Chapter 8
Cognitive Predictors of Early Reading Ability in Arabic: A Longitudinal Study from Kindergarten to Grade 2

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Abstract The present study set out to explore the underpinnings of early reading acquisition in Arabic among native Arabic speakers. Specifically, we compared the contribution of intra-lexical versus supra-lexical factors, assessed in kindergarten, to individual differences in later word recognition and reading comprehension. Our aim was to determine the extent to which word recognition in Arabic can be characterized as "modular" given the unique complexities of this script. At the end of kindergarten, 194 native Arabic speakers living in Israel were administered a battery of tests assessing a variety of intra-lexical factors and supra-lexical factors. Word recognition and reading comprehension were assessed at the beginning of Grade 2. The results revealed that decoding skill in Arabic at the beginning of Grade 2 is relatively poor compared to English and Hebrew. Word recognition skill was found to depend mainly on sub-lexical and lexical abilities which together explained 33 % of the variance in Grade 2. The stronger predictors were phonemic awareness and phonological processing followed by early print concepts, morphology and visual-orthographic processing. Alongside these intra-lexical abilities, supra-lexical abilities also accounted for 11 % of the variance in word recognition, consistent with the multiple complexities of the script. Reading comprehension skill was found to rely heavily on decoding skill but also on higher-order linguistic and cognitive abilities.

Keywords Arabic · Longitudinal study · Modularity · Orthography · Phonemic awareness · Reading acquisition

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8.1 Introduction

Over the past several decades a substantial body of research has focused on the pre-school foundations of reading development. Much of this work has been motivated by the need for early identification and intervention aimed at preventing later literacy difficulties (Snow et al. 1998). It is important to keep in mind, however, that reading is a not a single unitary construct, but includes at least two distinct components. The first is the identification of printed words (word recognition), and the second the comprehension of text. It is often unclear whether the findings of studies aimed at elucidating the factors that place the pre-school child at risk of later reading difficulties apply to word recognition, reading comprehension, or both. Studies examining reading comprehension have demonstrated that this skill is partly dependent on efficient word recognition such that good comprehenders are typically good decoders (Perfetti 1985; Stanovich 1982). This literature has also highlighted other factors related to reading comprehension, most notably broader oral language competencies such as listening comprehension, syntax, and vocabulary (see, e.g., Catts et al. 2003). In addition, many studies have pointed to the role of higher-order cognitive abilities in reading comprