strong. Therefore, if the assignment of dots is not the result of a complete linguistic analysis, at least it has brought about semantic and some visual and phonological values.

2.3.1.3 Various Shapes of Letters

For the majority of Persian alphabetic letters, there are an initial, a medial and a final form. These forms may be connected or disconnected to the following and preceding letter depending on the letters whether they are continuous or noncontinuous.²³ In this regard, Persian alphabetic letters can be divided into three groups: single-shape letters (e.g., /r/ ر), double-shape letters (e.g., /s/ س) and four-shape letters (e.g., /h/ ه).

These variations across the shape of letters will confuse the child and cause him hesitation and uncertainty; ultimately, they slow down the process of spelling. This process becomes more complicated when a child has to select the appropriate form among many alternatives.

2.3.1.4 Homophones

Homophones which present different graphemes for a single sound fall into five sets: a) z-sound homophones, b) s-sound homophones, c) t-sound homophones, d) h-sound homophones and d) q-sound homophones. To clarify the problems that Persian children confront while learning to spell, a comparison between Persian and Arabic is made in (3).

²³Noncontinuous letters consist of seven letters which never join to the following letter.

(3) <u>Persian</u>	<u>Arabic</u>
a. ظ ض ذ ز /z/ /z/ /z/ /z/	a. ظ ض ذ ز /z/ /ð/ /d/ /z̤/
b. ث ص س /s/ /s/ /s/	b. ث ص س /s/ /s̤/ /θ/
c. ط ت /t/ /t/	c. ط ت /t/ /t/
d. ح ه /h/ /h/	d. ح ه /ħ/ /h/
e. ق غ /q/ /q/	e. ق غ /q/ /ɣ/

As can be seen, the letters in each group are pronounced distinctly by Arabs whereas Persians pronounce each set uniquely. The mapping of the above phonemes onto graphemes are totally unpredictable and; therefore, Persian children cannot always write correctly by using the sound-to-symbol conversion. As a case in point, the word زن /zan/ can be legally written in four ways (زن 'woman', ظن 'nonsense', ذن 'nonsense', هنن 'nonsense').

In sum, homophonic letters are the same as other alphabetic letters, but the problem they show is that different orthographic letters represent the same phoneme. While sound-spelling information may be used to activate a group of appropriate candidates, the refutation of wrong candidates, and consequently the selection of the right candidate, is hardly predictable by the sound-to-spelling rule alone.

2.3.1.5 Homographs

Homographs, as illustrated below, present different sounds for a single letter. Homographic letters produce problems for beginning readers in the early stages of reading acquisition, and may even affect reading speed and reading comprehension (Qazanfari 1975).

- a. The letter ا represents four phonemes: 1) /â/(e.g., باد /bâd/), 2) /a/ (e.g., اسب /asb/ 'horse'), 3) /e/(e.g., اجبار /ejbâr/ 'obligation') and, 4) /o/ (e.g., اتاق /otâq/ 'room').

- b. The letter **و** represents three phonemes: 1) /o/ (e.g., خوشبخت /xošbaxt/²⁴ 'happy'), 2) /u/(e.g., سوت /sut/ 'whistle') and, 3) /v/(e.g., /vaqt 'time', داور /dâvar/ 'referee')
- c. The letter **ی** represents two phonemes: 1) /i/(e.g., دیر /dir/ 'late') and, 2) /y/(e.g., یک /yek/ 'one', کیک /keyk/ 'cake')

2.3.1.6 Silent Letters

In Persian, there are some silent letters which are written but never pronounced. Because of inconsistent phoneme-to-grapheme conversion, these letters create problems for Persian learners especially in the early stages of learning to read and spell. These letters as demonstrated by Qazanfari (1975:23) are:

- a. The silent letter <و> (e.g., خواندن /xândan/ 'reading', خواهش /xâheš/ 'request').
- b. The silent letter <ا> (e.g., نامه /nâme/ 'letter', نه /na/ 'no')
- c. The silent letter <ی> (e.g., بالاخره /belaxare/ 'at last, finally')
- d. The silent letter <ل> (e.g., الساعه /assae/ 'immediately')
- e. The silent letters <ا> and <ل> (e.g., باطنبع /bettab/ 'consequently')
- f. The silent letters <ا> and <ی> (e.g., الی الابد /elalabad/ 'till forever').
- g. The silent letters <ا>, <ل> and <ی> (e.g., فی النار /fennâr/ 'in hell, in fire!').^{25, 26, 27}

2.3.1.7 Spoken and Written Persian

The spoken Persian used in conversation is different from the written form in its sound, vocabulary and word order. The differences between them essentially relate to various linguistic fields, namely, phonetics, phonemics, semantics and pragmatics. We are interested in phonemic

²⁴Some Persian speakers may consider **و** as a diphthong and represent it with the vowel /o/ and the glide /w/. However, note that the number and types of diphthongs in general and the existence of the glide /w/ in particular is highly controversial in Persian phonology.

²⁵The examples in 'd', 'e', 'f' and 'g' are purely Arabic words and are seldom used in modern Persian.

²⁶Note that there are only specific words in which silent letters are not pronounced.

²⁷The Persian examples in (b-f) are from Qazanfari (1975).

differences which affect the acquisition of literacy in the beginning stages of development. To clearly see variations across the spoken and written language, we consider the following examples.

(4) <u>Written Form</u>	<u>Spoken Forms</u>			
a. کردَم 'kardam'	کردَم /kardam/	کردَم /kardom/	کردَم /kerdam/	کردَم /kerdom/
b. کبوتر 'kabutar'	کبوتر /kabutar/	کفتَر /kaftar/	کفتَر /kafter/	کفدر /kafder/
c. حتی 'hatti'	حتی /hâtâtâ/			
d. خیار 'xeyar'	خیار /xiyar/			
e. چهار 'čahâr'	چاهار /čâhâr/			
f. هلو 'holu'	هولو /hulu/			

The examples given above reveal two sorts of discrepancy between the spoken and written language. One is the comparable differences among various dialects in Iran which may be considered as a source of learning difficulty in general. As can be seen from the first two examples above, almost all phonemes are available but their distributions are different. Note that all school children regardless of their dialects practice standard Persian at the very beginning of literacy acquisition. Colloquially speaking, a child belonging to the Tehrani dialect pronounces کردَم /kardam/ 'I did' as /kardam/.²⁸ It is pronounced as /kerdem/ by an Isfahani child. In Shiraz, it is uttered as /kerdom/, and as /kerdam/ in Ahvaz. Here in the early stages of literacy development, all children come under one linguistic umbrella. They use standard Persian for reading and writing purposes. This means that the inconsistent pronunciation

²⁸The Tehrani dialect is considered the most prestigious variety of Persian since it highly corresponds to the written pronunciation.

resulting from a variety of sociolinguistic backgrounds is resolved to some extent.

The second sort of discrepancy which may cause reading and spelling difficulties for all children regardless of their dialects is the inconsistent relationship between the written form and its pronunciation. A Persian child wonders why s/he writes 'hatti', 'xeyâr', 'čâhâr' and 'holu', but s/he reads /hattâ/, /xiyâr/, /čâhâr/ and /hulu/. Note that some of these conversions are phonologically predictable. For example, the written words 'xeyâr', 'čâhâr' and 'holu' convert to /xiyar/, /čâhâr/ and /hulu/. In the case of 'xeyâr', /e/ assimilates into /i/ when followed by /i/. As the result of vowel harmony, the short vowels /a/ and /o/ in 'čâhâr' and 'holu' convert to the long vowels /â/ and /u/ in /čâhâr/ and /hulu/. Note further that school children would figure out the phonological rules underlying some of these examples. For instance from exposure to formal teaching of the Holy Koran, a third- or fourth-grade student would understand why the spellings of such words as خیار /xiyâr/ and حتی /hattâ/ do not convey their pronunciations. S/he would never figure out the phonological rules underlying the examples چهار /čâhâr/ and هلو /hulu/ since such phonological predictions require some formal linguistic awareness, in the first place.

2.3.1.8 Summary and Implications

It appears that Persian shows some degree of inconsistencies between the spoken and written forms. However, these inconsistencies do not make it as deep as English orthography. The Persian orthography is very consistent even though the same phoneme/grapheme may be spelled/read in different ways. In general, these features of Persian orthography (presented in 2.3) may affect reading and spelling acquisition. In particular, the regularity of grapheme-phoneme/phoneme-grapheme correspondences may lead to much greater reliance on the phonetic strategy than lexical strategy at the beginning stages of literacy acquisition.

2.4 Educational Policy

2.4.0 Introduction

The educational system in Iran is centralized and depends on the Ministry of Education. The Ministry of Education, the largest ministry in the country, has responsibility for the comprehensive organization and administration of all educational activities at all levels of education. The educational system is divided into four parts: Kindergarten, Primary, Guidance and Secondary.²⁹ They require one, five, three and four year(s) of completion, respectively. Here we have a brief look at the primary stage and disregard the three others.

2.4.1 Primary Education

Primary Education consists of five grades. Grade one marks the beginning of reading skills. Alphabetic instruction, which is required to enable beginners to read and write, is offered only during the first year. Failure to achieve an optimal skill in literacy in this grade leads to reading and spelling difficulties, mainly the inability to integrate sounds to their corresponding graphemes. In subsequent grades, the focus is mainly on strengthening and developing reading and writing skills. In addition, students are introduced to a variety of literary forms and genres such as prose, dialogue, plays and poems.

Thus the first grade of Primary Education constitutes the base in literacy development.³⁰ Success in other grades is highly related to the degree of competence attained in this grade. The apparent reason is that while reading in first grade is the subject of instruction, in subsequent grades, it is mainly a tool for further studying. Therefore, those students who acquire only a

²⁹The school curriculum and program requirements for secondary have substantially been changed since several years ago. High school students require to select a combination of courses leading to 96 credits for graduation. These courses provide them with good foundation for personal career as well as university studies.

³⁰The main objective of kindergarten in Iran is to foster children's expressive and receptive forms through different types of activities. Thus kindergarten children may develop some sort of phonological awareness such as dividing sentences into words and words into syllables.

bare minimum in Grade one, they have not acquired an optimal degree of proficiency to read effectively and to perform efficiently in other subject areas.³¹ The following grades, i.e., Grades two, three and four are considered to be foundation years since mastery is mainly accomplished in these grades. Reading and writing problems become very evident in these years. Grade five constitutes the automaticity phase of literacy acquisition since upon completion of this grade, students are expected to identify words accurately, effortlessly and rapidly; to read longer and more complicated texts with comprehension and rate; to do some analysis of texts, for example, discovering cause-and-effect relationships and making comparisons and contrasts; to extract details of texts; and to develop reasoning and imagination.

2.4.2 Educational Materials

Textbooks, as the main source of educational material, are issued by the Ministry of Education and are used by all students including the normal, the mentally retarded and the auditorially and visually impaired. Although the same textbooks are used for general students and, consequently, it may result in too little stimulation, the methodology and circumstances dominating each group is tentatively planned to concord with the needs of each group of learners. For example, for normal pupils, the teaching speed is not comparable to that of the mentally retarded. In the case of the latter, the teaching speed is reduced to a very large extent. As another case in point, the same textbooks are available in Braille as well as on tape for the visually impaired pupils.

³¹According to Slavin, Karweit and Wasik (1992/1993), success in early grades does not automatically mean success throughout the subsequent school years, but failure in the early grades does virtually lead to failure in later schooling.

CHAPTER THREE

METHODOLOGY

3.0 Orientation

This study generally attempted to explore the development of literacy acquisition in Persian first language learners. To achieve this goal, the study considered the development of phonological awareness, orthographic knowledge and working memory, on the one hand, and their contribution to reading and spelling achievement and to group separation, on the other hand. The study, as outlined below, was administered in five phases with 12 research questions which framed the research.

3.1 Phases of the Study

3.1.1 Phase I: Phonological Awareness

The main thrust of this phase was to chart the development of phonological awareness in kindergarten and grade-one groups. More specifically, this phase answered the following two research questions:

(R.Q.1) *Is there a significant correlation among various measures of phonological awareness?*

(R.Q. 2) *Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?*

3.1.2 Phase II: Orthographic Knowledge

The second phase of this study examined the developmental trend in the acquisition of orthographic knowledge. More specifically, this phase answered the following two research questions:

(R.Q.3) *Is there a significant correlation among various levels of orthographic knowledge?*

(R.Q.4) *Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?*

3.1.3 Phase III: Working Memory

The third phase of this study was to address the concept of working memory. The research questions related to this phase are the following:

(R.Q.5) *Is there a significant correlation among working memory spans?*

(R.Q.6) *Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?*

3.1.4 Phase IV: Contribution of Phonological Awareness, Orthographic Knowledge and Working Memory to Reading and Spelling Achievement

The goal of Phase Four was to investigate the individual and combined contributions of phonological awareness, orthographic knowledge and working memory to reading and spelling achievement. More precisely, this phase answered the following four research questions:

(R.Q.7) *Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?*

(R.Q.8) *Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?*

(R.Q.9) *Is there a significant relationship among measures of working memory and measures of reading and spelling achievement? If so, which aspects of working memory are more strongly related to reading and spelling achievement?*

(R.Q.10) *Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?*

3.1.5 Phase V: Discriminant Function and Number of Factors

This phase examined the discriminant function of variables in group separation and their loadings all together. More precisely, this phase answered the following research questions:

(R.Q.11) *What variables have the most discriminatory power to distinguish among groups?*

(R.Q.12) *How do different variables factor together?*

3.2 Subjects

The study was carried out in Baghbadoran, one of the most beautiful and mountainous towns of the province of Isfahan, situated in the East of Iran, 600 km from the capital, Tehran. 142 Persian children (boys and girls) aged 5 years 10 months to 11 years 9 months old, in kindergarten through fifth grade participated in this study. Kindergartners were from the Laleh kindergarten. Since school children study separately in Iran, the boys were students from the Mostafa-Pouladi public school and the girls were students from the Esteqlal public school. Fourteen undergraduate students from Payam-e Noor University of Zarrinshahr served as the control group. Table 1 shows grouping of the subjects by grade level.

Table 1
Number of Subjects at Each Grade Level

Group	Level	Number
0/K	Kindergarten	21
1	Grade 1	23
2	Grade 2	23
3	Grade 3	25
4	Grade 4	25
5	Grade 5	25
6/U	University	14

3.3 Development of Experimental Measures

Experimental measures comprised six tests of phonological awareness, seven tests of orthographic knowledge and three tests of working memory. To construct orthographic

knowledge tests, insightful guidelines were found by studying such standardized tests in English as The Wide Range Achievement Test (Jastak 1978), The Woodcock Reading Test-Revised (Woodcock 1987), The Diagnostic Reading Scales (Spache 1981), and The Reading Skills Diagnostic Test (Bloomer 1983). The items of orthographic knowledge tests were taken from the reading textbooks used in various primary school grades in Iran. Since the same textbooks are used for reading and spelling, the word lists constructed for reading were also used for spelling.

The phonological awareness tests were developed from phonological awareness tests in English (e.g., Catts 1991, Liberman 1973). As judged by four first-grade teachers, items of the phonological awareness tests were simple and in students' word repertoire.

The working memory tests were constructed from a study of working memory tests in English, such as the Visual Aural Digit Span Test (Koppitz 1977) and the Bloomer Learning Test (Bloomer 1978). As judged by the four first-grade teachers, items of the working memory tests were in students' word repertoire.

Following Woodcock (1987), for example, all test items of phonological awareness, orthographic knowledge and working memory proceeded from easier items to harder allowing for the operating range, basal level and ceiling level for each subject.³² The operating range is the set of items below which the subject has essentially a perfect chance of answering all items correctly (i.e., the basal level) and above which s/he has virtually no chance of completing any items correctly (i.e., the ceiling level). The underlying idea is that administering extremely easy items to subjects is a waste of time; it is also pointless to give test items to subjects when they will be left unanswered (Woodcock 1987). Therefore, economy and efficiency require the administration of those items that are within the operating range. The operating range is assumed to extend from the basal level to the ceiling level marked by four consecutive errors. At this point, it is important to note that the ceiling level, for instance, in Woodcock (1987) is

³²There was no ceiling level for the tests of reading nonwords, spelling words and spelling nonwords. The students were required to read and spell all items.

six consecutive errors. Since Persian is a shallow orthography, four consecutive errors were tentatively proposed to determine the ceiling level.

3.3.1 Phonological Awareness Measures

Phonological awareness measures consisted of two types of tests: syllable awareness measures and phoneme awareness measures (refer to Appendix B).

3.3.1.1 Syllable Awareness Measures

Syllable awareness measures consisted of three tasks: syllable blending, syllable segmentation and syllable deletion.

a. Syllable Blending Task

This test examined the student's ability to blend syllables to form meaningful words. There were 15 items (simple and complex words) graded in complexity by the number of syllables. Two practice items preceded the test. The testing continued until the student completed item 15 or s/he made four consecutive errors.

b. Syllable Segmentation Task

This task was designed to assess the student's ability to identify the number of syllables in a simple or complex word. Words included all syllabic patterns of Persian such as VC, CV, CVC and CVCC. Stimuli consisted of 15 words graded in terms of the number of syllables. The test started with two demonstration samples. The student was asked to count the number of syllables in a word. One point was scored for each item that was correctly syllabified. The ceiling level was determined by four consecutive errors.

c. Syllable Deletion Task

This task assessed the student's ability to delete a specific syllable from a simple or complex

word. It began with deletion of the initial syllable of a simple two syllable word and progressed to delete syllables from either the beginning or end of the word. For example, the student was asked to say بادام /bâdâm/ without با /bâ/. A total of 15 items comprised the syllable deletion task. Two demonstration samples preceeded the test. The test was discontinued after the student made four consecutive errors.

3.3.1.2 Phoneme Awareness Measures

Phoneme awareness measures consisted of three tasks: phoneme blending, phoneme segmentation and phoneme deletion (refer to Appendix B).

a. Phoneme Blending Task

The phoneme blending test assessed the student's ability to blend a sequence of sounds to form a meaningful word. Stimuli consisted of 15 words starting with words containing only two phonemes and continuing with words with increasingly larger numbers of phonemes. The student was asked to listen to the investigator uttering the phonemes of a word one at a time, and then to say the whole word. The task began with two practice items to ensure that the student knew what to do. Whenever the student gave an incorrect response on practice items, the demonstration was repeated until s/he performed correctly. The test was stopped after four consecutive errors.

b. Phoneme Segmentation Task

The phoneme segmentation task determined the student's ability to orally count the number of phonemes in a word. There were 15 items graded in difficulty in terms of the number of phonemes. The student was asked to listen to a word and verbalize the individual phonemes heard in the word. For example, given the word آن /ân/ 'that', the student would indicate that it has two sounds /â/ and /n/. The test began with three practice items. Whenever the student gave an incorrect response, s/he was coached until s/he gave the right answer. After that, the

15 items were presented in succession without any further demonstration. The testing continued until the student reached the criterion of four consecutive errors or completed the last item.

c. Phoneme Deletion Task

This task assessed the student's ability to delete a phoneme from the initial or final position of a simple word. For example, the word **باد** /bâd/ without **ب** /b/, leaves **اد** /-âd/. Stimuli consisted of 15 items. Three practice items preceded the test. The ceiling level was decided by four consecutive errors.

3.3.2 Orthographic Knowledge Measures

Orthographic knowledge measures consisted of: alphabetic knowledge tests, the orthographic choice test and reading and spelling measures. All tests began with two practice items.

3.3.2.1 Alphabetic Knowledge Measures

a. Letter-Name Knowledge Task

This task assessed the student's experience with the alphabetic written language system. The student was required to name 22 letters (vowels and consonants) presented visually. The letter items were arranged in order of difficulty.³³ The test began with the first item, and it continued until the subject made four consecutive errors or responded to the last item.

b. Letter-Sound Knowledge Task

In this task, the student was asked to select a letter (vowel or consonant) that match the letter sound given by the examiner from an array of three final-shape letters. The test contained 14 items beginning with more frequent sounds and continuing with less frequent ones.

³³The level of difficulty of alphabetic letters was determined by their order of presentation appearing in the first-grade textbook.

3.3.2.2 Orthographic Choice Measure

This test consisted of 75 items used as a measure of spelling pattern knowledge. It required the student to select the correct spelling of a word from two alternatives, one which was orthographically correct and the other which was phonetically identical but not orthographically correct. There were estimated orthographic choice grade levels and suggested starting items.

Testing was stopped after four consecutive errors. For example:

- (5) a. غذا /qazâ/ 'food'
 b. قزا /qazâ/ 'nonsense'

3.3.2.3 Reading Measures

Reading measures consisted of reading words and reading nonwords given to students in a random order.

a. Reading Words

The word recognition test assessed the student's ability to recognize and read words in isolation. There were 124 words in the test word list arranged in difficulty based on different grades' textbooks. The words assigned for each grade level were of increasing complexity, beginning with simple monosyllabic patterns and progressing to complex multisyllabic combinations. There were estimated reading grade levels and suggested starting items (see Appendix C). So each group of students was to start the test from the estimated grade level. Testing was stopped after four consecutive errors.

b. Reading Nonwords

This task measured the student's ability to sound out and read nonsense words through phonics or analogy with a real word. There were 20 items made by changing the initial phoneme of real words. The student was required to read all items since there was no ceiling level.

3.3.2.4 Spelling Measures

Spelling measures consisted of spelling words and spelling nonwords given to each group of subjects in a random order.

a. Spelling Words

This test assessed the student's ability to the spelling of words. The list of items used for reading was also applied for spelling, with the exception that each group of subjects was assigned to those items estimated for that grade level. Materials were read slowly and clearly to allow students time to write their responses. Each word was read at a normal reading pace.

b. Spelling Nonwords

This task measured the student's ability to sound out and spell nonwords through the application of phonic and structural analysis skills or analogy with a known word. It consisted of 20 items used for reading nonwords. Materials were read slowly and clearly to allow students time to write their responses.

3.3.3 Working Memory Measures

Working memory was measured by three kinds of memory span: Word Span, Syllable Span and Letter Span (refer to Appendix D). All tasks began with two practice items. Test items were arranged in an increasing order of difficulty in terms of the number of items. The student was asked to recall each series of items in the order presented. Credit was given only if each set of items were recalled in the correct serial order. For all spans, the ceiling level was decided by four consecutive errors.

3.3.3.1 Word Span

This memory span test contained 12 sets of common words starting with two words and going up to eight words. The student was told to listen and to say exactly what the experimenter said.

A successful trial was one in which the student repeated correct words in the correct order. Testing was discontinued when four consecutive trials were incorrect.

3.3.3.2 Syllable Span

This task consisted of 12 sets of syllables that varied in the number of syllables. It required the student to recall series of syllables increasing in number from 2 to 8. A correct trial was one in which the student repeated correct syllables in the correct order. Testing was discontinued when the student made four consecutive incorrect responses.

3.3.3.3 Letter Span

This task required the student to recall 12 sets of letters in the correct order. An ascending order was used in which the number of letters was increased from 2 to 8. Testing was discontinued if the student made four consecutive errors or repeated the last series of letters verbatim in the correct order.

3.4 Procedure

Measures of orthographic knowledge and working memory were administered individually to all students, except for spelling tasks administered in group. Kindergarten students were not assigned to the tests of reading words, reading nonwords, spelling words, spelling nonwords and orthographic choice since they had no sense of them. Phonological awareness tests and alphabetic knowledge tests were given to kindergarten and grade-one students only. All experimental tests were administered during the regular school day. Each subject was tested individually in a room separate from the classrooms in one session of approximately 45 minutes, during which the full range of tasks was administered in no predetermined order.

3.5 Data Collection

In April 1997, I had the opportunity to go to Iran to collect data on Persian first language

learners. First, the goals of research were explained to the Chair of Baghadoran Board of Education and the executive assistant of Payam-e Noor University of Zarrinshahr in order to get admission to administer the tests. Voluntarily, 14 undergraduate students participated in the project after presenting them a brief introduction of the investigation.

Administration of experimental tests to primary school students was more complicated. First, the aims and nature of the tests were reviewed with teachers and principals of the two public schools, Esteghlal and Mostafa Pouladi primary schools, as well as the Laleh kindergarten. All subjects were informed of the nature of testing in general terms. Students were also informed that test results would not affect their school grades. Finally, to assist the researcher with this project, two teachers (with two years of university study) were explained the details of the research project and instructed on how to administer and tape the tests. The testing was completed over three weeks between 6-30 in April.

3.6 Data Analysis

This study was designed to investigate the developmental differences in phonological awareness, orthographic knowledge and working memory and to examine the contribution of these variables to the ability of reading and spelling and to group discrimination. Phonological awareness, i.e., syllable awareness and phoneme awareness, was determined by six measures including syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion. Various levels of orthographic knowledge were examined by different measures including letter-name knowledge, letter-sound knowledge, reading words, reading nonwords, spelling words, spelling nonwords and orthographic choice. Working memory was addressed by three working memory spans, i.e., word span, syllable span and letter span.

To study the bivariate relationship among the six tests of phonological awareness, the seven tests of orthographic knowledge and the three tests of working memory, a series of correlation coefficients was computed.

To examine the development of phonological awareness between kindergarten and first-grade students, a series of independent t-tests was performed on the data.

To address the development of orthographic knowledge and working memory, series of univariate analyses of Anova with the Scheffé posteriori test were computed.

To investigate the contribution of phonological awareness, orthographic knowledge and working memory to reading and spelling achievement, sets of stepwise multiple regression analyses were computed.³⁴ In one analysis, phonological awareness measures were independent variables and reading words, reading nonwords, spelling words and spelling nonwords were criterion variables. In another analysis, orthographic knowledge measures were independent variables and reading measures and spelling measures were criterion variables. In the third attempt, working memory spans as independent variables were predictors of reading and spelling measures as criterion variables. The contribution of all variables together to reading and spelling achievement was also surveyed by additional series of stepwise multiple regression analyses. Inspection was provided by R^2 , adjusted R and the significance of variance.³⁵

To determine the variables which have the greatest discriminatory power in group distinction, the discriminant function analysis was computed.³⁶

³⁴Multiple regression analysis is a method of analysing the contribution of two or more predictors (independent variables) to explore the criterion (dependent) variable (see Achen 1982, Cohen and Cohen 1983, Licht 1995).

³⁵ R^2 represents the amount of shared variance in the dependent variable that can be explained by independent variables. Adjusted R^2 compensates for chance fluctuations due to the small size sample. When adjusted R^2 is determined, the remaining portion of variance is due to random variation or variables which were not included in the analysis (see Achen 1982, Licht 1995).

³⁶Discriminant function analysis (DFA) is a powerful method of measurement that determines how well variables allows one to distinguish among groups. The principle technique in DFA is the canonical discriminant function which is the linear combinations of variables contributing maximally to group distinction. Each canonical function shows one dimension along which groups differ (see Silva and Stam 1995).

To address how different variables factor together, the Equamax rotation³⁷ was computed. Inspection was provided by the eigenvalue and percentage of variance.

3.7 Scoring

With the exceptions of spelling words, spelling nonwords and reading nonwords, other tests were assigned a ceiling level marked by four consecutive errors. This means that students got credit for the items assigned below their grade level. For each variable, an overall score was computed for each subject by counting the number of correct responses. One credit was given to each correct answer. An answer was considered correct in memory spans if each set of items was recalled in the correct serial order.

³⁷Equamax rotation is a method of the principal components analysis which enters all variables in computation and groups them together based on their close relationship (see Bryant and Yarnold 1995, Duntzman 1989, Gorusch 1983).

CHAPTER FOUR

RESULTS

4.0 Orientation

The present investigation analysed and synthesized different skills in order to explore more closely the developmental nature of Persian literacy and to understand the strategies that different groups of students may employ in reading and spelling. The study consisted of five phases, each of which treated a major issue defined by specific research questions. Phase I of the study focussed on the development of phonological awareness. Phase II concentrated on the development of different levels of orthographic knowledge. In Phase III, the development of working memory was addressed. The individual and combined contributions of phonological awareness, orthographic knowledge and working memory to reading and spelling achievement were examined in Phase IV. In the final phase of the study, Phase V, the discriminant function and number of factors were surveyed.

4.1 Reliability of Experimental Tests

To have an idea of internal consistency of the experimental tests, series of Cronbach's alpha were performed on the scores of randomly selected students. For orthographic knowledge tests reliability was established on 12 randomly selected students, 2 from each grade. To determine reliability of the phonological awareness measures and alphabetic knowledge tests, we randomly selected 6 kindergartners and 6 first graders, since the tests of phonological awareness and alphabetic knowledge were assigned only to these groups of students. For working memory spans, reliability was established on 14 students, two from each group. The results are in Table 2.

Table 2
Reliability of Experimental Tests

Experimental Measure	alpha
Syllable Blending	.88
Syllable Segmentation	.92
Syllable Deletion	.93
Phoneme Blending	.93
Phoneme Segmentation	.95
Phoneme Deletion	.95
Letter-Name Knowledge	.97
Letter-Sound Knowledge	.97
Reading Words	.96
Reading Nonwords	.65
Spelling Words	.61
Spelling Nonwords	.64
Orthographic Choice	.97
Word Span	.80
Syllable Span	.74
Letter Span	.78

4.2 Phase I: Phonological Awareness

Phase one of the study was an attempt to answer the following research questions. Recall that the students who participated in Phase I were limited to kindergarten and grade-one groups since mastery in phonological awareness was assumed to be achieved by the completion of first grade.

(R.Q.1) Is there a significant correlation among various measures of phonological awareness?

(R.Q.2) Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?

(R.Q.1) *Is there a significant correlation among various measures of phonological awareness?*

To test whether or not various levels of phonological awareness were related to one another, a series of Pearson Product Moment correlation coefficients was computed. A significant linear relationship between variables is observed whenever p is less than .05. See Table 3 for the results.

Table 3
Correlation Coefficients
Among Phonological Awareness Measures
for Kindergarten and Grade-One Groups Combined
(N= 44)

	SB	SS	SD	PB	PS	PD
Syllable Blending	—					
Syllable Segmentation	.35*	—				
Syllable Deletion	.53**	.47**	—			
Phoneme Blending	.65**	.49**	.69**	—		
Phoneme Segmentation	.50**	.40**	.71**	.88**	—	
Phoneme Deletion	.53**	.55**	.80**	.82**	.88**	—

Two-tailed significance, * $p < .01$, ** $p < .001$

As Table 3 reveals, all phonological awareness measures were significantly intercorrelated at the .001 level for kindergarten and Grade one combined, with the exception of syllable blending and syllable segmentation which were significant at the .01 level.

(R.Q.2) *Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?*

To promote clarity the second research question focussing on the development of phonological awareness was subdivided into two questions, each of which was further subdivided into three subquestions.

(2.1) *Is there a significant developmental trend in syllable awareness?*

(2.1.1) *Is there a significant developmental trend in syllable blending?*

(2.1.2) *Is there a significant developmental trend in syllable segmentation?*

(2.1.3) *Is there a significant developmental trend in syllable deletion?*

(2.2) *Is there a significant developmental trend in phoneme awareness?*

(2.2.1) *Is there a significant developmental trend in phoneme blending?*

(2.2.2) *Is there a significant developmental trend in phoneme segmentation?*

(2.2.3) *Is there a significant developmental trend in phoneme deletion?*

To chart the pattern of development of phonological awareness, we made a comparison between kindergarten students and first graders to whom phonological awareness measures were given. The results visually and numerically are shown in Figure 1 and Table 4.

Figure 1

Phonological Awareness Measures
for Kindergarten and Grade-One Groups

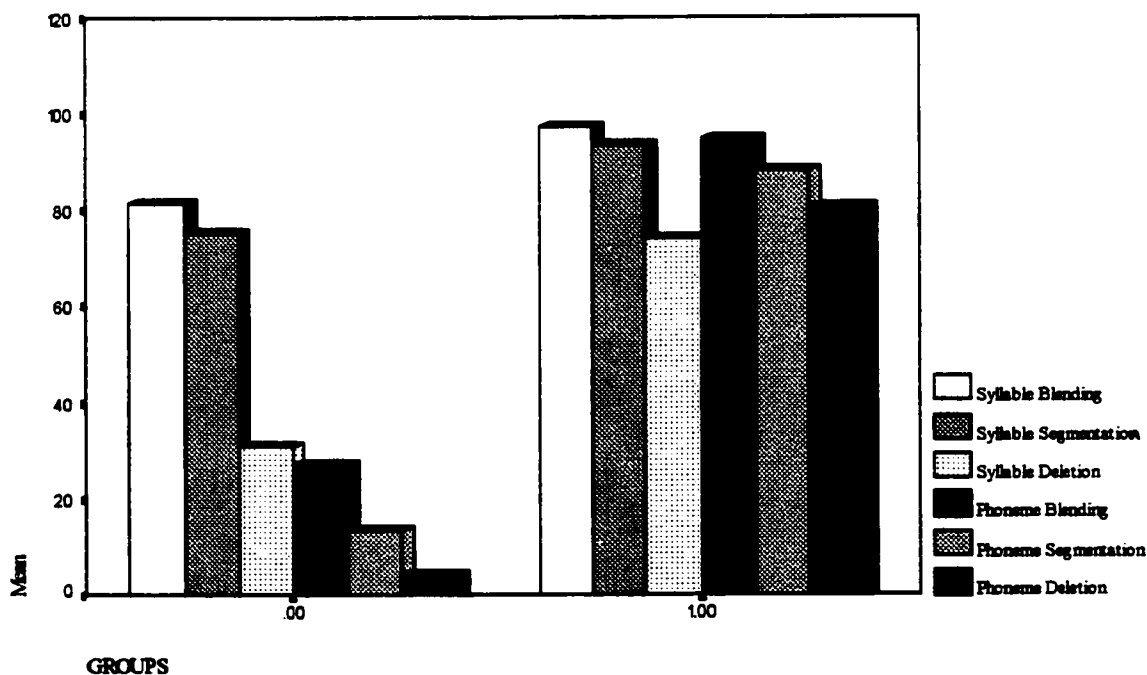


Figure 1 shows that kindergartners had an inferior performance in all phonological awareness measures to that of first graders. This inferiority was more pronounced at the level of phoneme awareness than syllable awareness. See Table 4 for numerical differences in the means, standard deviations and t-Tests.

Table 4
Means(%), Standard Deviations and T-Tests
of Phonological Awareness Measures for Kindergarten and Grade-One Groups

Task	Kindergartners Mean(SD) (N= 21)	First Graders Mean(SD) (N= 23)	Mean Diff	DF	T-Value	P-Value
Syllable Blending	81.58(17.75)	97.39(07.97)	15.81	42	3.87	<i>p</i> <.001
Syllable Segmentation	75.55(22.54)	93.61(17.93)	18.06	42	2.95	<i>p</i> <.005
Syllable Deletion	31.10(21.63)	74.20(26.07)	43.09	42	5.99	<i>p</i> <.001
Phoneme Blending	27.30(23.75)	95.07(07.57)	67.77	42	12.99	<i>p</i> <.001
Phoneme Segmentation	13.34(07.60)	88.12(17.62)	74.77	42	17.97	<i>p</i> <.001
Phoneme Deletion	4.45(10.40)	80.86(25.92)	76.41	42	12.60	<i>p</i> <.001

An examination of Table 4 indicates that for kindergartners, syllable awareness tasks (i.e., syllable blending, syllable segmentation and syllable deletion) were easier than phoneme awareness tasks. The phoneme awareness tasks (i.e., phoneme blending, phoneme segmentation and phoneme deletion) were considerably more difficult for those youngest subjects. Indeed, in the kindergarten group, 18 subjects received a score of zero in phoneme awareness tasks (one zero in phoneme blending, one in phoneme segmentation and 16 on phoneme deletion). More importantly, there appeared to be significant differences at the .001 and .005 levels in the performance of kindergartners and first graders, with first graders outperforming kindergartners on all measures of phonological awareness. The differences were highly pronounced at the level of phoneme, suggesting that phoneme awareness measures were possibly better tests to distinguish first graders from kindergartners.

4.2.1 Concluding Remarks

4.2.1.1 Conclusion

The main objectives of Phase One were to determine if there is a significant correlation among phonological awareness tests and, if a significant developmental trend exists in phonological awareness between kindergartners and first graders.

The relationship among phonological awareness measures was detected by computing a series of correlation coefficients. Measures of phonological awareness were strongly correlated with one another. Moreover, a significant developmental growth in phonological awareness was distinguished by statistically significant differences found in phonological awareness between kindergarten and first-grade groups. The performance of grade-one students was superior in all phonological awareness measures to that of kindergartners.

4.2.1.2 Answers to Research Questions 1-2

(R.Q.1) Is there a significant correlation among various measures of phonological awareness?

Yes. Various measures of phonological awareness, i.e., syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion, were significantly intercorrelated with one another.

(R.Q.2) Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?

Yes. A significant developmental trend was charted at the syllable and phoneme levels.

4.3 Phase II: Orthographic Knowledge

Phase Two of the study was an attempt to find answers for the following research questions. Recall that with the exception of alphabetic knowledge tests (i.e., letter-name knowledge and letter-sound knowledge tests) given to kindergartners as well as first graders, other tests were administered to all subjects in Grades 1-5 and university.

(R.Q.3) *Is there a significant relationship among various levels of orthographic knowledge?*

(R.Q.4) *Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?*

(R.Q.3) *Is there a significant relationship among various levels of orthographic knowledge?*

To examine whether or not various levels of orthographic knowledge were related to one another, a series of correlation coefficients was computed. See Table 5 for the results.

Table 5
Correlation Coefficients
Among Various Levels of Orthographic Knowledge
for Grades 1-5 and University Combined
(N= 23, 44, 135)³⁸

	LN	LS	RW	RNW	SW	SNW	OC
Letter Name	—						
Letter Sound	.99***	—					
Reading Words	NS	NS	—				
Reading Nonwords	.46**	.40**	.63***	—			
Spelling Words	.40**	.42**	NS	NS	—		
Spelling Nonwords	.66***	.56***	.39***	.47***	.29*	—	
Orthographic Choice	NS	NS	.97***	.60***	NS	.38***	—

Two-tailed Significance * $p < .01$, ** $p < .05$, *** $p < .001$

NS= Not Significant

A review of Table 5 reveals 14 significant intercorrelations, 8 of which were significant at the .001 level, one at the .01 level, and 4 at the .05 level. Interestingly, the matrix also revealed two particularly strong coefficients: letter-name knowledge and letter-sound knowledge ($r = .99$) and orthographic choice and reading words ($r = .97$).

³⁸The number of students for the correlation among orthographic knowledge measures was 135, except for the tests of letter-name knowledge and letter-sound knowledge that the number was 44. And for the letter-name knowledge/letter-sound knowledge test with any other measure, the number of students was 23.

(R.Q.4) *Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?*

To promote clarity the research question above was subdivided into seven subquestions.

(4.1) *Is there a significant developmental trend in the acquisition of alphabetic knowledge?*

(4.2) *Is there a significant developmental trend in the acquisition of reading words?*

(4.3) *Is there a significant developmental trend in the acquisition of reading nonwords?*

(4.4) *Is there a significant developmental trend in the acquisition of spelling words?*

(4.5) *Is there a significant developmental trend in the acquisition of spelling nonwords?*

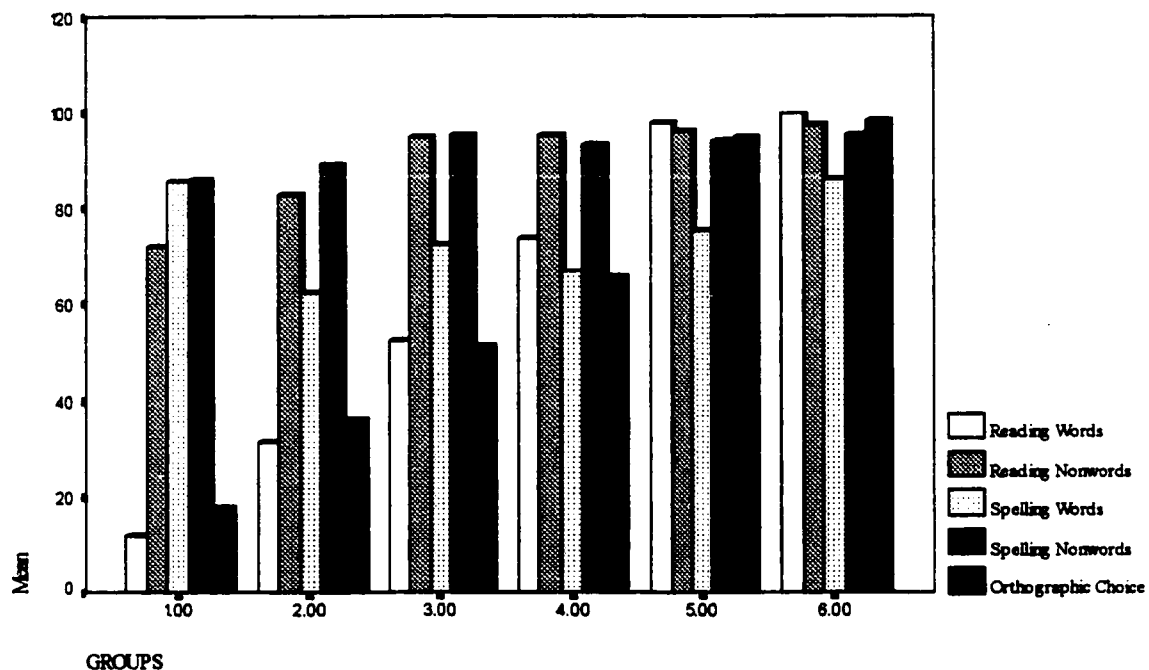
(4.6) *Is there a significant developmental trend in the acquisition of orthographic choice?*

(4.7) *Is there a significant developmental trend in the use of analogy and phonology in reading and spelling of nonwords?*³⁹

To address the development of orthographic knowledge, means and standard deviations of different orthographic knowledge tests were computed at each grade level. These tests were: a) alphabetic knowledge tests (i.e., letter-name knowledge and letter-sound knowledge tests), b) reading words, c) reading nonwords, d) spelling words, e) spelling nonwords and, f) orthographic choice. See Figure 2 and Table 6 for the visual and numerical presentations of results.

³⁹This question will be answered separately.

Figure 2
Orthographic Knowledge Measures
Across Grades 1-5 and University



As Figure 2 shows, except for the test of spelling words, there is a consistent development with increasing grade level in all orthographic knowledge tasks.⁴⁰ Differences in the means and standard deviations are shown in Table 6.

⁴⁰It should be noted that the test of spelling words was different across grades; therefore, no consistent development was expected. In the case of spelling nonwords, there is an increasing growth in all subsequent grades except for Grades 3 and 4 which show a similar behaviour.

Table 6
Means(%) and Standard Deviations
of Orthographic Knowledge Measures for Each Grade Level

Task	Kindergarten		Grade 1	Grade 2	Grade 3
	Mean(SD)		Mean(SD)	Mean(SD)	Mean(SD)
	(N= 21)		(N= 23)	(N= 23)	(N= 25)
Alphabetic Knowledge					
Letter Name	4.5		99.01(3.34)	—	—
Letter Sound	0.00		99.42(1.93)	—	—
Reading Words	—	—	11.78(03.39)	31.37(05.26)	52.48(05.66)
Reading Nonwords	—	—	72.17(17.24)	82.83(13.64)	95.00(05.20)
Spelling Words	—	—	85.78(07.92)	62.45(13.72)	72.66(11.93)
Spelling Nonwords	—	—	86.09(08.91)	89.35(07.28)	95.40(05.19)
Orthographic Choice	—	—	17.95(03.25)	36.18(04.35)	51.25(04.26)
Task					
			Grade 4	Grade 5	U Students
			Mean(SD)	Mean(SD)	Mean(SD)
			(N= 25)	(N= 25)	(N= 14)
Alphabetic Knowledge					
Letter Name			—	—	—
Letter Sound			—	—	—
Reading Words			73.80(08.24)	97.98(01.33)	99.71(0.51)
Reading Nonwords			95.20(05.10)	96.20(04.85)	97.50(3.25)
Spelling Words			66.92(10.24)	75.43(11.66)	86.18(7.02)
Spelling Nonwords			93.40(07.03)	94.20(05.89)	95.36(4.14)
Orthographic Choice			66.07(06.61)	95.00(03.01)	98.29(1.23)

Note: — indicates that the test was not administered to that group.

To see whether or not differences among groups are significant, series of one-way Anovas with the Scheffé posthoc test were performed on the data. Tables 7 and 8 display the results.

Table 7
One-Way Analysis of Variance
of Orthographic Knowledge Measures
for Grades 1-5 and University Combined
(N= 135)

Task	F-Value	P-Value
Reading Words	F(6, 129)= 166.58	<i>p</i> <.0001
Reading Nonwords	F(6, 129)= 23.56	<i>p</i> <.0001
Spelling Words	F(6, 129)= 16.27	<i>p</i> <.0001
Spelling Nonwords	F(6, 129)= 7.01	<i>p</i> <.0001
Orthographic Choice	F(6,129)= 170.55	<i>p</i> <.0001

As Table 7 indicates, Grades 1-5 and university significantly differed in terms of all orthographic knowledge measures. The between-group differences were highly pronounced for the measures of reading words and orthographic choice. To see the exact positions where groups differ, we consider the Scheffé posthoc test results in Table 8.

Table 8
Scheffé Posthoc Test Results of Orthographic Knowledge Measures

	Grade 2	Grade 3	Grade 4	Grade 5	U
Grade 1	RW*	RW*	RW*	RW*	RW*
	RNW*	RNW*	RNW*	RNW*	RNW*
	SW*▼	SW*▼	SW*▼	SW	SW
	SNW	SNW*	SNW*	SNW*	SNW*
	OC*	OC*	OC*	OC*	OC*
Grade 2		RW*	RW*	RW*	RW*
		RNW*	RNW*	RNW*	RNW*
		SW	SW	SW*	SW*
		SNW	SNW	SNW	SNW
		OC*	OC*	OC*	OC*
Grade 3			RW*	RW*	RW*
			RNW	RNW	RNW
			SW	SW	SW*
			SNW	SNW	SNW
			OC*	OC*	OC*
Grade 4				RW*	RW*
				RNW	RNW
				SW	SW*
				SNW	SNW
				OC*	OC*
Grade 5					RW
					RNW
					SW
					SNW
					OC

*shows a significant difference at the .05 level.

*▼ shows a significant difference at the .05 level but in favour of the lower grade.

RW= Reading Words, RNW= Reading Nonwords, SW= Spelling Words, SNW= Spelling Nonwords,
 OC= Orthographic Choice

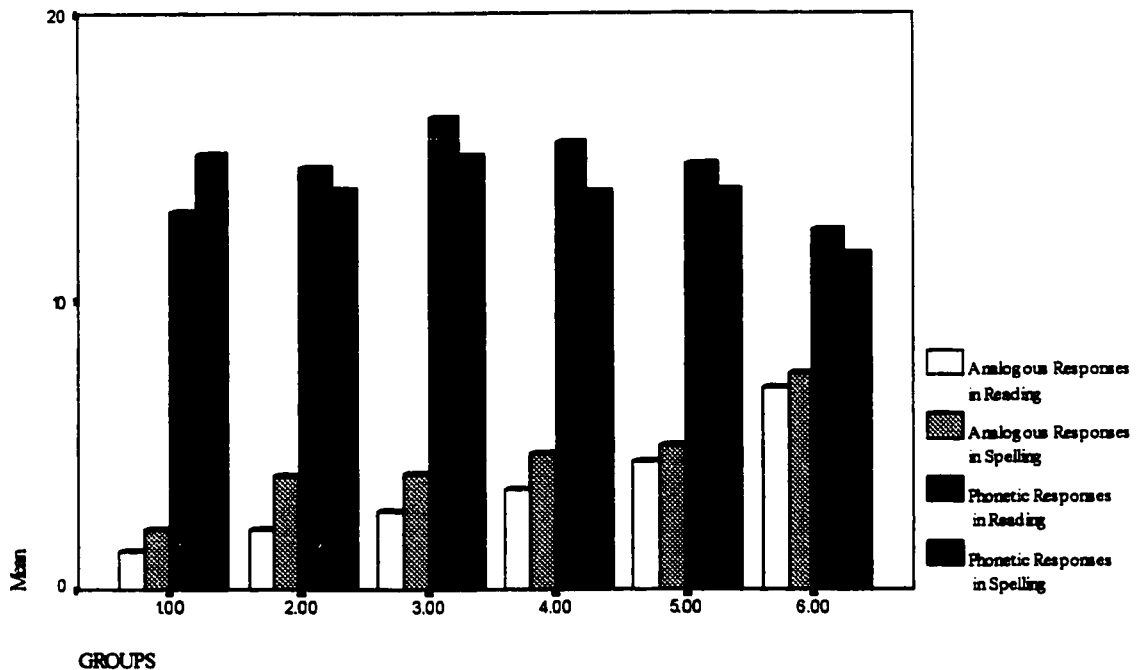
The Scheffé posthoc test further revealed interesting results. The grade-one group had the lowest performance in 4 out of 5 tasks, that is, reading words, reading nonwords, spelling nonwords and orthographic choice. However, first graders performed significantly better than students in Grades 2, 3 and 4 in spelling words. In reading words and orthographic choice, there was a significant progression consistent across all groups. University students were superior to lower level students in all measures of orthographic knowledge. The performance of grade-five students was comparable to university students since the Scheffé results showed no significant differences between university students and fifth graders.

(R.Q.4.7) Is there a significant developmental trend in the use of analogy and phonology in reading and spelling of nonwords?

To address this question, we analysed more closely the performances of different groups of students in reading and spelling of nonwords. In nonwords tasks, all items (i.e., 20 items) could be read or spelled through phonology or orthography, that is, in a way which is analogous to a real word.⁴¹ For example, the nonsense word متى could be read phonetically as 'matti' or analogously as 'mattâ'; or /hâhar/ could be spelled phonetically as حامر or analogously as حوامر which is analogous to the real word خواهر /xâhar/'sister'. Two types of correct responses were recorded, i.e., phonetic responses and analogous responses. Means and standard deviations of phonetic and analogous responses in reading and spelling of nonwords at each grade level were calculated. Additionally, a univariate analysis of variance with the Scheffé posthoc test was used to find how significantly groups differ. Numerical and visual presentations of the results are in Figure 3 and Tables 9 and 10.

⁴¹There were two types of words in the nonwords tasks: a) words which derived from irregular or exception words and; b) words which had homophonic letters.

Figure 3
Analogous and Phonetic Responses
in Reading and Spelling of Nonwords Across Grades 1-5 and University



A brief look at Figure 3 indicates developmental differences across different groups of subjects in reading and spelling of nonwords. The use of analogy in reading and spelling of nonwords increased consistently across grades. Though the use of phonology improved consistently from Grade 1 to Grade 3, it followed a decreasing pattern across Grades 4-5 and university. Interestingly, all grades made use of both phonology and analogy but in different degrees. More analogous responses were seen in spelling nonwords than reading words. While university students had the largest portion of analogous responses in both tasks of reading and spelling nonwords, first graders had the least. To see differences in the means and standard deviations see Table 9.

Table 9
Means and Standard Deviations
of Analogous and Phonetic Responses at Each Grade Level

Grade	<u>Analogous Responses</u>		<u>Phonetic Responses</u>	
	Reading	Spelling	Reading	Spelling
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Grade 1 (N= 23)	1.34(0.98)	2.08(0.73)	13.08(1.45)	15.13(1.93)
Grade 2 (N= 23)	2.08(1.24)	3.95(1.06)	14.65(3.24)	13.91(1.44)
Grade 3 (N= 25)	2.72(1.54)	4.04(2.13)	16.4(1.41)	15.08(2.48)
Grade 4 (N= 25)	3.52(1.29)	4.76(1.42)	15.52 (1.47)	13.80(1.60)
Grade 5 (N= 25)	4.44(1.63)	5.00(1.63)	14.80(1.68)	13.88(1.39)
U (N= 14)	7.00(1.46)	7.5(1.01)	12.50(1.45)	11.64(1.49)

Generally speaking, students in all groups tended to employ more phonology than orthography in reading and spelling of nonwords. However, more analogous responses were seen in upper grades than lower grades. The mean score of analogous responses in reading for

Grade one was 1.34; it increased steadily from Grade one and reached almost three times and six times first-graders' in Grade 5 and university, respectively. Similarly, a steady developmental progression was seen in the use of analogy in spelling nonwords. First graders had a mean score of 2.08 in analogous responses, whereas fifth graders and university students scored more than two times and three times first graders'. To see whether or not the differences are significant, we consider Tables 10 and 11 in which the univariate analysis of variance with the Scheffé posteriori test results are reported.

Table 10
One-Way Analysis of Variance
of Analogous and Phonetic Responses in Reading and Spelling of Nonwords
for Grades 1-5 and University Combined
(N= 135)

Task	F-Value	P-Value
Analogous Responses in Reading Words	F(6, 129)= 37.48	<i>p</i> <.0001
Analogous Responses in Spelling Words	F(6, 129)= 26.33	<i>p</i> <.0001
Phonetic Responses in Reading Nonwords	F(6, 129) = 7.89	<i>p</i> < .0001
Phonetic Responses in Spelling Nonwords	F(6, 129)= 8.45	<i>p</i> <.0001

An analysis of variance displayed in Table 10 revealed significant differences in the use of analogy and phonology across different groups of subjects. Consider Table 11 to see the exact positions where differences lie.

Table 11
Scheffé Posthoc Test Results
of Analogous and Phonetic Responses in Reading and Spelling of Nonwords

	Grade 2	Grade 3	Grade 4	Grade 5	U
Grade 1	AR	AR*	AR*	AR*	AR*
	AS*	AS*	AS*	AS*	AS*
	PR	PR*	PR*	PR	PR
	PS	PS	PS	PS	PS*▼
Grade 2		AR	AR*	AR*	AR*
		AS	AS	AS	AS*
		PR	PR	PR	PR
		PS	PS	PS	PS*▼
Grade 3			AR	AR*	AR*
			AS	AS	AS*
			PR	PR	PR*▼
			PS	PS	PS*▼
Grade 4				AR	AR*
				AS	AS*
				PR	PR*▼
				PS	PS*▼
Grade 5					AR*
					AS*
					PR
					PS*▼

*shows a significant difference at the .05 level.

*▼ shows a significant difference at the .05 level but in favour of the lower grade.

AR= Analogous Responses in Reading, AS= Analogous Responses in Spelling,

PR= Phonetic Responses in Reading, PS= Phonetic Responses in Spelling

The Scheffé posthoc test further revealed two clear patterns of development in analogous responses: significant growth and developmental tendency. The developmental tendency (i.e., growth which is not significant) was patterned in all subsequent grades. However, significant growth indicating a significant difference was observed in almost all nonsubsequent grades. The performance of university students in analogous responses in reading and spelling of nonwords was significantly higher than all other groups. Conversely, all groups of students performed better than university students in phonetic responses which reached the significance level in spelling nonwords.

4.3.1 Concluding Remarks

4.3.1.1 Conclusion

The second phase of the study aimed to determine if there is a significant correlation among various levels of orthographic knowledge and, if a significant developmental growth exists in the acquisition of orthographic knowledge.

The results of a series of correlation coefficients revealed that various levels of orthographic knowledge were intercorrelated with one another ranging from nonsignificant to .99.

The results of a series of Anovas with the Scheffé posteriori test revealed a significant developmental pattern in all levels of orthographic knowledge which was highly pronounced for reading words and orthographic choice. Interestingly, the ratio of analogous responses in reading and spelling of nonwords was more pronounced in upper grades than lower grades, suggesting that upper grades were more willing to challenge orthographic coding than phonological coding.

4.3.1.2 Answers to Research Questions 3-4

(R.Q.3) Is there a significant correlation among various levels of orthographic knowledge?

Yes. With a few exceptions (see 6.6), various levels of orthographic knowledge, i.e., letter-

name knowledge, letter-sound knowledge, reading words, reading nonwords, spelling words, spelling nonwords and orthographic choice were significantly intercorrelated.

(R.Q.4) Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?

Yes. A significant developmental trend was observed in all the levels of orthographic knowledge across different grades.

4.4 Phase III: Working Memory

Phase Three of the study was an attempt to find answers for the following research questions:

(R.Q.5) Is there a significant correlation among working memory spans?

(R.Q.6) Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?

(R.Q.5) Is there a significant correlation among working memory spans?

A series of Pearson Product Moment correlation coefficients was performed to examine the bivariate relationship among working memory spans. See Table 12 for the results.

Table 12
Correlation Coefficients
Among Working Memory Spans
for Kindergarten, Grades 1-5 and University Combined
(N= 156)

	Word Span	Syllable Span	Letter Span
Word Span	—		
Syllable Span	.54*	—	
Letter Span	.56*	.55*	—

Two-tailed Significance, * $p < .001$

As apparent from Table 12, all working memory spans (i.e., word span, syllable span and letter span) were significantly intercorrelated.

(R.Q.6) *Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?*

To promote clarity the above research question was subdivided into three subquestions:

(6.1) *Is there a significant developmental trend in word span across different grades?*

(6.2) *Is there a significant developmental trend in syllable span across different grades?*

(6.3) *Is there a significant developmental trend in letter span across different grades?*

To detect a pattern in the development of working memory, a comparison was made among kindergarten, Grades 1-5 and university to whom working memory spans were given. See Figure 4 for the visual demonstration of results.

Figure 4
Working Memory Spans
Across Kindergarten, Grades 1-5 and University

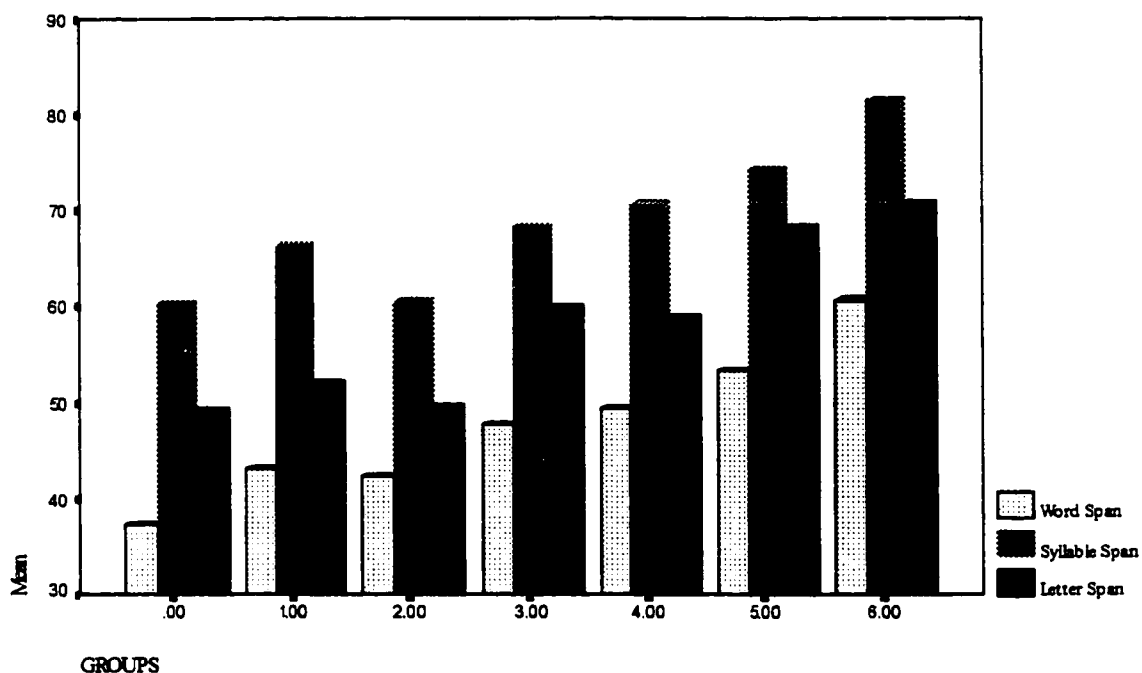


Figure 4 indicates developmental differences in memory spans among different groups of students. While university students revealed the best performance in all three spans of working memory, first graders had the worst. Grade-five students also appeared to be superior to their lower grades on all three tasks of working memory. With the exception of grade-two students who performed poorer than grade-one students in all tasks of working memory, other groups were developmentally different than their lower groups. See Table 13 for differences in the means and standard deviations.

Table 13
Means(%) and Standard Deviations
of Working Memory Spans for Kindergarten, Grades 1-5 and University

Span	Kindergarten	Grade 1	Grade 2	Grade 3
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Word Span	37.30(05.04)	43.13(10.25)	42.39(09.03)	47.66(11.17)
Syllable Span	60.32(16.44)	66.30(15.17)	60.51(18.50)	68.34(15.41)
Letter Span	49.20(14.88)	52.17(12.62)	49.63(14.10)	60.00(13.18)
Span		Grade 4	Grade 5	University
		Mean(SD)	Mean(SD)	Mean(SD)
Word Span		49.34(09.89)	53.33(12.50)	60.71(09.50)
Syllable Span		70.66(14.45)	74.34(15.00)	81.55(08.13)
Letter Span		59.00(11.26)	68.33(12.73)	70.84(09.10)

An examination of means and standard deviations in Table 13 indicates a developmental growth in working memory spans across different groups of subjects. The pattern of development in word span, syllable span and letter span ranged respectively from a mean score of 37.30%, 60.32% and 49.20% in kindergarten to 60.71%, 81.55% and 70.84% at university. The performance of all subjects in syllable span was much better than other spans, possibly suggesting that the syllable type of tasks are more easily recalled. The results of a series of one-way Anovas with the Scheffé posteriori test results are reported in Tables 14 and 15.

Table 14
One-Way Analysis of Variance
of Working Memory Spans for the General Sample,
Kindergarten, Grades 1-5 and University Combined
(N= 156)

Span	F-Value	P-Value
Word Span	F(7, 149)= 10.99	$p < .0001$
Syllable Span	F(7, 149)= 4.49	$p < .0005$
Letter Span	F(7, 149)= 9.24	$p < .0001$

Table 15
Scheffé Posthoc Test Results
of Word Span, Syllable Span and Letter Span

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	U
Kindergarten	WS	WS	WS	WS*	WS*	WS*
	SS	SS	SS	SS	SS	SS*
	LS	LS	LS	LS	LS*	LS*
Grade 1		WS	WS	WS	WS	WS*
		SS	SS	SS	SS	SS
		LS	LS	LS	LS*	LS*
Grade 2			WS	WS	WS*	WS*
			SS	SS	SS	SS*
			LS	LS	LS*	LS*
Grade 3				WS	WS	WS*
				SS	SS	SS
				LS	LS	LS
Grade 4					WS	WS
					SS	SS
					LS	LS
Grade 5						WS
						SS
						LS

*shows a significant difference at the .05 level.

WS= Word Span, SS= Syllable Span, LS= Letter Span

An analysis of variance in Table 14 reveals significant differences at the levels of $p < .0001$ and $p < .0005$ in all memory spans. The results of Scheffé posteriori analyses further indicated significant differences in almost all memory spans among university students and lower grades (i.e., kindergarten and Grades 1-3), favouring the university group. Grade-five students scored significantly higher than kindergarten and grade-two groups on word span and letter span. In letter span, grade-five students also performed significantly better than grade-one students. Second graders had an inferior performance to first graders' in all working memory tasks. However, this inferiority was minor and did not reach the significance level. Subsequent groups revealed no significant between-group differences in memory spans.

4.4.1 Concluding Remarks

4.4.1.1 Conclusion

The purpose of Phase Three of the study was to find if there is a significant correlation among working memory spans and, if a significant pattern of development exists in working memory.

The results of a series of correlation coefficients revealed significant intercorrelations among working memory tasks.

The univariate analysis of Anova with the Scheffé posteriori test detected developmentally significant differences among groups which were more pronounced in word span than the two others. Subsequent grades revealed no significant differences in the memory span tasks.

4.4.1.2 Answers to Research Questions 5-6

(R.Q.5) Is there a significant correlation among working memory spans?

Yes. The spans of working memory (i.e., word span, syllable span and letter span) were significantly intercorrelated.

(R.Q.6) Is there a significant developmental trend in working memory across different grades

in terms of the memory spans given?

Yes. A significant developmental trend was attained in all working memory spans.

4.5 Phase IV: Contribution of Phonological Awareness, Orthographic Knowledge and Working Memory to Reading and Spelling Achievement

Phase Four of the study was an attempt to answer the following research questions.

(R.Q.7) Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?

(R.Q.8) Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?

(R.Q.9) Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

(R.Q.10) Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?

(R.Q.7) Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?

To answer the first part of this question the correlation coefficient formula was computed. The results are reported in Table 16.

Table 16
Correlation Coefficients
Among Phonological Awareness Measures and Reading and Spelling Measures
(Grade 1, N= 23)

	RW	RNW	SW	SNW
Phoneme Blending	.40*	.38*	NS	.41*
Phoneme Segmentation	NS	NS	NS	.48*
Phoneme Deletion	.57***	.66**	.45*	.41*
Syllable Blending	.43*	.66**	NS	.53****
Syllable Segmentation	NS	NS	.34*	NS
Syllable Deletion	.57***	.58***	NS	NS

Two-tailed Significance, * $p < .05$, ** $p < .002$, *** $p < .005$, **** $p < .009$

NS= Not Significant

First graders' scores on phoneme blending correlated significantly with their scores on reading words, reading nonwords and spelling nonwords. Phoneme deletion had a significant correlation with all measures of reading and spelling, whereas phoneme segmentation correlated with spelling nonwords only. Though syllable blending and syllable deletion had significant correlations with reading measures, no significant correlation was addressed between syllable segmentation and reading measures. Similarly, syllable blending and syllable segmentation had a significant intercorrelation respectively with spelling nonwords and spelling words, whereas syllable deletion was not significantly related to spelling measures. To further investigate the nature of these relationships found above, four series of stepwise multiple regression were computed.

Table 17
Results of the Stepwise Multiple Regression
Analysis Using Phonological Awareness Tests as Predictors of
Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords
(Grade 1, N= 23)

Criterion Variable	Step	Predictor	R ²	Adjusted R ²	P
Reading Words	1	Phoneme Deletion	.33	.30	.003
Reading Nonwords	1	Phoneme Deletion	.44	.41	.0005
	2	Syllable Blending	.55	.51	.03
Spelling Words	1	Phoneme Deletion	.20	.16	.007
	2	Syllable Segmentation	.38	.37	.008
Spelling Nonwords	1	Syllable Blending	.28	.24	.008

As noted in Table 17, phoneme deletion made a substantial contribution to reading performance. That is, it accounted for 33% of the variance in reading words whereas other variables did not enter the predictive stepwise equation at all. Phoneme deletion and syllable blending were significant predictors of reading nonwords. They accounted respectively for 44% and 11% (.55-.44) of the variance. When spelling words was the criterion variable, its best predictors were phoneme deletion and syllable segmentation explaining a total of 38% of the variance. Syllable blending accounting for 28% of the variance was the only significant variable entering the multiple regression equation on spelling nonwords. Other variables did not enter the predictive equation and, therefore, they did not significantly contribute to encoding nonwords.

(R.Q.8) *Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?*

The results of a series of correlation coefficients and multiple regression analyses displayed in Tables 18 and 19 clarify the answer to the above research question.

Table 18
Correlation Coefficients
Among Orthographic Knowledge Measures
(Grade 1, N= 23)

	LN	LS	RW	RNW	SW	SNW	OC
Letter Name	—						
Letter Sound	.54**	—					
Reading Words	NS	NS	—				
Reading Nonwords	.46*	.40*	.64***	—			
Spelling Words	.40*	.42*	NS	.54**	—		
Spelling Nonwords	.66***	.56**	NS	NS	.71***	—	
Orthographic Choice	NS	NS	.44*	NS	NS	NS	—

Two-tailed Significance * $p < .05$, ** $p < .005$, *** $p < .001$

NS= Not Significant

Table 19
Results of the Stepwise Multiple Regression
Analysis Using Orthographic Knowledge Tests as Predictors
of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords
(Grade 1, N= 23)

Criterion Variable	Step	Predictor	R ²	Adjusted R ²	P
Reading Words	1	Reading Nonwords	.41	.39	.009
Reading Nonwords	1	Reading Words	.41	.39	.009
	2	Spelling Words	.57	.53	.001
Spelling Words	1	Spelling Nonwords	.50	.48	.001
	2	Reading Nonwords	.60	.56	.04
Spelling Nonwords	1	Spelling Words	.50	.48	.001
	2	Letter Name	.67	.64	.004

A brief look at Table 18 reveals that measures of orthographic knowledge correlated with reading and spelling measures ranging from nonsignificant to .71 ($p < .001$). Furthermore, as displayed in Table 19, when reading words was the criterion variable, only reading nonwords entered as the predictive variable presenting 41% of the variance. Reading words and spelling words were predictors of reading nonwords, accounting respectively for 41% and 16% of the variance. The test of spelling words was dependent first upon spelling nonwords and then reading nonwords, explaining a total of 60% of the variance. The best predictor of spelling nonwords was first spelling words occupying 50% of the variance, and then letter name occupying a small but significant portion of the variance (17%).

(R.Q.9) Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

To address the above research question, we consider Tables 20 and 21 in which the results of a series of correlation coefficients and multiple regression analyses are presented.

Table 20
Correlation Coefficients
Among Working Memory Spans and Reading and Spelling Measures
(Grades 1-5 and University Combined, N=135)

	RW	RNW	SW	SNW
Word Span	.44*	.37*	.37*	.37*
Syllable Span	.34*	.30*	.30*	.27**
Letter Span	.48*	.34*	.33*	.29*

Two-tailed Significance, * $p < .001$, ** $p < .002$

Table 21
Results of the Stepwise Multiple Regression
Analysis Using Working Memory Spans as Predictors
of Reading Words, Reading Nonwords, Spelling Words and Spelling Nonwords

Criterion Variable	Step	Predictor	R ²	Adjusted R ²	P
Reading Words	1	Letter Span	.23	.22	.0000
	2	Word Span	.27	.26	.004
Reading Nonwords	1	Word Span	.14	.13	.005
	2	Letter Span	.17	.15	.03
Spelling Words	1	Word Span	.13	.13	.006
	2	Letter Span	.16	.15	.04
Spelling Nonwords	1	Word Span	.13	.13	.0000

An examination of Tables 20 and 21 reveals interesting results. Significant correlations were found among working memory tasks and reading and spelling measures. Though reading words correlated significantly with all three spans of working memory, the best predictors of reading words were letter span and word span. This means the student's ability in reading words appeared to depend on his/her ability in letter span and word span. Similarly, reading nonwords and spelling words were primarily predicted by word span and secondarily by letter span. Word span explaining 13% of the variance was the only significant predictor of spelling nonwords.

(R.Q.10) Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?

Since phonological awareness measures and alphabetic knowledge tests were given to kindergartners and first graders, we investigated this research question by subdividing it into two subquestions:

(10.1) *Among phonological awareness, orthographic knowledge and working memory variables given to first graders, which variables are more strongly related to reading and spelling achievement?*

(10.2) *Among orthographic knowledge and working memory variables given to Grades 1-5 and university, which variables are more strongly related to reading and spelling achievement?*

(R.Q.10.1) *Among phonological awareness, orthographic knowledge and working memory variables given to first graders, which variables are more strongly related to reading and spelling achievement?*

To answer this research question, the multiple regression analysis was performed on the scores obtained from the first-grade group. The results are in Table 22.

Table 22

**Results of the Stepwise Multiple Regression Analysis
Using Phonological Awareness, Orthographic Knowledge and Working Memory
Tests as Predictors of Reading Words, Reading Nonwords, Spelling words and Spelling Nonwords
(Grade 1, N= 23)**

Criterion Variable	Step	Predictor	R ²	Adjusted R ²	P
Reading Words	1	Reading Nonwords	.41	.39	.0009
Reading Nonwords	1	Phoneme Deletion	.44	.41	.0005
	2	Syllable Blending	.55	.51	.02
Spelling Words	1	Word Span	.53	.51	.001
	2	Spelling Nonwords	.72	.69	.000
	3	Letter Name	.78	.75	.003
	4	Reading Nonwords	.83	.79	.002
	5	Syllable Blending	.87	.84	.01
Spelling Nonwords	1	Spelling Words	.50	.48	.001
	2	Letter Name	.67	.64	.003
	3	Word Span	.74	.70	.004
	4	Syllable Segmentation	.83	.79	.007

When including all variables in the computational system, reading nonwords was the only predictor of reading words. This means that if a student is good in reading nonwords, we can predict a good performance for him/her in reading words. The best predictors of reading nonwords were phoneme deletion and syllable blending explaining a total of 55% of the variance. Spelling words was significantly predicted by five variables. In the first step, word span entered presenting 53% of the variance. Spelling nonwords entered in the second step representing an additional 19% of the variance. In subsequent regression steps, letter name, reading nonwords and syllable blending entered explaining small but significant portions of the variance. With spelling nonwords as the criterion variable, spelling words, letter name, word span and syllable segmentation were significant contributors accounting respectively for 50%, 17%, 13% and 9% of the variance.

(R.Q.10.2) Among orthographic knowledge and working memory measures given to Grades 1-5 and university which variables are more strongly related to reading and spelling achievement?

To answer this research question, a series of stepwise multiple regression analyses was performed on the scores obtained from Grades 1-5 and university combined. Note that the variables involved were limited to orthographic knowledge and working memory .

Table 23
Results of the Stepwise Multiple Regression
Analysis Using Orthographic Knowledge and Working Memory Tests
as Predictors of Reading Words, Reading Nonwords, Spelling words and Spelling Nonwords
(N= 135)

Criterion Variable	Step	Predictor	R ²	Adjusted R ²	P
Reading Words	1	Orthographic Choice	.95	.95	.0000
	2	Reading Nonwords	.96	.96	.002
Reading Nonwords	1	Reading Words	.40	.39	.0000
	2	Spelling Nonwords	.46	.45	.0000
Spelling Words	1	Word Span	.13	.13	.0000
	2	Letter Span	.16	.15	.04
	3	Spelling Nonwords	.18	.17	.02
Spelling Nonwords	1	Reading Nonwords	.22	.21	.0000
	2	Spelling Words	.26	.25	.006

Excluding the tests of phonological awareness and alphabetic knowledge from the computational system, we arrived at similar results. The best predictors of reading words were orthographic choice and reading nonwords occupying a total of 96% of the variance. With reading nonwords as the criterion, reading words and spelling nonwords accounted for significant portions of the variance. Again spelling words relied on memory spans and encoding of nonwords. Representing a total of 26% of the variance, reading nonwords and word span appeared to be reliable predictors of spelling nonwords.

4.5.1 Concluding Remarks

4.5.1.1 Conclusion

The main objectives of Phase Four of the study were: a) to determine the correlation among measures of phonological awareness, orthographic knowledge, working memory, reading and spelling and, b) to detect the contribution of phonological awareness, orthographic knowledge and working memory separately and together to reading and spelling achievement.

Series of correlational analyses revealed that measures of phonological awareness, orthographic knowledge and working memory were correlated with measures of reading and spelling ranging from nonsignificant to significant.

The pattern of the relationship among phonological awareness, orthographic knowledge and working memory to reading and spelling achievement was further analysed jointly and individually with series of stepwise multiple regression analyses. The combined results indicated that: a) the best predictors of reading words appeared to be phoneme deletion, syllable blending, reading nonwords, orthographic choice, letter span and word span; b) the best predictors of reading nonwords appeared to be phoneme deletion, syllable blending, reading words, letter span and word span; c) the best predictors of spelling words appeared to be phoneme deletion, phoneme blending, syllable segmentation, letter name, reading nonwords, spelling nonwords, letter span and word span and; d) the best predictors of spelling nonwords appeared to be syllable blending, syllable segmentation, letter name, spelling words, reading nonwords and word span. All predictive variables explained a significant portion of the variance in the criterion variable.

4.5.1.2 Answers to Research Questions 7-10

(R.Q.7) Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. With a few exceptions (see 6.6), measures of phonological awareness revealed significant correlations with reading words, reading nonwords, spelling words and spelling nonwords.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was phoneme deletion.
- b. The significant predictors of reading nonwords were phoneme deletion and syllable blending.
- c. The significant predictors of spelling words were phoneme deletion and syllable segmentation.
- d. The significant predictor of spelling nonwords was syllable blending.

(R.Q.8) Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. With a few exceptions (see 6.6), measures of orthographic knowledge revealed significant correlations with reading words, reading nonwords, spelling words and spelling nonwords.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was reading nonwords.
- b. The significant predictors of reading nonwords were reading words and spelling words.
- c. The significant predictors of spelling words were spelling nonwords and reading nonwords.
- d. The significant predictors of spelling nonwords were spelling words and letter name.

(R.Q.9) Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. All measures of working memory significantly correlated with reading words, reading nonwords, spelling words and spelling nonwords.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictors of reading words were letter span and word span.
- b. The significant predictors of reading nonwords were word span and letter span.
- c. The significant predictors of spelling words were word span and letter span.
- d. The significant predictor of spelling nonwords was word span.

(R.Q.10) Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?

When entering all measures of phonological awareness, orthographic knowledge and working memory as predictors of reading and spelling measures and using the scores of first graders, we come up with the following predictors more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was reading nonwords.
- b. The significant predictors of reading nonwords were phoneme deletion, syllable blending and phoneme deletion.
- c. The significant predictors of spelling words were word span, spelling nonwords, letter-name knowledge, reading nonwords and syllable blending.
- d. The significant predictors of spelling nonwords were spelling words, letter name, word span and syllable segmentation.

When entering measures of orthographic knowledge and working memory as predictors of reading and spelling measures and using the scores of 135 students from Grades 1-5 and university combined, we come up with the following predictors more strongly related to reading and spelling achievement.

- a. The significant predictors of reading words were orthographic choice and reading nonwords.
- b. The significant predictors of reading nonwords were reading words and spelling nonwords.
- c. The significant predictors of spelling words were word span, letter span and spelling nonwords.
- d. The significant predictors of spelling nonwords were reading nonwords and spelling words.

4.6 Phase V: Discriminant Function and Number of Factors

Phase Five of the study was an attempt to answer the following research questions:

(R.Q.11) *What variables have the most discriminatory power to distinguish among groups?*

(R.Q.12) *How do different variables factor together?*

(R.Q.11) *What variables have the most discriminatory power to distinguish among groups?*

To address this question the discriminant function analysis was used to determine what variables contribute maximally to group distinction, and which have a less important role to discriminate among groups. Reading words, reading nonwords, spelling words, spelling nonwords, orthographic choice, word span, syllable span and letter span were the measures entered in the discriminant function procedure. To assess the importance of these variables, the pooled within groups correlation as well as the eigenvalue and percentage of variance were computed. The results are reported in Tables 24 and 25.

Table 24
Pooled Within-Groups Correlations
Among Discriminating Variables and Canonical Discriminant Functions
for Grades 1-5 and University Combined
(N= 135)

	Func 1	Func 2	Func 3	Func 4	Func 5
Orthographic choice	.7990*	.3639	.2950	.3679	.0323
Reading Words	.7631*	.1058	.6225	.0895	.0827
Spelling Words	.0012	.6988*	.5000	.4786	.1047
Reading Nonwords	.1000	.3467	.6802*	.2316	.2864
Spelling Nonwords	.0505	.1714	.1579	.6511*	.1385
Letter Span	.0658	.1515	.1818	.3843*	.2209
Word Span	.0585	.1520	.1352	.2231	.7416*
Syllable Span	.0396	.1601	.2421	.1231	.3822*

*denotes largest absolute correlation between each variable and any discriminant function.

Table 25
Eigenvalue and Percentage of Variance of Discriminant Functions
for Grades 1-5 and University Combined
(N= 135)

Function	Eigenvalue	Percentage of Variance
1*	70.7627	97.89
2*	1.0855	.50
3*	.2891	.40
4*	.1222	.17
5*	.0270	.04

*marks the 5 canonical discriminant functions remaining in the analysis.

An examination of Tables 24 and 25 reveals interesting results. In Table 24, variables were ordered by the size of the correlation within the function. Orthographic choice and reading words appeared to be the variables with the largest absolute correlation with Function 1. This indicated their largest discriminatory power among variables which was further supported in Table 25. Function 1 (including orthographic choice and reading words) with an eigenvalue of 70.76 had the strongest indication in between-group differences. Function 2 with an eigenvalue of 1.08 also contributed to group separation. However, since other functions had an eigenvalue less than one, they were not considered to play a significant contributing role in group separation.

(R.Q.12) How do different variables factor together?

Bivariate coefficients showed a linear relationship among different measures of phonological awareness, orthographic knowledge and working memory. Univariate analyses of variance with the Scheffé posteriori test indicated differences among groups on each variable. We did also attend to multivariate patterns of variables by computing series of stepwise multiple regression and discriminant function analyses. Though each type of analysis produced important information, we did not substantially establish how these variables factor together. In order to see how all variables involved in the study factor together, a principal factor analysis (with Equamax rotation) was conducted. Since phonological awareness measures and alphabetic knowledge tests were assigned to kindergarten and grade-one groups,⁴² the factor analysis was done with two sets of data: one taking into consideration the scores obtained from Grades 1-5 and university combined, the other considering scores obtained from Grade 1 only. See Tables 26 and 27 for the results.

⁴²The assumption was that an optimal level in phonological awareness and alphabetic knowledge (i.e., letter-name knowledge and sound-letter knowledge) is achieved by the completion of first grade.

Table 26

Initial Factor Analysis:

Factors, Eigenvalues and Percentages of Variance Accounted for
by Orthographic Knowledge and Working Memory Measures
(Grades 1-5 and University Combined, N= 135)

Factor	Eigenvalue	Percentage of Variance
1	3.8704	48.4
2	1.4074	17.6

Note: the correlation between the two factors is .67 ($p < .001$).

Table 27

Final Factor Analysis:

Loadings of Orthographic Knowledge and
Working Memory Measures on Factors after Equamax Rotation
(Grades 1-5 and University Combined, N= 135)

Variable	Factor 1	Factor 2
Word Span		.7048
Syllable Span		.6996
Letter Span		.6696
Reading Words	.9286	
Reading Nonwords	.8043	
Spelling Words		.7970
Spelling Nonwords	.5091	
Orthographic Choice	.9105	

As shown in Tables 26 and 27, two factors were computed for the eight variables involved with the six groups of subjects. These factors exceeded the eigenvalue ≥ 1 criterion

for number of factors, and they accounted for a total of 66% of the variance. Factor 1 comprised reading words, reading nonwords, spelling nonwords and orthographic choice. In Factor 2 the spans of working memory and spelling words were included.

The factor analysis procedure was repeated taking into consideration the scores of 23 first graders. The results are reported in Tables 28 and 29.

Table 28

Initial Factor Analysis:

**Factors, Eigenvalues and Percentages of Variance Accounted for
by Phonological Awareness, Orthographic Knowledge and Working Memory Measures
(Grade 1, N= 23)**

Factor	Eigenvalue	Percentage of Variance
1	6.4665	51.8
2	2.2727	18.9
3	1.6088	10.2
4	1.2875	8.2
5	1.2184	6.1

Having added phonological awareness and alphabetic knowledge variables to the factor analysis procedure, the computational system distinguished five factors. Factor 1 accounted for 51.8 percent of the variance. An additional 18.9 percent of the variance was explained by Factor 2. Factors 3, 4 and 5 accounted for the remaining portions of the variance. To load variables on the resulted factors, an Equamax rotation was performed. The results are in Table 29.

Table 29
Final Factor Analysis:
Loadings of Phonological Awareness, Orthographic
Knowledge and Working Memory Measures on Factors after Equamax Rotation
(Grade 1, N= 23)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Word Span			.7102		
Syllable Span			.8180		
Letter Span			.7453		
Syllable Blending	.5427			.5090	
Syllable Segmentation					.9346
Syllable Deletion	.7203				
Phoneme Blending	.7717				
Phoneme Segmentation	.6563				
Phoneme Deletion					.7288
Reading Words				.8181	
Reading Nonwords				.7491	
Spelling Words		.5214	.5706		
Spelling Nonwords		.8093			
Orthographic Choice				.7122	
Letter Name		.6073			
Letter Sound		.8550			

Note: The correlation among factors ranged from .41($p<.01$) to .78 ($p<.001$)

As Table 29 indicates, syllable blending, syllable deletion, phoneme blending and phoneme segmentation measures loaded on Factor 1. In Factor 2, letter sound, letter name, spelling words and spelling nonwords were loaded. Like the first procedure, Factor 3 comprised word span, syllable span, letter span and spelling words revealing their close relationship. As well, the components of Factor 4 were syllable blending, reading words,

reading nonwords and orthographic choice. Factor 5 included syllable segmentation and phoneme deletion. Spelling words and syllable blending had an option to be loaded on two alternate factors, the former on Factor 2 or 3, and the latter on Factor 1 or 4.

4.6.1 Concluding Remarks

4.6.1.1 Conclusion

The final phase of the study centred around two main objectives: first, to find what variables contribute most to group separation and, secondly, to detect how different variables are grouped together. The discriminant function analysis which is the linear combination of variables allowed us to know that orthographic choice and reading words appeared to possess the largest discriminatory power in group distinction. The principal components analysis with Equamax rotation allowed us to further figure out the answer to the second objective mentioned above. Taking into consideration the scores of grade-one students, the computational system explored five loading factors on which all variables of phonological awareness, orthographic knowledge and working memory were loaded. Excluding the phonological awareness and alphabetic knowledge tests from the computational system, two main factors rotated on the scores obtained from Grades 1-5 and university combined.

4.6.1.2 Answers to Research Questions 11-12

(R.Q.11) What variables have the most discriminatory power to distinguish among groups?

Orthographic choice and reading words appeared to have the largest discriminating power to distinguish among groups.

(R.Q.12) How do different variables factor together?

In the first attempt, taking into consideration scores of the general sample (Grades 1-5 and university) and including orthographic knowledge and working memory variables, we came up with two distinct but related factors.

Factor 1: Reading Words, reading nonwords, spelling nonwords and orthographic choice.

Factor 2: Word span, syllable span, letter span and spelling words.

In the second attempt, taking into account the scores of first graders and including the general variables (i.e., phonological awareness, orthographic knowledge and working memory), we came up with five distinct but related factors. Note that syllable blending and spelling words were loaded on two alternate factors.

Factor 1: Syllable blending, syllable deletion, phoneme blending and phoneme segmentation.

Factor 2: Letter sound, letter name, spelling words and spelling nonwords.

Factor 3: Word span, syllable span, letter span and spelling words.

Factor 4: Syllable blending, reading words, reading nonwords and orthographic choice.

Factor 5: Syllable segmentation and phoneme deletion.

CHAPTER FIVE

DISCUSSION

The purpose of this study was to analyse and synthesize different components of literacy acquisition including phonological awareness, orthographic knowledge and working memory. The study was divided into five phases: 1) phonological awareness, 2) orthographic knowledge, 3) working memory, 4) contribution of phonological awareness, orthographic knowledge, working memory to reading and spelling achievement and, 5) discriminant function and number of factors. We begin discussing these issues in this chapter by combining Phases 1, 2, 3 and 5 with their own relevant questions in Phase 4, as follows.

5.1 Phonological Awareness: Correlation, Development and Contribution to Reading and Spelling Achievement

This part discusses the following research questions previously addressed in Phases 1 and 4 of the study.

(R.Q.1) Is there a significant correlation among various measures of phonological awareness?

(R.Q.2) Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?

(R.Q.7) Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?

A number of research studies conducted in English looked seriously at the strong relationship between children's reading and their awareness of sound. Findings indicate that phonological awareness is a prime factor and the best predictor of success in learning to read (e.g., Adams 1990, Blachman 1989, Bradley and Bryant 1983, 1985, Liberman 1989, Lundberg, Frost and Peterson 1988, Mann and Liberman 1984, Pratt and Brady 1988). Additionally, many researchers have identified that deficits in phonological awareness are underlying severe word decoding problems displayed by reading disabled individuals (e.g.,

Bruck 1990, 1992, Frith 1981, Galaburda 1988, Liberman and Shankweiler 1985, Stanovich 1986).

In this study, the combined scores of kindergartners and first graders on tests of phonological awareness including syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion, correlated significantly with one another giving evidence to the construct validity of these tests. The two-tailed correlations ranged from .35 ($p < .01$) between syllable segmentation and syllable blending to .88 ($p < .001$) between phoneme deletion and phoneme segmentation.

Though kindergarten students received no formal instruction in syllabification, they performed much better in syllable awareness than phoneme awareness. In kindergarten, the total mean percentage of syllable awareness was four times the total mean percentage of phoneme awareness. For kindergarten students, syllable blending appeared to be the easiest task whereas phoneme deletion and syllable deletion were the most difficult. These findings are on a par with research findings in English that awareness of syllables develops early and without instruction (Morais et al. 1986, Wimmer et al. 1991), whereas the ability to segment phonemes appears to be a consequence of literacy development (e.g., Lie 1991, Morais et al. 1986, Perfetti et al. 1987, Read et al. 1986, Wimmer et al. 1991).

First graders had significant performance in syllable awareness and phoneme awareness tasks. They had a total mean percentage of 88.40 in syllable awareness and 88.01 in phoneme awareness. Despite the fact that first graders performed lower in syllable deletion and phoneme deletion than other tasks of phonological awareness, their performance on these tasks was respectively two times and twenty times higher than kindergartners'.

Liberman and colleagues (Liberman et al. 1974, Liberman and Shankweiler 1979, Shankweiler and Liberman 1976) have shown that the ability to segment a word into phonemes does not appear until about age five. Though kindergartners had an average age of 5 years 10 months, still phoneme awareness tasks were highly difficult for them. One possible reason is that phonemes constituting syllables overlap; therefore, analysing the acoustic signal into its

phonemes is hardly available for children who have not been exposed to formal reading instruction. This difficulty of phoneme segmentation is also observed by other researchers (e.g., Calfee, Chapman and Venezky 1972, Elkonin 1973, Gleitman and Rozin 1973, Helfgott 1976, Leong and Haines 1978). For both kindergartners and first graders, the phoneme blending task was easier than the phoneme deletion task. This gives further support to research findings in English. For example, Perfetti, Beck and Haughes (1981, mentioned in Yopp 1988) found that phoneme blending precedes the ability to delete phonemes as revealed in the performance of first-grade students. Yopp (1988) also demonstrated that phoneme blending is easier than phoneme deletion for kindergarten students.

For both kindergarten and grade-one students, phoneme deletion and syllable deletion were more difficult than other tasks of phonological awareness. Cognitively speaking, the syllable/phoneme deletion tasks are highly demanding since the child must first delete one syllable/phoneme from the initial, middle or final position of the word, hold the whole word in memory and then say what the remaining part of the word is.

Many researchers (e.g., see Liberman et al. 1974, Shankweiler and Liberman 1976) have suggested that it may be necessary to acquire phonological awareness abilities prior to learning to read. Others have suggested that these abilities may develop as a result of formal instruction or experience with print (e.g., see Olofsson and Lundberg 1983, Read et al. 1986). Since kindergartners in this study had some phonological awareness, it confirms that phonological awareness is developed in the course of learning speech and, since kindergartners scored lower on all tasks of phonological awareness than first graders, it further indicates that instruction enhances the pattern of development in phonological awareness. It is therefore suggested that preschool children should be exposed to activities involving the segmentation and manipulation of syllables and phonemes.

A significant developmental pattern in the acquisition of phonological awareness was addressed in this study. Compared to kindergartners, the performance of first graders was superior in all measures of phonological awareness. The results of a series of t-Tests revealed

a significant developmental growth ($p < .001$, $p < .005$) in syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion. Such results are in line with other research conducted in English (e.g., see Fox and Routh 1975).

The relationship between phonological awareness and reading and spelling achievement reached the significance level. Previous research conducted in English (or in other languages) has shown a high relationship between phoneme segmentation ability and success in reading at the earlier grade levels (e.g., see Liberman 1973, Liberman et al. 1974, Cardoso-Martins 1995). There continues to be a significant relationship between some levels of phonological awareness and reading and spelling achievement in Persian. First-grade children's scores on phoneme blending, phoneme deletion, syllable blending and syllable deletion showed a significant correlation with their scores on reading words and reading nonwords. Phoneme deletion was more strongly related to reading measures than spelling measures. Thus this present investigation clearly supports that children's ability to conceptualize and manipulate syllables and phonemes is important in early stages of reading and spelling.

Turning to the contribution of phonological awareness to reading and spelling achievement, the results of stepwise multiple regression analyses were interesting. Phoneme deletion accounted for 33% of the variance in reading words, 44% in reading nonwords and 20% in spelling words, entering multiple regression equations first in all instances. Syllable blending accounted for an additional 11% of the variance in reading nonwords. Note that it was the only variable that made a contribution of 28% in the variance of spelling nonwords. Despite the fact that phoneme blending, phoneme deletion, syllable blending and syllable deletion had significant correlations with reading words and reading nonwords, all of them did not enter the predictive equation. The best predictor of reading words was phoneme deletion, and the best predictor of reading nonwords was first phoneme deletion and then syllable blending. This means, that the child's ability to read words and nonwords can first be predicted by his ability to delete phonemes. In a similar vein, the child's ability to spell words is primarily predicted by phoneme deletion and secondarily by syllable segmentation. Though spelling nonwords

correlated significantly with both phoneme blending and syllable blending, only the latter had a predictive contribution to encoding nonwords.

Overall, this present research has supported the following theoretical views on phonological awareness: a) there is a close correlation among all measures of phonological awareness; b) there exist a sharp pattern of development in phonological awareness between kindergartners and first graders; c) phonological awareness is linked to exposure of both spoken and written language and; d) there are important predictive relationships between phonological awareness and reading and spelling achievement.

5.2 Orthographic Knowledge: Correlation, Development and Contribution to Reading and Spelling Achievement

This section is a discussion of the following research questions addressed before in Phases 2 and 4 of the study.

(R.Q.3) Is there a significant correlation among various levels of orthographic knowledge?

(R.Q.4) Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?

(R.Q.8) Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?

Research asserts that knowledge and skill of the alphabetic principle is a necessity for the acquisition of reading and spelling (Adams 1990, Chall 1967,1983, Gough and Hillinger 1980, Jorm and Share 1993, Liberman and Shankweiler 1979, Perfetti 1985, Williams 1986). However, as readers mature and get more knowledge and experience with print, phonological coding is accompanied or superseded by orthographic coding (see Coltheart 1978, Marsh et al. 1980, Pennington et al. 1987, 1990).

The Persian language is an alphabetic script and is made up of 32 letters which represent 22 segmental units. In this language, there is a one-to-one correspondence between

letters and sounds. However, this language is not always shallow, it represents some inconsistencies in terms of homophones, homographs, silent letters and the relationship between spoken and written language. Similar to the Hebrew language (see Frost 1992), Persian unvowelized writing further represents a deep language because "phonology is not only ambiguous but also incomplete."

Knowledge of the correspondence between phonemes and graphemes/graphemes and phonemes are vital in order to read and spell an alphabetic language such as English and Persian (see Amini 1997, Gough and Hillinger 1980, Gough and Turner 1986, Jorm and Share 1983, Stanovich 1986). To read and to spell, the child must internalize the alphabetic principle that speech is linearly encoded by sequences of graphemic symbols and that print is sounded out by sequences of phonological segments. This knowledge of the alphabetic principle would allow beginning readers to read and spell words reliably on phonetic grounds. Readers and spellers will obtain fluency if their decoding and encoding processes are rapid and automatic (see Adams 1990, LaBerge and Samuels 1974).

To chart the development of various levels of orthographic knowledge including letter-name knowledge, letter-sound knowledge, reading words, reading nonwords, spelling words, spelling nonwords and the use of analogy and phonology in reading and spelling of nonwords, series of means, standard deviations and univariate analyses of Anova with the Scheffé posteriori test were performed.

An examination of alphabetic knowledge given to kindergartners and first graders yielded interesting results. Kindergartners had a mean percentage of zero and 4.5% in letter-sound knowledge and letter-name knowledge tests, whereas first graders revealed almost a perfect performance with a mean percentage of 99.42 in the letter-sound knowledge test and 99.01 in the letter-name knowledge test. Without doubt, a sharp growth in alphabetic knowledge was patterned from kindergarten to first grade.

Reading nonwords also showed a steady progression across different grades. The mean percentage of reading nonwords in Grade one was 72.17, it reached 96.20 in Grade 5 and

97.50 at the level of university. Almost the same pattern of development was seen in spelling nonwords. The mean percentage of spelling nonwords ranged from 86.09 in Grade 1 to 94.20 in Grade five and 95.36 at university. The between-group differences in reading and spelling nonwords reached the significance level. When considering spelling words, grade-one students represented a distinct group since they significantly better performed in spelling words than students in Grades 2, 3 and 4.

We probed the use of the analogy strategy and phonetic strategy in reading and spelling of nonwords. Generally speaking, nonwords are read and spelled by grapheme-to-sound/sound-to-grapheme conversion rules. However, nonwords can also be read or spelled by analogy, a strategy which looks up a similar real word in the mental lexicon. For example, the nonsense word حوامر could be read phonetically, among others, as /havâhar/ or /hevâhar/, but analogically as /hâhar/, which resembles the real word خواهر /xâhar/ 'sister'. The nonword حوامر could be read or spelled by three mechanisms. The reader may employ a purely phonetic or analogic strategy. There is also the possibility that the reader employs a mixed strategy. That is, the first syllable of حوامر could be read or spelled through analogy and the second one through phonology. It is important to note that the nonword حوامر does not have a single spelling. Thus, هواحر, حواحر, حوامر and حاحر are equally correct since all show the plausible representations of the word. Following Frith (1980) and Treiman (1993), we consider حواحر and هواحر as conventional spellings, and the two others as unconventional or plausible. The conventional spellings, as Frith (1980) suggested, are selected on the basis of analogy with real words.

The use of analogy in reading and spelling of nonwords improved consistently from first grade to upper grades. University students revealed significantly more analogous responses in reading and spelling of nonwords. Conversely, other groups performed better than university students in phonetic responses, which was significant in spelling nonwords. Although university and fifth-grade students were comparable in all measures of orthographic knowledge, the results of the current study indicated reliable differences in the use of analogy and phonology between these two groups of students.

Baron (1977, 1979) noted that adult readers consistently use analogies to pronounce pseudowords. Similarly, Marsh et al. (1977) found that fifth-grade children use the analogy strategy as often as adults in a judgement task but not as often as adults in a production task. In their later study, Marsh et al. (1980) noted a marked developmental shift in the use of analogy strategy in spelling between Grades two and five. Similar to this situation in English, there are quantitative differences between the strategies used by young Persian children who are at the beginning stages of reading and spelling as well as older children and university students who are better readers and spellers. Students in upper grades were more willing to challenge orthographic reading and spelling of nonwords. This may be due to the fact that because of exposure to print, older children and university students have a vast repertoire of accurately pronounced or spelled words in the output lexicon and; therefore, they apply this knowledge base to generate analogous responses in reading and spelling of nonwords. Overall, my findings indicate that Persian children can use analogy in reading and spelling from the time they use alphabetic knowledge reliably. This further suggests that the analogy strategy is not only linked with skilled reading and spelling but also with beginning reading and spelling. This lends support to Goswami's (1988) finding.

Among various levels of orthographic knowledge, the sharpest development was seen in the use of orthographic choice. The F-value of the orthographic choice test revealed the highest between-group differences (170.55, $p < .0001$) which was significant in all grades even subsequent ones. However, grade-five and university students did not differ significantly in orthographic choice. The assumption that the use of orthographic skill increases with schooling grade is also supported by other research. For example, Azzam (1992) found that in reading Arabic grade-five and grade-six students made more use of orthographic skills than lower grades. She supported this finding by the following observations: a) almost total disappearance of sequencing errors in Grade six, b) noticeable decline of errors of additions and omissions in Grades five and six, c) considerable decrease of errors related to context sensitive rules such as Tanvin in Grade five and, d) a decreasing number of errors with increasing grade level. In

the present study, the performance of fifth graders and university students in orthographic choice was five times first graders' and three times second graders'. These results confirmed that all subjects attempted to employ the lexical strategy in recognizing spelling patterns available in the task of orthographic choice. However, university students tended to employ the lexical strategy more frequently than younger students. The fact that young children at the beginning stages of reading and spelling rely heavily on print-to-sound/sound-to-print correspondence rules is not surprising. Young children have very limited practice and exposure to print and, therefore, their repertoire does not allow them to employ the lexical strategy to a large extent in reading and spelling. On the basis of these findings, I suggest that reading and spelling in Persian have two routes in the course of development: a) a phonetic route (also called nonlexical/nonvisual/nonorthography route) and, b) an orthographic route (also called nonphonetic/lexical/visual route). While university students made the largest use of the orthographic route, beginning students demonstrated the least use of this route.

Another important objective of this study was to detect the correlation among reading, spelling and other measures of orthographic knowledge. Reading words had no significant correlation with spelling words, though it was significantly correlated with spelling nonwords. A significant correlation was further seen between reading words and orthographic choice as well as reading words and reading nonwords. When considering the scores of kindergarten and first graders separately and together, letter-name knowledge and letter-sound knowledge tests appeared to be significantly correlated in both cases. Spelling words and spelling nonwords were more strongly intercorrelated in Grade 1 ($r = .71, p < .001$) than the combined Grades of 1-5 and university ($r = .29, p < .01$)

Of interest here is the nonsignificant correlation between reading and spelling. In a simple definition, reading involves moving from print to sound whereas spelling requires moving from sound to print. However, the print-to-sound correspondence rules, which are employed at the beginning stages of reading, and which can be used for reading unfamiliar words at any stage of acquisition, are somewhat different from the sound-to-print rules of

spelling. The speller often has to make a choice between two or more alternatives. As a case in point the reading of **داس** /dâs/ certainly is unambiguous because there is only a single possible pronunciation. However, the spelling of **داس** is not simple because the speller has to choose the right spelling from three alternatives, all of which are plausible on phonetic grounds. If we add the possibility of different shapes of the letter **س** /s/ (i.e., **س**, **س**, **س**), the issue becomes more complicated since the right candidate must be selected from several alternatives. Therefore, in spelling, the child must identify the sounds in speech and convert them into appropriate symbols and then write them down in sequence. In the case of Persian, one more step is required, that is, the child must also identify the right grapheme among various alternatives. Thus it seems that the child cannot encode words as easily as s/he can decode them.

Another explanation for the nonsignificant relationship between reading and spelling performance could be related to the disparity between the number of phonemes and graphemes. For example, the word **خواهر** /xâhar/ has five phonemes but it is represented by six graphemic letters. Though in Amini (1997) it was tentatively proposed that the literacy stages employed for learning to read are also vital in learning to spell, at some point in the course of acquisition, reading and spelling seem to impose particular demands on learners. Unvowelized reading places particular demands for readers, especially beginners. Homophones, homographs and silent letters put additional demands on all spellers especially beginning students. Therefore, these script particularities may be another reason why reading and spelling did not reveal reliable intercorrelation.

Additionally, if reading and spelling were such highly related skills, we would expect competent readers/spellers in Persian also to perform competently in spelling/reading. However, good readers are not always good spellers (Gibson and Levin 1975). This reflects the fact that reading and spelling are two different processes tapping two different knowledge bases. Thus, a prediction of, e.g., spelling on the basis of reading performance would bring about inaccurate results.

The dissociation of reading and spelling has been argued by many researchers (e.g., Gibson and Levin 1975, Henderson and Chard 1980, Smith 1980).⁴³ Henderson and Chard (1980) viewed spelling and word recognition as two independent processes. To them, the fact that people can correctly read words that they cannot correctly spell is evidence that decoding and encoding share little correlation. Gibson and Levin (1975) suggested that a major difference between these skills relates to memory in that reading calls on recognition memory whereas spelling relies on the ability to recall. They conclude that the necessity to recall graphemes and spell words in the absence of any benefit from the environmental context is the factor that distinguishes spelling from reading. This apparent dissociation between reading and spelling was also confirmed in Persian by a series of stepwise multiple regression analyses. Neither spelling words nor reading words had a predictive role for each other. This means predicting, e.g., one's reading on the basis of spelling would not be very accurate.

Barron (1980) argues that spelling is a phonological, rule-governed cognitive behaviour, while recognition is a visual orthographic matching with a lexical entry. In a similar line, Smith (1980:48) demonstrates that "reading and spelling skills tap different components of our linguistics abilities: in particular, spelling appears to have a phonological component that is absent from reading." However, the findings of the present study do not support the idea that the distinction between reading and spelling is due to the dichotomy between visual and phonological processes. More specifically, the performances of different groups of students in the use of analogy and phonology in reading and spelling of nonwords revealed that readers and spellers in Persian employ both processes in decoding and encoding. However, greater reliance is placed on the phonetic strategy in the beginning stages of reading and spelling acquisition.⁴⁴

⁴³However, some other researchers argue for the view that reading and spelling are strongly related skills (e.g., Ehri 1978, 1980).

⁴⁴Amini (1997) hypothesized that beginning readers/spellers may read or spell visually using salient alphabetic features. Note that the visual strategy used by beginning readers/spellers differs from the visual strategy used by skilled readers/spellers. The visual strategy used by skilled readers and/or speller is the result of automatic reading and spelling, whereas the visual strategy used by beginners is the result of insufficient graphophonemic information.

The contribution of orthographic knowledge variables to reading and spelling achievement was determined by four stepwise multiple regression analyses using the scores of 23 first graders. For reading words as the criterion variable, reading nonwords was the best predictor explaining 41% of the variance; other variables did not enter the predictive equation, however. Reading words and spelling words contributed respectively 41% and 16% of the variance in reading nonwords. Spelling nonwords and reading nonwords had predictive contributions to spelling words. Similarly, the predictors of spelling nonwords were the tests of spelling words and letter-name knowledge explaining a total of 67% of the variance.

Overall, the developmental differences in orthographic knowledge found across different groups of subjects may be due to differences in the cognitive development and memory span system of individuals. It is quite well known that reading and spelling are not the same for all students at various stages of literacy development. Beginners who are at the alphabetic stage read and spell by letter-to-sound/sound-to-letter correspondence rules. In contrast, older students who are at the postalphabetic stage have greater exposure to the rules and structure of written language and can more easily access this knowledge base and apply it to new words. Therefore, we would expect to find automatic word recognition more readily in the performance of older students than younger students because the former are cognitively more mature and have a wider base of experience and knowledge (see Smith 1973). Moreover, the results of working memory tasks in the present investigation revealed that younger students have a poorer span than older students. If the acquisition of orthographic knowledge requires working memory skills, then we may suggest that students who have a large span would be able to hold information more efficiently while decoding and encoding words.

5.3 Working Memory: Correlation, Development and Contribution to Reading and Spelling Achievement

This section discusses the following research questions addressed previously in Phases 4 and 5 of the study.

(R.Q.5) Is there a significant correlation among working memory spans?

(R.Q.6) Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?

(R.Q.9) Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

There is considerable evidence that poor readers recall less information from memory span tasks (Katz and Deutsch 1964, Shankweiler et al. 1979, Torgesen and Houck 1980), and that poor readers make use of phonological processing in working memory less efficiently than do good readers (Baddeley 1982, Brady 1991, Liberman et al., 1977, Torgesen and Greenstein 1982, Wagner and Torgesen 1987). It thus seems reasonable to expect that older/more knowledgeable readers might do better on working memory tasks than younger/less knowledgeable readers.

Analysis of the data in the present study collected from 156 students in kindergarten, Grades 1-5 and university indicated that working memory spans were significantly related to each other giving evidence to the construct validity of these tests. All tests had almost the same strength ranging from $r = .54$ to $r = .56$ at the .001 level of significance. The highest correlation was seen between letter span and word span ($r = .56, p < .001$).

One of the most striking aspects of the data was the finding that there were significant correlations among all spans of working memory and reading and spelling measures. The correlation ranged from $r = .27$ ($p < .001$) between syllable span and spelling nonwords to $r = .48$ ($p < .001$) between letter span and reading words.

The degree to which reading and spelling achievement rely on working memory was given insight by looking into the multiple regression analysis results. R square revealed the relative importance of three working memory spans in the variance of reading and spelling measures. For reading words, letter span and word span were significant predictors suggesting that the ability to read words can be judged by the student's ability first in letter span and

then word span. The same two variables had the predictive role for reading nonwords and spelling nonwords, with the exception that word span was the first significant predictor and letter span was the second. For spelling nonwords, only word span entered the predictive equation.

Univariate analyses of Anova with the Scheffé posteriori test detected developmentally significant between-group differences in working memory which were more pronounced in word span than syllable span and letter span. University students revealed a significant performance in almost all memory spans to that of lower grades (i.e., kindergarten and Grades 1-3). In word span, grade-5 students performed significantly better than kindergarten, grade-one and grade-two groups. My findings are similar to other research findings. For example, in a study conducted with English-speaking children, Wagner et al. (1993) found that older students appeared to be much better at recalling digits presented to them both orally and visually. Similarly, Cacace and Mcfarland (1993) asserted that young children possess a memory span significantly shorter in length than adults.

An appropriate question here is on what factors the association between working memory and reading/spelling depend? Utilizing a sentence span task as a measure of working memory, Daneman and Carpenter (1980, 1983) found significant correlations between working memory and reading comprehension. They suggested that the interrelationship between reading and working memory is high because both share the same specific processes. Thus, according to Daneman and Carpenter (1980), working memory capacity is dependent on the particular process used to accomplish the task. Literature gives some support to the task oriented notion of working memory when applied to learning disabilities. For example, Fletcher (1985) found that children poor in arithmetics obtained lower scores on a visual-spatial memory task whereas children poor in the area of reading skills obtained lower scores on a verbal memory task. In contrast, some other researchers have suggested that there are different working memory systems (e.g., Smith and Jonides 1997), different codes and input modalities (e.g., Baddeley 1986), and that working memory capacity is independent of the task-related strategy (e.g.,

Turner and Engle 1989).

The model advanced by Turner and Engle (1989) competes with Daneman and Carpenter's. According to Turner and Engle, people's general working memory is independent of reading skill. Poor readers have weaker working memory than good readers because their memory-span length is shorter than good readers to perform either a reading or a nonreading related task. Baddeley (1986) has suggested that the process of different tasks involves the activation of different codes in working memory such as phonological code and semantic code. From a neuroimaging viewpoint, the study of Smith and Jonides (1997:5) indicates that: "a) there are different working memory systems for spatial, object and verbal information (with the spatial system localized more in the right hemisphere, and the verbal system more in the left hemisphere); b) within at least the spatial and verbal systems, separable components seem to be responsible for the passive storage of information and the active maintenance of information (with the storage component being localized more in the back of the brain, and the maintenance component in the front; and c) there may be separable components responsible for processing the contents of working memory (localized in prefrontal cortex)."

Incorporating the two theoretical views mentioned above (i.e., task and process oriented views of working memory), I speculatively suggest that two factors underlie individual differences in working memory in Persian: a) the efficiency with which the learners read and spell and, b) the general capacity system of individuals. My reason, though not clear-cut, is that if working memory relies solely on either the efficiency of reading and spelling tasks or the general capacity of individuals, we might not expect to find sharp between-group differences in orthographic choice ($F= 170.55, p<.0001$) and reading words ($F= 166.58, p<.0001$), but somehow low, though significant, between-group differences in letter span ($F= 9.24, p<.0001$), syllable span ($F= 4.49, p<.0005$) and word span ($F= 10.99, p<.0001$). Under the mixed proposal suggested for Persian, we would expect good readers/spellers to require fewer and faster processes than poor readers/spellers when reading and spelling words. For good readers and spellers, the phoneme-grapheme/grapheme-phoneme correspondence rule is easily and

readily accessible and may be accompanied or even superseded by faster lexical access. However, poor readers and spellers do not possess this efficiency since their reading and spelling require much attention and demand. We would also expect that, e.g., good readers and spellers with a large working memory capacity reveal a better performance in working memory tasks than other corresponding good readers and spellers with shorter memory span. Thus, under the task and process oriented notions of working memory, the superior performance in reading and nonreading tasks would be expected to be seen in the performance of high span good readers and/or spellers.

5.4 Discriminant Function, Number of Factors and Contribution of all Variables to Reading and Spelling Achievement

This section discusses the following questions addressed previously in Phases 4 and 5 of the study.

- (R.Q.10) *Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?*
- (R.Q.11) *What variables have the most discriminatory power to distinguish among groups?*
- (R.Q.7) *How do different variables factor together?*

Children's acquisition of reading and spelling does not occur in a vacuum; on the contrary, it is influenced by many factors (see Adams 1990, Harris and Sipay 1985). As previously addressed, reading and spelling achievement correlated with phonological awareness, orthographic knowledge and working memory. Using phonological awareness, orthographic knowledge and working memory variables to predict reading and spelling achievement, the stepwise multiple regression analyses yielded interesting results.

Taking into consideration the scores of first graders, the computational system distinguished reading nonwords to be the significant predictor of reading words. Phoneme deletion and syllable blending were predictive variables of reading nonwords. For spelling

words, word span accounted for the largest portion of the variance (53%). Still four other variables, i.e., spelling nonwords, letter name, reading nonwords and syllable blending, survived as independent predictors explaining small but significant portions of the variance in spelling words. Similarly, spelling nonwords was primarily dependent upon spelling words and then letter name, word span and syllable segmentation.

When repeating the stepwise multiple regression analysis with data collected from 135 students attending Grades 1-5 and university, we excluded phonological awareness and alphabetic knowledge measures from the computational system and used the remaining orthographic knowledge and working memory variables to predict reading and spelling achievement. The results revealed that the test of orthographic choice explaining 95% of the variance was the primary predictor of reading words leaving only 1% of the variance accounted for by reading nonwords. Reading nonwords was first predicted by reading words occupying 40% of the variance. After removing the variance accounted for by reading words, spelling nonwords accounted for a small but significant portion of the variance (4%) in reading nonwords. Spelling nonwords played a significant predictive role for spelling words. For spelling nonwords, reading nonwords as the first predictor and spelling words as the second predictor explained a total of 26% of the variance.

A discriminant function analysis confirmed that orthographic choice and reading words with a total eigenvalue of 70.76 appeared to possess the strongest indication in between-group differences. Henderson and Chard (1980) maintained that word recognition knowledge is more sophisticated than the knowledge used in spelling. Due to the omission of diacritic vowels, Persian has an entrance ambiguity of its own that perhaps makes reading more distinct than spelling. Thus, membership in higher levels of orthographic knowledge most likely involves strong word recognition skills. Note that reading and orthographic choice should be considered as recognition skills which are highly interdependent.

The final step in this investigation was to determine how different variables factor together. Two series of principal components analyses with Equamax rotation were conducted.

In the first, based on the scores of 135 students, a total of 8 variables belonging to working memory and orthographic knowledge constructs were incorporated. Two distinct but related factors were resulted. Factor 1 reflected orthographic knowledge measures including reading words, reading nonwords, spelling nonwords and orthographic choice. Measures of working memory together with spelling words factored out separately, supporting the existence of a strong link between these constructs.

In the second factor analysis, general variables (i.e., 16 variables) rotated leading to five distinct but related factors. Syllable blending, syllable deletion, phoneme blending and phoneme segmentation tests grouped in Factor 1. Factor 2 included spelling words, spelling nonwords, letter-name knowledge and letter-sound knowledge. In Factor 3, working memory spans and spelling words were grouped. Factor 4 comprised syllable blending, reading words, reading nonwords and orthographic choice. Factor 5 grouped together syllable segmentation and phoneme deletion.

The results of a series of correlation coefficients and multiple regression analyses also supported the strong link between these constructs factored out above. Integration of these constructs needs to be taken into consideration in the course of learning to read and spell Persian. As Hart (1983) suggests, one does not learn to ride a bicycle by separate practice on steering, pedalling and balancing. The integration and contribution of all these subskills makes possible the riding of a bicycle. Likewise, students learning to read and spell Persian must integrate the subskills of phonological awareness, orthographic knowledge and working memory.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

6.0 Orientation

This study generally endeavoured to explore the development of literacy acquisition in Persian first language learners. To achieve this multivariate goal, the study was administered in five phases and took into consideration the development of phonological awareness, orthographic knowledge and working memory, on the one hand, and their contribution separately and together to reading and spelling achievement as well as to group separation, on the other hand. The aforementioned variables constituted the basis for the following 12 research questions.

- (R.Q.1) *Is there a significant correlation among various measures of phonological awareness?*
- (R.Q.2) *Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?*
- (R.Q.3) *Is there a significant correlation among various levels of orthographic knowledge?*
- (R.Q.4) *Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?*
- (R.Q.5) *Is there a significant correlation among working memory spans?*
- (R.Q.6) *Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?*
- (R.Q.7) *Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?*
- (R.Q.8) *Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?*
- (R.Q.9) *Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly*

related to reading and spelling achievement?

(R.Q.10) *Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?*

(R.Q.11) *What variables have the most discriminatory power to distinguish among groups?*

(R.Q.12) *How do different variables factor together?*

6.1 Phonological Awareness: Research Questions 1-2

(R.Q.1) *Is there a significant correlation among various measures of phonological awareness?*

(R.Q.2) *Is there a significant developmental trend in phonological awareness across kindergarten and grade-one groups?*

The results of a series of correlation coefficients revealed that all phonological awareness measures were significantly intercorrelated. Moreover, a significant developmental trend in phonological awareness was charted between kindergarten students and first graders. First graders significantly outperformed kindergartners on all phonological awareness tasks. The differences, though significant, were less pronounced at the level of syllable awareness than phoneme awareness possibly suggesting that recognition and manipulation of syllables demand less cognitive effort.

6.2 Orthographic Knowledge: Research Questions 3-4

(R.Q.3) *Is there a significant relationship among various levels of orthographic knowledge?*

(R.Q.4) *Is there a significant developmental trend in the acquisition of orthographic knowledge?*

Various levels of orthographic knowledge were intercorrelated ranging from nonsignificant to .99. No significant correlation was detected between reading words and spelling words. The performances of different groups of students significantly differed in all levels of orthographic knowledge including: a) alphabetic knowledge (i.e., letter-name

knowledge and letter-sound knowledge), b) reading words, c) reading nonwords, d) spelling words, e) spelling nonwords, f) orthographic choice and, h) the use of analogy and phonology in reading and spelling of nonwords.

A significant progression developmentally was addressed in all measures of orthographic knowledge. First graders and university students were two distinct groups since the former had the lowest performance in almost all experimental tasks while the latter outperformed all groups in almost all tasks. The sharpest developmental differences were seen in reading words and orthographic choice. This suggests that a primary level of literacy in Persian requires the ability to read words and to recognize orthographic choice, and that membership in an advanced level of literacy in Persian requires a good command in reading words and orthographic choice. Except for the use of phonetic responses in reading and spelling of nonwords, university students were superior to lower level students in all measures of orthographic knowledge. The performance of fifth graders compared to the performance of university students in all measures except for the use of analogy and phonology in reading and spelling of nonwords.

Of special interest here is the significant between-group differences found in orthographic choice and in the use of analogy and phonology in reading and spelling of nonwords. Students in all grades made use of both phonology and analogy indicating that: a) reading and spelling are not completely visual or phonological across different grades and, b) the analogy strategy is not merely a strategy characteristic of upper grades (i.e., skilled readers). More analogous responses were seen in spelling nonwords than in reading nonwords. The use of more analogous responses in spelling nonwords than reading nonwords contradicted the findings of earlier research in English (e.g., see Kay and Marcel 1981) which demonstrated that the use of analogy is more apparent in reading than in spelling. According to the findings of the present study, university students had the largest portion of analogous responses in spelling nonwords whereas first graders had the least. In a similar line, all groups improved on orthographic choice as grade level increased and performed at a significantly different level of

competence from one another. Overall, these findings support the idea that the visual route to the lexicon is more accessible for skilled students than less-skilled students.

6.3 Working Memory: Research Questions 5-6

(R.Q.5) *Is there a significant correlation among various spans of working memory?*

(R.Q.6) *Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?*

Working memory spans (i.e., word span, syllable span and letter span) appeared to have a significant bivariate relationship with one another. Moreover, a significant pattern of growth was confirmed in working memory in the general sample consisting of kindergarten, Grades 1-5 and university students. The between-group differences in word span was higher than other spans possibly suggesting that word span is a reliable task to distinguish different groups of learners. Students in upper grades recalled more information in working memory tasks than students in lower grades. Significant differences in all working memory spans were found between university students and lower grades (i.e., kindergarten and Grades 1-3), favouring the university group. Subsequent groups revealed no between-group differences in all working memory spans.

6.4 Interrelation and Contribution of all Variables to Reading and Spelling

Achievement: Research Questions 7-10

(R.Q.7) *Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more strongly related to reading and spelling achievement?*

(R.Q.8) *Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?*

(R.Q.9) *Is there a significant relationship among measures of working memory and measures*

of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

(R.Q.10) Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?

First graders' scores on experimental phonological awareness tests correlated with their scores on reading words, reading nonwords and spelling nonwords, ranging from nonsignificant to significant. The bivariate relationships were also confirmed at the multivariate level. The first three multiple regression analyses considered phoneme deletion as the prime predictor of reading words, reading nonwords and spelling words. In the second step, reading nonwords and spelling words were dependent respectively on syllable blending and syllable segmentation. Similarly, with spelling words as the criterion variables, syllable blending accounted for a significant portion of the variance.

The fact that phonological awareness is the best predictor of success in learning to read (e.g., Wagner and Torgesen 1987) has been demonstrated not only for English, but also cross-linguistically for other languages such as Danish (Brennun and Ireson 1997, Lundberg, Frost and Peterson 1988, Olofsson and Niedersoe 1997), French (Algeria, Pignot and Morais 1982), German (Landerl, Linortner and Wimmer 1992), Italian (Cossue et al. 1988), Portuguese (Cardoso-Martins 1995), Russian (Elkonin 1973) and Swedish (Lundberg, Olofsson and Wall 1980). This continued to be supported in Persian, suggesting perhaps that phonological awareness has a universal validity in alphabetic languages.

Ignoring a few exceptions, correlation coefficients also revealed significant interrelations among measures of orthographic knowledge and reading and spelling. It was important to see the bivariate level at the multivariate level by considering which variables contribute significantly to reading and spelling measures. Reading words and reading nonwords were the primary predictors for each other suggesting that the better a student performs on reading words the better s/he is likely to do in reading nonwords. Reading nonwords was secondarily dependent on spelling words. With spelling words as the criterion variable, spelling

nonwords and reading nonwords entered the predictive equation. Similarly, spelling nonwords was dependent first upon spelling words and then letter name. This indicates that a student's spelling level and letter-name knowledge are likely to be good indicators of his/her spelling nonwords level.

Significant correlations were found among working memory spans and reading and spelling measures. Though reading words correlated significantly with all three spans of working memory, the best predictors of reading words were letter span and word span. This means the student's ability in reading words appeared to depend on his/her ability in letter span and word span. Similarly, reading nonwords and spelling words were predicted first by word span and secondly by letter span. Word span also appeared to have a predictive role for spelling nonwords.

Since phonological awareness and alphabetic knowledge tests were given to kindergartners and first graders, we divided Research Question 8 into two subquestions. First, we investigated the contribution of general variables including phonological awareness, orthographic knowledge and working memory to reading and spelling achievement using the scores of first graders only. Second, excluding phonological awareness measures and alphabetic knowledge tests, we investigated the contribution of orthographic knowledge and working memory to reading and spelling achievement in a larger sample consisting of Grades 1-5 and university.

When including the scores of phonological awareness and alphabetic knowledge tests in the computational system of multiple regression analysis, reading nonwords was the only significant predictor of reading words. This means that if a student is good in reading nonwords, we would predict a good performance for him/her in reading words. The best predictors of reading nonwords were phoneme deletion and syllable blending explaining significantly a large portion of the variance. The ability to spell words was predicted by five variables entering the regression equation in the following order: word span, spelling nonwords, letter name, reading nonwords and syllable blending. The predictors distributed themselves

somewhat similarly with respect to spelling nonwords. That is, the best predictors of spelling nonwords appeared to be spelling words, letter name, word span and syllable segmentation explaining significant portions of the variance. However, with reading nonwords as the criterion variable, memory spans never entered the predictive equation.

When excluding the phonological awareness and alphabetic knowledge tests from the computational system, the multiple regression analysis was performed on the scores obtained from Grades 1-5 and university. The best predictors of reading words were orthographic choice and reading nonwords occupying almost the whole portion of the variance. Reading nonwords relied on reading words and spelling nonwords. With spelling words as the criterion variable, word span, letter span and spelling nonwords were significant contributors to the predictive equation. Similarly, spelling words dependent on reading nonwords and spelling nonwords occupying significant portions of the variance.

6.5 Discriminant Function and Number of Factors: Research Questions 11-12

(R.Q.11) What variables have the most discriminatory power to distinguish among groups?

(R.Q.12) How do different variables factor together?

Results of the discriminant function analysis confirmed the results obtained from the correlation coefficients and the univariate analyses of Anova.⁴⁵ Orthographic choice and reading words appeared to have the largest discriminatory power to distinguish among groups.

The results of two sets of factor analysis revealed interesting results. When considering the scores obtained from Grades 1-5 and university, two factors were computed for the eight variables involved with the six groups of subjects. Factor 1 reflected orthographic knowledge. The second factor pertained to memory spans and spelling words. Having added the phonological awareness and alphabetic knowledge variables to the factor analysis procedure, the computational system considered the scores of first graders and distinguished five

⁴⁵Recall that we obtained an almost perfect correlation between reading words and orthographic choice. At the univariate analysis, the largest between-group differences belonged to reading words and orthographic choice.

substantial factors. Factor 1 comprised phonological awareness measures. Factor 2 was related to lower levels of orthographic knowledge. Like the first procedure, the constructs of working memory were represented by a single factor (i.e., Factor 3) tapping their close relationship. Factor 4 can be interpreted to reflect mainly higher levels of orthographic knowledge. Syllable segmentation and phoneme deletion were the components of Factor 5. The results of the two procedures above uniquely revealed that there is only one level in the theoretical construct of working memory. Merging the results from the two factor analysis above, the possibility of two distinct but related levels in the construct of orthographic knowledge can be assumed. Similarly, the construct of phonological awareness would be subdivided into two levels depending perhaps on the cognitive complexity of the tasks. Given a stronger correlation among measures of phoneme awareness, and a moderate correlation among measures of syllable awareness and phoneme awareness, the possibility of dividing them into more than one level seems logical.

Overall, the correlation coefficients, multiple regression and principal components analyses provided in the present study indicate that phonological awareness, orthographic knowledge and working memory are related components of literacy development in Persian. These components make up an integrated system. Consequently, the deficiencies in one of these constructs could be underlying causes of reading and spelling disability in Persian.

6.6 Answers To Research Questions

(R.Q.1) Is there a significant correlation among various measures of phonological awareness?

Yes. Various measures of phonological awareness, i.e., syllable blending, syllable segmentation, syllable deletion, phoneme blending, phoneme segmentation and phoneme deletion were significantly intercorrelated with one another.

(R.Q.2) Is there a significant developmental trend in phonological awareness across

kindergarten and grade-one groups?

Yes. A significant developmental trend was charted at the syllable and phoneme levels.

(R.Q.3) Is there a significant correlation among various levels of orthographic knowledge?

Yes. With a few exceptions, various levels of orthographic knowledge (i.e., letter-name knowledge, letter-sound knowledge, reading words, reading nonwords, spelling words, spelling nonwords and orthographic choice) were significantly intercorrelated. The exceptions to the correlational trend are (refer to Table 5):

- a. Reading words and orthographic choice had no significant correlations with the tests of letter-name knowledge, letter-sound knowledge and spelling words.
- b. Reading nonwords had no significant correlation with spelling words.

(R.Q.4) Is there a significant developmental trend in the acquisition of orthographic knowledge across different grades?

Yes. A significant developmental trend was observed in all the levels of orthographic knowledge across different grades.

(R.Q.5) Is there a significant correlation among working memory spans?

Yes. With no exception, the spans of working memory (i.e., word span, syllable span and letter span) were significantly intercorrelated.

(R.Q.6) Is there a significant developmental trend in working memory across different grades in terms of the memory spans given?

Yes. A significant developmental trend was attained in all spans of working memory.

(R.Q.7) Is there a significant relationship among measures of phonological awareness and measures of reading and spelling? If so, which aspects of phonological awareness are more

strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. Generally, measures of phonological awareness correlated significantly with reading words, reading nonwords, spelling words and spelling nonwords. However, there were some exceptions to the correlational trend (refer to Table 16). These exceptions are:

- a. Phoneme blending and syllable blending had no significant correlations with spelling words.
- b. Phoneme segmentation had no significant correlation with reading words, reading nonwords and spelling words.
- c. Syllable segmentation had no significant correlation with reading words, reading nonwords and spelling nonwords.
- d. Syllable deletion had no significant correlation with spelling words and spelling nonwords.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was phoneme deletion.
- b. The significant predictors of reading nonwords were phoneme deletion and syllable blending.
- c. The significant predictors of spelling words were phoneme deletion and syllable segmentation.
- d. The significant predictor of spelling nonwords was syllable blending.

(R.Q.8) Is there a significant relationship among measures of orthographic knowledge and measures of reading and spelling? If so, which aspects of orthographic knowledge are more strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. In general, measures of orthographic knowledge revealed significant correlations with reading words, reading nonwords, spelling words and spelling nonwords. However, there were some exceptions to the correlational trend (refer to Table 18). These exceptions are:

- a. Reading words had no significant correlations with letter-name knowledge, letter-sound knowledge, spelling words and spelling nonwords.
- b. Orthographic choice had no significant correlations with letter-name knowledge, letter-sound knowledge, reading nonwords, spelling words and spelling nonwords.
- c. Reading nonwords had no significant correlation with spelling words.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was reading nonwords.
- b. The significant predictors of reading nonwords were reading words and spelling words.
- c. The significant predictors of spelling words were spelling nonwords and reading nonwords.
- d. The significant predictors of spelling nonwords were spelling words and letter name.

(R.Q.9) Is there a significant relationship among measures of working memory and measures of reading and spelling? If so, which aspects of working memory are more strongly related to reading and spelling achievement?

Answer to the First Part of the Question

Yes. With no exception, all measures of working memory significantly correlated with reading words, reading nonwords, spelling words and spelling nonwords.

Answer to the Second Part of the Question

The following predictors were more strongly related to reading and spelling achievement.

- a. The significant predictors of reading words were letter span and word span.
- b. The significant predictors of reading nonwords were word span and letter span.
- c. The significant predictors of spelling words were word span and letter span.
- d. The significant predictor of spelling nonwords was word span.

(R.Q.10) Among all variables involved in the study, which variables are more strongly related to reading and spelling achievement?

When entering all measures of phonological awareness, orthographic knowledge and working memory as predictors of reading and spelling measures and using the scores of first graders, we come up with the following predictors more strongly related to reading and spelling achievement.

- a. The significant predictor of reading words was reading nonwords.
- b. The significant predictors of reading nonwords were phoneme deletion, syllable blending and phoneme deletion.
- c. The significant predictors of spelling words were word span, spelling nonwords, letter-name knowledge, reading nonwords and syllable blending.
- d. The significant predictors of spelling nonwords were spelling words, letter name, word span and syllable segmentation.

When entering measures of orthographic knowledge and working memory as predictors of reading and spelling measures and using the scores of 135 students from Grades 1-5 and university combined, we come up with the following predictors more strongly related to reading and spelling achievement.

- a. The significant predictors of reading words were orthographic choice and reading nonwords.
- b. The significant predictors of reading nonwords were reading words and spelling nonwords.
- c. The significant predictors of spelling words were word span, letter span and spelling nonwords.

d. The significant predictors of spelling nonwords were reading nonwords and spelling words.

(R.Q.11) What variables have the most discriminatory power to distinguish among groups?

Orthographic choice and reading words appeared to have the largest discriminatory power to distinguish among groups.

(R.Q.12) How do different variables factor together?

In the first attempt, taking into consideration the scores of the general sample (Grades 1-5 and university) and including orthographic knowledge and working memory variables, we came up with two distinct but related factors.

Factor 1: Reading Words, reading nonwords, spelling nonwords and orthographic choice.

Factor 2: Word span, syllable span, letter span and spelling words.

In the second attempt, taking into account the scores of first graders and including the general variables (i.e., phonological awareness, orthographic knowledge and working memory), we came up with five distinct but related factors. Note that syllable blending and spelling words were loaded on two alternate factors.

Factor 1: Syllable blending, syllable deletion, phoneme blending and phoneme segmentation.

Factor 2: Letter sound, letter name, spelling words and spelling nonwords.

Factor 3: Word span, syllable span, letter span and spelling words.

Factor 4: Syllable blending, reading words, reading nonwords and orthographic choice.

Factor 5: Syllable segmentation and phoneme deletion.

6.7 Educational Implications

The present study has potential implications on both theoretical and practical levels as follows.

a. The kindergartners in the present study had serious difficulties in phoneme awareness and

had no knowledge of the alphabetic principle. They are neither cognitively disabled nor learning disabled but rather curricularly disabled. That is, their difficulties may have been due not to deficits in children but to the reading curriculum. The Persian curriculum in preschool needs to be revised in such a way so that kindergarten students be exposed to learning phonological awareness and alphabetic knowledge information.

- b. A significant developmental growth was seen in all measures of phonological awareness and orthographic knowledge indicating that we have to consider these variables as high-level cognitive processes and complex perceptual skills which develop systematically in the course of acquisition. In this framework, the focus of schooling must change from teaching to learning, from passive acquisition of information to active acquisition of solving problems. This transition makes the role of both teachers as problem advisers and students as problem solvers important. Activities, assignments, assessments and instruction must meet the needs of individuals and fulfill the goals on which the curriculum is based.
- c. This study demonstrated that reading nonwords and spelling nonwords are important variables contributing to reading and spelling achievement. The contribution of these variables should be addressed in the curriculum.
- d. This study also demonstrated that working memory has important contributions to reading and spelling achievement. Its importance should be emphasized in the reading curriculum.
- e. This study further revealed evidence that syllable awareness and phoneme awareness are linked to reading and spelling ability. Thus, children need to be involved in activities which will assist them in developing an ear for phonemes and syllables in words. Singing and rhyming games all help prepare children for the beginning reading stage.
- f. Based on the results of the study, students in different grades may fall into one of four categories reflecting their level of competency: nonalphabetic, alphabetic, nonautomatic and automatic. Each group of students needs separate instructional approaches, with various types of practice and different amounts of time devoted for each practice (that depend on the phase of reading and spelling acquisition). Kindergarten children appear to have a

particular difficulty in phoneme awareness and alphabetic knowledge that may result in later reading and spelling difficulties. This youngest group of students needs a phonics instruction to systematically learn decoding and encoding skills. It is highly doubtful that for these children an instruction that emphasizes whole language would be as helpful as a phonics instruction is.⁴⁶The method of Baghchiban used in Iran over years for reading instruction in first grade would be a good method for teaching kindergartners since it emphasizes one-to-one correspondence between phonemes and graphemes in reading and spelling. Thus, the preschool reading curriculum is suggested to be merged with this instructional approach. The alphabetic students, referring here to students who have almost completed Grade one, have acquired the alphabetic principle. What they need is to enhance the abstract conceptualization of grapheme-phoneme association by reading various simple stories and prose. A method which emphasizes more whole-word approach seems to be helpful for this group of students. Nonautomatic readers have acquired the basic skills for decoding and encoding of words. In other words, they do not need decoding and encoding instruction to read and spell a word since their decoding and encoding abilities have reached an adequate level in these respects. What they do need is practice to develop automatization in decoding and encoding skills. The type of instruction that might be helpful is the whole-word instruction whereby they can benefit from reading by choice and reading in context. Moreover, they need to be exposed to a variety of readings such as genres, poems and prose that will help them meet the demands of coping with new vocabulary, concepts and text organization they will encounter. Further, given the fact that homophones in spelling and intrinsic ambiguity of unvowelized reading in Persian create difficulty for all groups of learners, practice and exposure to different types of material would be helpful even for

⁴⁶Algeria, Pignot and Morais (1982) found that children receiving phonics instruction developed phonological awareness faster than those who were exposed to the whole-word method. Similarly, Jorm and Share (1983) also found that students who were taught phonics progressed further in reading than children who were taught by the whole-word method.

automatic readers referring here to university students and possibly fifth graders.⁴⁷

- g. Though a method respecting the needs of students would ensure that students understand what they are presented, the connections between students and textbooks cannot be ignored. If the reading textbook is better matched to the student's ability, there is a tendency for them to read longer and to communicate better (Fry 1990). Thus, textbooks must be readable in that they must not exceed the student's ability. Semantic and syntactic factors are two major inputs for measuring the readability of a text (see Fry 1977, 1990, Chall and Dale 1995). The semantic factor is measured by word difficulty and the syntactic factor is measured by the number of words in a sentence (see Fry 1990 to read how readability formulas work).
- h. As in English, reading and spelling achievement in Persian is linked to phonological awareness. Thus, the appropriate question raised here is: What types of assessment are good to test phonological awareness? Since there are no standard phonological awareness tests in Persian, there is an increasing need to develop such tests. This researcher has developed her own tests of phonological awareness. Some practitioners may wish to use these tests as a base for the development of standardized tests, or may wish to develop their own measures of phonological awareness. When developing phonological awareness tests in such alphabetic languages as Persian, we should bear in mind that phonological awareness tasks involve spoken language and not written form. Therefore, students are not required to read or write but analyse spoken units given by an examiner. Secondly, phonological awareness tasks vary considerably in the level of difficulty. Such simple tasks as syllable awareness and rhyme awareness measure the recognition and manipulation of syllables and rhyming units.

⁴⁷Gibson and Levin (1975) recommend the flexible use of all sources of information: phonological, graphemic, semantic and syntactic for reading and reading comprehension. Although they recognize that some students and some subskills require more practice and emphasis than others, Gibson and Levin argue that drills on separate subskills create a new problem for students. They propose a multilevel approach emphasizing that subcomponents of a skill should never be practiced in isolation, but only within a meaningful context and in relation to other levels. Relatedly, considering reading as a unitary skill comprising of integrated subskills, Vernon (1957) postulates two causes of reading failure: a) failure to understand reading in the cognitive phase and, b) failure to integrate the developing subskills which are prerequisites for attaining mastery and automaticity.

They can be easily learned through simple poems and mothers' lullabies. Cognitively more demanding tasks such as phoneme awareness require the recognition and manipulation of sound segments. This type of task is substantially related to exposure to written material and formal reading instruction.

- i. Unlike the multitude of standardized tests for measuring word-recognition skills in English in decoding, encoding and orthographic choice, there are no standardized tests of word recognition and spelling assessment in Persian. In the present study, the tests developed to measure orthographic knowledge can be a base for the development of standardized tests in Persian. In assessing children's word recognition and spelling ability, practitioners should keep in mind that decoding and encoding are the basic skills that beginning readers and spellers need. Thus, thoughtful attention must be paid for preparing and designing them. In order to help children achieve the alphabetic principle more efficiently, reading textbooks and alphabet books should be designed with a variety of lively pictures and bright colours. Moreover, words demonstrating alphabetic letters must be interesting and in the child's word repertoire. Abstract words must be avoided as far as possible unless they serve religious purposes. Another technique useful for developing symbol-sound association is repeating a word to trace a letter through singing, clapping and playing. 'Bâbâ Zangir Bâft,'⁴⁸ a popular Persian game, is recommended here. Through this game the teacher and children

⁴⁸Bâbâ Zangir Bâft is a traditional game used also for teaching alphabet. This game can be summarized as below with the teacher and children serving as participants.

Teacher: bâbâ zangirbâf! (an old man who makes chains is called 'babazangirbaf')

Children: bale! (Yes!)

Teacher: zangir-e-ma râ bâfti?! (Did you make my chain?!)

Children: bale! (Yes!)

Teacher: pošt-e kuh andâxti?! (Did you throw it behind the mountain?!)

Children: bale! (Yes!)

Teacher: bâbâ âmade, çi çi âvorde, noxod-o kišmiš, boxor-o biyâ, be sedây-e çi? (Dad has come back; what he has brought; hickpeas and raisins, eat them and come back, and now with what voice?!)

Children (with the help of the teacher): gorbe (e.g.) (cat)

Children and teacher: g, g, g, g, g, g,...

Note that each time the name of an animal is given and the initial letter of the word is repeated.

happily sing, clap and finally say the name of an animal (serving as a key word) so that they trace, repeat and learn an alphabetic letter.

- j. To help children acquire accurate word recognition abilities and encoding skills, they need to be taught to make full use of the phonological information available in a word. One possible technique is that if the child reads or spells a word partially (e.g., آبد /âbâd/ is spelled or read as آبد), s/he should be taught in a caring manner by a comparison made between his misreading and/or misspelling and the correct reading and/or spelling. Words and nonwords of different lengths are suggested here. But note that too much correction and individual attention may bring about negative emotional and educational results.
- k. To help children acquire correct spelling of words, they need practice to acquire the word visually and semantically. This is because homophones making orthographic choice words are highly demanding. Even skilled spellers sometimes wonder which spelling to choose. One suggestion for practitioners is to develop and categorize such words based on the semantic family of words. For example عادل 'just', عدالت 'justice', عدل 'justice' can be grouped together. Beginners should be encouraged to memorize them on purely visual analysis. Gradually, they should be encouraged to make use of semantic and syntactic contexts.
- l. To help children develop automatic word recognition, they should be exposed to a variety of exercises, genres and discourse types such as prose, poems, dialogue, etc. They should be encouraged to memorize a dialogue, to recite a poem, to repeat an exercise, to discuss the reading assignment and to read with accuracy and speed. The teachers and students should keep in mind that automaticity of any task is achieved when it is no longer requires the attention of the doer (e.g., Hasher and Zacks 1979, Schneider and Shiffrin 1977, Shiffrin and Schneider 1977), which is in turn achieved through practice (see Hogaboam and Perfetti 1978).⁴⁹

⁴⁹Hogaboam and Perfetti (1978) manipulated the frequency of exposure to pseudowords and found that both skilled and unskilled readers become faster with exposure; however, the less skilled readers progressed much more with practice.

- m. Overall, Persian curricula need to take into account the subskills required in the development of reading and spelling. According to the present investigation, the subskills a student integrates with reading and spelling achievement are phonological awareness, orthographic knowledge and working memory.

6.8 Limitations of the Study

The results, conclusions and implications from this research must be interpreted with a knowledge of several limitations inherent in this study and its design.

- a. The data were collected from a relatively small number of children in each grade; consequently, the data pertaining to each may not generalize to a broader school population. A broader sampling therefore will be needed to generalize the results.
- b. Children were categorized by grade level whereas grouping according to, e.g., the stage of word recognition may yield more accurate implications.
- c. Subjects came from a population of students with normal intelligence and, therefore, the results may not generalize to retarded populations.
- d. Results of the comparison between reading and spelling should be treated with caution since there was no complete match between the tests of reading words and spelling words.

6.9 Suggestions for Further Research

The results of this study suggest a number of directions for further research. Some of these more pertinent to this investigation are presented below.

- a. The data and analyses in this investigation provide an account of the development of phonological awareness, orthographic knowledge and working memory. The evidence supporting it were both correlational and multivariate. However, evidence concerns data from group means as opposed to individual subjects. Further research is required to explore the correlational and multivariate evidence supporting phonological awareness, orthographic knowledge and working memory in more detail, examining both group data and individual

- data.
- b. First graders performed significantly well on all measures of phonological awareness. Further study is needed to ascertain whether poor readers/spellers perform less well than good readers/spellers on tasks of phonological awareness.
 - c. When considering the scores of first graders, a significant correlation was revealed phonological awareness and reading and spelling achievement. Further study is needed to confirm the bivariate relationships found among phonological awareness, reading and spelling in the performance of first-grade good readers and spellers as opposed to first-grade poor readers and spellers.
 - d. Though in the present study the performance of kindergartners and first graders were evaluated against each other to chart the pattern of development in phonological awareness, still the issue of causality remained untouched in Persian. Future research needs to measure phonological awareness before and after formal reading instruction has commenced to explore whether phonological awareness predicts reading ability or reading ability predicts phonological awareness.
 - e. Kindergartners in the present study revealed some knowledge of phonological awareness which somehow was satisfactory at the levels of syllable blending and syllable segmentation. Future research needs impose kindergartners on a training program to investigate whether the improvement of phonological awareness leads to an enhancement of reading skills in the subsequent year.
 - f. Kindergartners in the present study had severe difficulty in phoneme awareness. To better explore the nature of reading acquisition in Persian, a five-year follow-up study could examine whether children who evidence problems with phoneme recognition and manipulation tasks in kindergarten and/or first grade do exhibit reading disability in the subsequent years.
 - g. In the present study, we investigated the development of phonological awareness, orthographic knowledge and working memory across different groups of students. The

investigation can be replicated in a five-year follow-up study to explore in depth the development of literacy acquisition with the same students when acquiring literacy stage by stage.

- h. This study shows that both lexical and phonological access are available for Persian readers and spellers. Further study is needed to examine whether phonology is derived prelexically from the printed letters, or post-lexically from the word's orthographic structure.
- i. The precise relationship between phonetic and lexical channels is not clear from my study. How do these two channels work, cooperative, interactive, or parallel? Does the relationship between the two systems alter as a function of age or through the evolution of skilled reading and spelling over time?
- j. The present study examines the contribution of phonological awareness to reading and spelling achievement. The study can further be extended to examine the contribution of phonological awareness to working memory.
- k. The contribution of working memory was examined to reading and spelling achievement in the present study; the study can be extended to detect the contribution of working memory to phonological awareness.
- l. The individual differences in working memory in the present study were speculatively attributed to the efficiency of language processing and to the general storage function of working memory capacity. Further research is strongly needed to verify, modify or falsify this hypothesis.
- m. The present study investigated the development of reading across different grades. The development of reading rate remained unexplored, however. The study can further be extended to measure reading rate using vowelized and unvowelized reading words/nonwords.
- n. Sometimes readers who even make sufficient progress in word identification may have difficulty comprehending the more complex syntactic constructions that determine word and sentence meanings such as relative clauses, subordinators and conjunctions. The study can

be extended examining syntactic knowledge and reading comprehension.

- o. In the present study, we administered fifth graders and university students the same orthographic knowledge tests mainly developed based on the textbooks used in primary grades. The performance of fifth graders was comparable to the performance of university students in almost all tasks. The present study can be extended to explore the literacy acquisition of automatic/nonautomatic readers using more advanced tests developed based on general knowledge.
- p. Sample size in the present study to investigate the relation between phonological awareness and reading and spelling achievement was confined to 23 first graders, which is smaller than what is statistically desirable. This increases the possibility of Type II errors, that is, effects that a larger sample would have revealed were not detected. Future research therefore calls for a large sample size so that the results could be compared to the current findings in order to identify similar or varied results.
- q. The relationship, i.e., causal, interactive, or unidirectional, between measures of phonological awareness, orthographic knowledge, working memory and measures of reading and spelling is not clear from this study. Future research is needed to find the direction of effect in these literacy components.
- r. This research also opens the way for research in reading disability. The question is whether reading disability is due to a specific deficit in one of the literacy components, i.e., phonological awareness, orthographic knowledge and working memory, or it is an equal depression in all literacy components. Research is needed to assess Persian children with reading disabilities to find whether there is a unique developmental deficit in, e.g., phonological coding rather than an equal developmental delay across all components of reading and spelling skills.
- s. Although this study has looked at the development of spelling, a comprehensive framework has yet to be developed to understand spelling as a developing cognitive process and to elicit sources of spelling errors within the developmental framework.

- t. Though this study looked at the relationship between reading and spelling, the insignificant relationship of reading and spelling must be treated with caution since reading and spelling tests did not match completely. Therefore, the question that remains pertains to the nature of the interrelationships between reading and spelling. Are the two skills significantly correlate? Are the two skills share certain similarities but not significantly correlate? Does the acquisition of one skill enhance the acquisition of the other? Does at some point in the course of acquisition certain script particularities enhance growth in one but hinder growth in the other?
- u. Though the subjects were boys and girls of different age groups, the study did not take into consideration, the performance of boys as opposed to girls. Further study is needed to investigate this issue.
- v. This study examined the development of phonological awareness, orthographic knowledge and working memory. The subjects who participated in the study were from a kindergarten and two public schools. Further studies can survey the same phenomenon with children from different socioeconomic backgrounds.
- w. The present study can further be repeated using the large population of Persian Heritage Language learners in Canada and the U.S.A. The results can be compared to the present study exploring the effect of concurrent bilingualism in the acquisition of reading and spelling in Persian.

APPENDIX A

**FACTOR ANALYSIS
IN INDIVIDUAL CONSTRUCTS**

Table 1
Initial Factor Analysis
Factors, Eigenvalues and Percentage of Variance
Accounted for by Phonological Awareness Tests
(N= 44)

Variable	Factor	Eigenvalue	Percentage of Variance
Phoneme Blending	1	4.17	69.6
Phoneme Segmentation	2	.68	11.5
Phoneme Deletion	3	.58	9.8
Syllable Blending	4	.35	5.9
Syllable Segmentation	5	.13	2.2
Syllable Deletion	6	.06	1.1

Table 2
Final Factor Analysis
Loadings of Phonological Awareness on Factor after Equamax Rotation
(N= 44)

Variable	Factor 1
Phoneme Blending	.9261
Phoneme Segmentation	.9036
Phoneme Deletion	.9363
Syllable Blending	.7072
Syllable Segmentation	.6299
Syllable Deletion	.8529

Table 3

Initial Factor Analysis:
Factors, Eigenvalues and Percentage of Variance
Accounted for by Orthographic Knowledge Tests
(N= 135)

Variable	Factor	Eigenvalue	Percentage of Variance
Reading Words	1	2.78	55.8
Reading Nonwords	2	1.06	21.3
Spelling Words	3	.71	14.3
Spelling Nonwords	4	.41	8.3
Orthographic Choice	5	.01	.4

Table 4

Final Factor Analysis:
Loadings of Orthographic Knowledge Tests on Factors after Equamax Rotation
(N= 135)

Variable	Factor 1	Factor 2
Reading Words	.9328	-.1606
Reading Nonwords	.8092	-.0973
Spelling Words	.1199	.9337
Spelling Nonwords	.6302	.3734
Orthographic Choice	.9236	-.1286

Table 5

Initial Factor Analysis:
Factors, Eigenvalues and Percentage of Variance
Accounted for by Working Memory Spans
(N= 156)

Variable	Factor	Eigenvalue	Percentage of Variance
Word Span	1	2.10	70.3
Syllable Span	2	.46	15.4
Letter Span	3	.43	14.4

Table 6

Final Factor Analysis:
Loadings of Working Memory Spans on Factors after Equamax Rotation
(N= 156)

Variable	Factor 1
Word Span	.8374
Syllable Span	.9320
Letter Span	.8453

APPENDIX B

PHONOLOGICAL AWARENESS MEASURES

SYLLABLE BLENDING TASK

- | | | |
|------|-------------|-------------|
| (1) | غذا | qaza |
| (2) | خرما | xorma |
| (3) | ليون | livan |
| (4) | ديوار | divar |
| (5) | تابلو | tablou |
| (6) | مدرسه | madrese |
| (7) | معلم | mo'allem |
| (8) | خوراکی | xouraki |
| (9) | محکمر | mohkamtar |
| (10) | اتومبیل | otomobil |
| (11) | همکلاسان | hamkelasān |
| (12) | کارخانه‌ها | karxaneha |
| (13) | آموزگاران | amuzegaran |
| (14) | مجسمه‌ها | mojasameha |
| (15) | آشپزخانه‌ها | ašpazxaneha |

SYLLABLE SEGMENTATION TASK

- | | | |
|------|------------|-------------|
| (1) | اتاق | otaq |
| (2) | ساقه | saqe |
| (3) | ریشه | riše |
| (4) | گندم | gandom |
| (5) | خوراک | xourak |
| (6) | فرفره | ferfere |
| (7) | مادران | madaran |
| (8) | اصفهان | esfahan |
| (9) | ذره بین | zarrebin |
| (10) | محصولات | mahsulat |
| (11) | آهنربا | ahanroba |
| (12) | آموزگار | amuzegar |
| (13) | جانوران | janevaran |
| (14) | خوشبختانه | xoušbaxtane |
| (15) | اقیانوس ها | oqiyanussha |

SYLLABLE DELETION TASK

- | | | |
|------|-----------|-------------|
| (1) | باربر | barbar |
| (2) | بادام | badam |
| (3) | گلدان | goldan |
| (4) | فنجان | fenjan |
| (5) | خوشحال | xošhal |
| (6) | فراموش | faramuš |
| (7) | زمستان | zemestan |
| (8) | شهرکرد | šahrekord |
| (9) | گرمترین | garmtarin |
| (10) | بیماریها | bimariha |
| (11) | گلخانهها | golxaneha |
| (12) | قهوه خانه | qahvexane |
| (13) | زنبورهای | zanburhayi |
| (14) | هوا شناسی | havašenasi |
| (15) | آذربایجان | azarbajejan |

PHONEME BLENDING TASK

- | | | |
|------|----------|-----------|
| (1) | آب | ab |
| (2) | از | az |
| (3) | نان | nan |
| (4) | داس | das |
| (5) | چوب | čub |
| (6) | رنگ | rang |
| (7) | شکل | šekl |
| (8) | آتش | ataš |
| (9) | سالم | salem |
| (10) | شاداب | šadab |
| (11) | قندان | qandan |
| (12) | مهتاب | mahtab |
| (13) | بهاران | baharan |
| (14) | پژمرده | pažmorde |
| (15) | کوهستانی | kuhestani |

PHONEME SEGMENTATION TASK

- | | | |
|------|---------|-----------|
| (1) | را | ra |
| (2) | آش | aš |
| (3) | باد | bad |
| (4) | پیر | pir |
| (5) | شن | šen |
| (6) | کشک | kašk |
| (7) | تازه | taze |
| (8) | کتاب | ketab |
| (9) | سوزن | suzan |
| (10) | کاکلی | kakoli |
| (11) | چشمش | češmaš |
| (12) | گهواره | gahvare |
| (13) | برادرم | baradaram |
| (14) | نگهداری | negahdari |
| (15) | مواظبت | movazebat |

PHONEME DELETION TASK

- | | | |
|------|--------|---------|
| (1) | رو | ru |
| (2) | با | ba |
| (3) | کوه | kuh |
| (4) | تاب | tab |
| (5) | پاره | pare |
| (6) | سرد | sard |
| (7) | ادب | adab |
| (8) | درس | dars |
| (9) | شاداب | šadab |
| (10) | داستان | dastan |
| (11) | زیرکی | ziraki |
| (12) | سپیده | sepide |
| (13) | پیراهن | pirahan |
| (14) | وسایل | vasayel |
| (15) | پشمالو | pašmalu |

APPENDIX C

ORTHOGRAPHIC KNOWLEDGE MEASURES

LETTER-NAME KNOWLEDGE TASK

- | | | |
|------|----|---|
| (1) | آ | a |
| (2) | ب | b |
| (3) | د | d |
| (4) | ر | r |
| (5) | م | m |
| (6) | ا | a |
| (7) | أ | o |
| (8) | إ | e |
| (9) | س | s |
| (10) | ت | t |
| (11) | ك | k |
| (12) | ز | z |
| (13) | و | v |
| (14) | ش | š |
| (15) | هـ | h |
| (16) | ي | y |
| (17) | ق | q |
| (18) | ج | č |
| (19) | ح | j |
| (20) | ف | s |
| (21) | ص | s |
| (22) | ع | ʿ |

LETTER-SOUND KNOWLEDGE TASK

- | | | | | |
|------|-----|---|---|---|
| (1) | /b/ | ب | پ | پ |
| (2) | /d/ | د | ر | ر |
| (3) | /r/ | ر | ز | ز |
| (4) | /m/ | م | ن | م |
| (5) | /a/ | ا | ا | ا |
| (6) | /o/ | ا | ا | ا |
| (7) | /e/ | ا | ا | ا |
| (8) | /s/ | س | ک | س |
| (9) | /t/ | ت | ت | پ |
| (10) | /k/ | ک | ک | س |
| (11) | /s/ | ب | ت | ت |
| (12) | /š/ | س | ش | م |
| (13) | /h/ | ح | ح | خ |
| (14) | /q/ | ق | ف | ی |

READING WORDS**Grade 1**

(1)	آش	aš
(2)	گم	gom
(3)	نوک	nok
(4)	فقط	faqat
(5)	مريض	mariz
(6)	تنور	tanur
(7)	صدا	seda
(8)	تفریح	tafrih
(9)	قدرت	qodrat
(10)	نقشه	naqše
(11)	کوهان	kohan
(12)	دروغ	doruq
(13)	طناب	tanab
(14)	خرم	xorram
(15)	لذت	lazzat
(16)	خواهر	xahar
(17)	خواندن	xandan
(18)	هزاران	hezaran
(19)	بچه‌ها	bačehā
(20)	همکاری	hamkari
(21)	مواظبت	movazebat
(22)	سیاسگزار	sepasgozar

Grade 2

(23)	شکر	šokr
(24)	رأى	rāy
(25)	حریر	harir
(26)	گله	galle
(27)	یونجه	yonje
(28)	بعداً	ba-dan
(29)	مثلاً	masalan
(30)	صیاد	sayyad
(31)	مخصوص	maxsos
(32)	عطسه	atse
(33)	بره‌ها	barreha
(34)	همهانگ	hamahang
(35)	خوابیدن	xabidan
(36)	لغزنده	laqzande
(37)	اتوبوس	otobus
(38)	حوصله	hosele
(39)	منتظر	montazer
(40)	تعجب	tajjob
(41)	غمخواری	qamxari
(42)	کبوتران	kabutaran
(43)	کتابخانه	ketabxane
(44)	طرفداری	tarafdari

Grade 3

(45)	نظم	nazm
(46)	نعمت	ne-mat
(47)	معلوم	ma-lom
(48)	آثار	asar
(49)	ایام	ayyam
(50)	رخنه	rexne
(51)	هولناک	holnak
(52)	اشغال	ešqal
(53)	صخره	saxre
(54)	تقدم	taqaddom
(55)	تحمل	tahammol
(56)	انتظار	entezar
(57)	حفاظت	hefazat
(58)	رهگذر	rahgozar
(59)	پیاکنویس	paknevis
(60)	واقعا	vaqean
(61)	کنجکاری	konjkavi
(62)	تصادف	tasadof
(63)	منظره	manzare
(64)	خاکروبه	xakrube
(65)	گزارش	gozareš
(66)	موافقت	movafegat
(67)	پالایشگاه	palayešgah
(68)	مقررات	moqarrarat

Grade 4

(69)	ذوق	zoq
(70)	حلال	halal
(71)	معروف	ma·rof
(72)	دفاع	defa·
(73)	عبث	abas
(74)	محنت	mehnat
(75)	مصدوم	masdum
(76)	معصوم	ma·sum
(77)	غوكان	qukan
(78)	خویشان	xišan
(79)	حتماً	hatman
(80)	تحقیق	tahqiq
(81)	تلفظ	talaffoz
(82)	مکتشف	moktašef
(83)	اجابت	ejabat
(84)	نظاره	nezare
(85)	مرمت	marammat
(86)	کشفیات	kašfiyyat
(87)	اختناق	extenaq
(88)	مرخص	moraxxas
(89)	تصفیه	tasfiye
(90)	مطلع	mottale·
(91)	مسئولان	mas·ulan
(92)	ارتعاشات	erte·ašat
(93)	عجولانه	·ajulane

(94) گواھینامه govahiname

Grade 5 (and University)

- (95) عمق ʔomq
 (96) غرق qarq
 (97) عزت ezzat
 (98) مبدأ mabdaʔ
 (99) حریق hariq
 (100) ابداع ebdaʔ
 (101) خواهان xahan
 (102) لغزش laqzeš
 (103) مشهود mašhud
 (104) مغلوب maqlub
 (105) حرمت hormat
 (106) عموم ʔomum
 (107) معرض maʔraz
 (108) اعتدال eʔtedal
 (109) آذوقه azuqe
 (110) تقاطع taqatoʔ
 (111) قریحه qarihe
 (112) استعداد esteʔdad
 (113) امتناع emtenaʔ
 (114) اصابت esabat
 (115) عبارات ʔebarat
 (116) گاهواره gahvare
 (117) عطوفت ʔotufat

(118)	مهمّات	mohemmat
(119)	مؤاخذه	moaxeze
(120)	تصادفات	tasadofat
(121)	موقتاً	movaqqatan
(122)	فعاليّت	fa'aliyat
(123)	متخلف	motoxallef
(124)	متأسّفانه	motoassefane

READING NONWORDS**Grades 1-5 and University**

(1)	بوك	bouk
(2)	ماغچه	maqče
(3)	حواهر	hahar
(4)	حوانندن	handan
(5)	كيشه	kiše
(6)	تاكٲ	taket
(7)	فدرت	fodrat
(8)	شحر	šahar
(9)	گوهها	guha
(10)	زوشن	zoušan
(11)	مٲى	matta
(12)	تٲلاً	tasalan
(13)	قحبٲ	qohbat
(14)	تسواك	tesvak
(15)	ظناب	zanab
(16)	قٲى	qatta
(17)	قٲلاً	qe-lan
(18)	كواهر	kahar
(19)	منگٲٲ	mangošt
(20)	كوانندن	kandan

SPELLING WORDS**Grade-One-Spelling Test**

- | | | |
|------|----------|------------|
| (1) | آش | aš |
| (2) | گم | gom |
| (3) | نوک | nok |
| (4) | فقط | fqat |
| (5) | مريض | mariz |
| (6) | تنور | tanur |
| (7) | صدا | seda |
| (8) | تفریح | tafrih |
| (9) | قدرت | qodrat |
| (10) | نقشه | naqše |
| (11) | کوهان | kohan |
| (12) | دروغ | doruq |
| (13) | طناب | tanab |
| (14) | خترم | xorram |
| (15) | لذت | lazzat |
| (16) | خواهر | xahar |
| (17) | خواندن | xandan |
| (18) | هزاران | hezaran |
| (19) | بچه‌ها | bačeha |
| (20) | همکاری | hamkari |
| (21) | مواظبت | movazebat |
| (22) | سپاسگزار | sepasgozar |

Grade-Two-Spelling Test

(1)	شکر	šokr
(2)	رای	ray
(3)	حریر	harir
(4)	گله	galle
(5)	یونجه	yonje
(6)	بعداً	ba:dan
(7)	مثلاً	masalan
(8)	صیّاد	sayyad
(9)	مخصوص	maxsos
(10)	عطسه	atse
(11)	برهه	barreha
(12)	همانگ	hamahang
(13)	خوابیدن	xabidan
(14)	لغزنده	laqzande
(15)	اتوبوس	otobus
(16)	حوصله	hosele
(17)	منتظر	montazer
(18)	تعجب	tajjob
(19)	غمخواری	qamxari
(20)	کبوتران	kabutaran
(21)	کتابخانه	ketabxane
(22)	طرفداری	tarafdari

Grade-Three-Spelling Test

(1)	نظم	nazm
(2)	نعمت	ne-mat
(3)	معلوم	ma-lom
(4)	آثار	asar
(5)	ایام	ayyam
(6)	رخنه	rexne
(7)	هولناک	holnak
(8)	اشغال	eşqal
(9)	صخره	saxre
(10)	تقدم	taqaddom
(11)	تحمل	tahammol
(12)	انتظار	entezar
(13)	حفاظت	hefazat
(14)	رهگذر	rahgozar
(15)	پاکنویس	paknevis
(16)	واقعاً	vaqean
(17)	کنجکاوی	konjkavi
(18)	تصادف	tasadof
(19)	منظره	manzare
(20)	خاکروبه	xakrube
(21)	گزارش	gozareš
(22)	موافقت	movafegat
(23)	پالایشگاه	palayeşgah
(24)	مقررات	moqarrarat

Grade-Four-Spelling Test

(1)	ذوق	zoq	(25)	عجولانه	ajulane
(2)	حلال	halal	(26)	گواھینامه	govahiname
(3)	معروف	ma·rof			
(4)	دفاع	defa·			
(5)	عبث	abas			
(6)	محنّت	mehnat			
(7)	مصدوم	masdum			
(8)	معصوم	ma·sum			
(9)	غوکان	qukan			
(10)	خویشان	xišan			
(11)	حتماً	hatman			
(12)	تحقیق	tahqiq			
(13)	تلفظ	talaffoz			
(14)	مکتشف	moktašef			
(15)	عجابت	ejabat			
(16)	نظاره	nezare			
(17)	مرمت	marammat			
(18)	کشفیات	kašfiyyat			
(19)	اختناق	extenaq			
(20)	مرخص	moraxxas			
(21)	تصفیه	tasfiye			
(22)	مطلع	mottale·			
(23)	مسئولان	mas·ulan			
(24)	ارتعاشات	erte·ašat			

Grade-5 (-and University)-Spelling Test

(1)	عمق	romq	(25)	مؤخذہ	moaxeze
(2)	غرق	qarq	(26)	تصادفات	tasadofat
(3)	عزت	ezzatz	(27)	موقتاً	movaqqatan
(4)	مبدأ	mabda	(28)	فعالیت	faaliyat
(5)	حریق	hariq	(29)	متخلف	motoxallef
(6)	ابداع	ebda	(30)	متأسفانہ	motoassefane
(7)	خواہان	xahan			
(8)	لغزش	laqzeš			
(9)	مشہود	mašhud			
(10)	مغلوب	maqlub			
(11)	حرمت	hormat			
(12)	عموم	romum			
(13)	معرض	maraz			
(14)	اعتدال	etedal			
(15)	آذوقہ	azuqe			
(16)	تقاطع	taqato			
(17)	قریحه	qarihe			
(18)	استعداد	estedad			
(19)	امتناع	emtena			
(20)	اصابت	esabat			
(21)	عبارات	ebarat			
(22)	گاموارہ	gahvare			
(23)	عطوفت	otufat			
(24)	مہمات	mohemmat			

SPELLING NONWORDS**Grades 1-5 and University**

(1)	بوك	bouk
(2)	ماغچه	maqče
(3)	حواهر	hahar
(4)	حواندن	handan
(5)	کيشه	kiše
(6)	تاکت	taket
(7)	فدرت	fodrat
(8)	شحر	šahar
(9)	گوهها	guha
(10)	زوشن	zoušan
(11)	مٹی	matta
(12)	تسالان	tasalan
(13)	قحبت	qohbat
(14)	تسواک	tesvak
(15)	ظناب	zanab
(16)	قتی	qatta
(17)	قعلان	qelan
(18)	کواهر	kahar
(19)	منگشت	mangošt
(20)	کواندن	kandan

ORTHOGRAPHIC CHOICE MEASURE

Grade 1

(1)	طوت	توت	tut
(2)	خواهر	خاهر	xahar
(3)	صابون	سابون	sabun
(4)	تناب	طناب	tanab
(5)	لسه	لث	lase
(6)	كوزه	كوز	kuze
(7)	تعطیل	تعتیل	ta:til
(8)	فصل	فسل	fasl
(9)	اید	عید	id
(10)	بهار	بحار	bahar
(11)	زشت	ذشت	zešt
(12)	مرغک	مرقک	morqak
(13)	رفیق	رفیق	rafiq
(14)	ناظم	ناظم	nazem
(15)	غنچه	قنچه	qonçe

Grade 2

(16)	سیر	صیر	sabr
(17)	آخور	آخر	axor
(18)	حوس	هوس	havas
(19)	قرس	قرص	qors
(20)	حتا	حتی	hatta
(21)	عبور	ابور	obur

(22)	نذر	نظر	nazar
(23)	گلزار	گلزار	golzar
(24)	تهویل	تحویل	tahvil
(25)	کاملاً	کاملن	kamelan
(26)	غنچه	قنچه	qonçe
(27)	طولانی	تولانی	tulani
(28)	غمخار	غمخوار	qamxar
(29)	مراغیت	مراقبت	moraqebat
(30)	استخان	استخوان	ostoxan

Grade 3

(31)	ذوق	ذوق	zoq
(32)	حدس	هدس	hads
(33)	زمین	نمین	zamin
(34)	آغاز	آقاز	aqaz
(35)	معمور	مأمور	ma·mur
(36)	زلفت	زلت	zellat
(37)	ورغ	ورق	varaq
(38)	خاندن	خواندن	xandan
(39)	حماسه	هماسه	hemase
(40)	دشنام	دوشنام	došnam
(41)	نصارت	نشارت	nesarat
(42)	مثلن	مثلاً	masalan
(43)	ارمقان	ارمقان	armaqan
(44)	توصیف	توسیف	tosif
(45)	فضیلت	فخیلت	fazilat

Grade 4

(46)	ازم	عزم	azm
(47)	اخذ	اخز	axz
(48)	حجاب	هجاب	hejab
(49)	همت	حمت	hemmat
(50)	سکنا	سکنى	sokna
(51)	قرآن	قرآن	qorran
(52)	خواهش	خواهش	xahesh
(53)	اطمینان	اطمینان	etminan
(54)	مصائب	مصائب	masaeb
(55)	نظاره	نزاره	nezare
(56)	سمره	ثمره	samare
(57)	نطق	نتق	notq
(58)	مرغد	مرقد	marqad
(59)	تعمّل	تأمل	ta'ammol
(60)	بنیانگذار	بنیانگذار	bonyangozar

Grade 5 (and University)

(61)	قربو	غربو	qariv
(62)	حلال	هلل	helal
(63)	حریق	هریق	hariq
(64)	حضور	حضور	hozur
(65)	مانوس	معنوس	ma'nus
(66)	غمخوار	غمخار	qamxar
(67)	ازهان	ازهان	azhan

(68)	عجابت	لجابت	ejabat
(69)	توسيه	توصيه	tousiye
(70)	قالبا	غالبا	qaleban
(71)	عطوفت	عتوفت	otufat
(72)	بضاعت	بظاعت	beza:at
(73)	قريبه	قريحه	qarihe
(74)	ضلام	ظلام	zalam
(75)	قلقله	غلغله	qolqole

APPENDIX D

WORKING MEMORY MEASURES

WORD SPAN

(1)	باد	اسب						
	bad	asb						
(2)	شانه	قوری						
	šane	quri						
(3)	کیف	توت	کاج					
	kif	tut	kaj					
(4)	صابون	دریا	خورشید					
	sabun	darya	xoršid					
(5)	گوش	چتر	کاج	دشت				
	guš	čatr	kaj	dašt				
(6)	درخت	نامه	گلدان	اردک				
	deraxt	name	goldan	ordak				
(7)	لانه	دامن	قایق	زمین	ماهی			
	lane	daman	qayeq	zamin	mahi			
(8)	ساعت	بازار	آتش	سرفه	کبوتر			
	sa:at	bazar	ataš	sorfe	kabutar			
(9)	لوبیا	نمک	انسان	پنبه	کاسه	قندان		
	lubia	namak	ensan	pambe	kase	qandan		
(10)	باغچه	گودال	واکسن	دفتر	آبپاش	حیوان		
	baqče	goudal	vaksan	daftar	abpaš	heivan		
(11)	مادر	گاری	آفتاب	هفته	دارو	مسواک	کلبه	
	madar	gari	aftab	hafte	daru	mesvak	kolbe	
(12)	دره	جاده	مهتاب	جمعه	آبگوشت	پارو	خواهر	چارو
	darre	jadde	mahtab	ja-be	abgušt	paru	xahar	jaru

SYLLABLE SPAN

- | | | | | | | | | |
|------|-----|----|----|----|----|----|----|----|
| (1) | سا | بی | | | | | | |
| | sa | bi | | | | | | |
| (2) | پی | نا | | | | | | |
| | pi | na | | | | | | |
| (3) | ار | قی | نو | | | | | |
| | ar | qi | nu | | | | | |
| (4) | مر | لا | شی | | | | | |
| | mar | la | ši | | | | | |
| (5) | دو | لا | کی | قا | | | | |
| | du | la | ki | qa | | | | |
| (6) | کا | زی | ا | خا | | | | |
| | qa | zi | o | xa | | | | |
| (7) | جو | وا | لی | کا | قا | | | |
| | ču | va | li | ka | qa | | | |
| (8) | کر | قی | نو | شا | می | | | |
| | kor | qi | nu | ša | mi | | | |
| (9) | خا | سه | پا | می | کا | شی | | |
| | xa | se | pa | mi | ka | ši | | |
| (10) | ا | پا | سا | سو | لی | تا | | |
| | o | ba | sa | su | li | ta | | |
| (11) | اف | دا | ری | تا | ما | زی | کو | |
| | of | da | ri | ta | ma | zi | ku | |
| (12) | کا | نا | فو | را | په | شو | سی | قا |
| | ko | na | fu | ra | ye | šu | si | qa |

LETTER SPAN

(1)	ب	پ						
	b	p						
(2)	س	ن						
	s	n						
(3)	ر	ن	م					
	r	n	m					
(4)	ج	س	د					
	j	s	d					
(5)	ز	ف	ق	ك				
	z	f	q	k				
(6)	آ	س	ن	ت				
	a	s	n	t				
(7)	گ	ن	ل	د	ج			
	g	n	l	d	j			
(8)	ب	ق	م	ر	ی			
	b	q	m	r	y			
(9)	ت	ث	د	هـ	ق	ر		
	t	ṯ	d	h	q	r		
(10)	م	د	ن	گ	ح	ذ		
	m	d	n	g	h	ẓ		
(11)	پ	ر	ج	ت	و	خ	م	
	p	r	ċ	t	v	x	m	
(12)	ز	ت	س	ی	ث	گ	ق	و
	z	t	s	y	ṯ	g	q	v

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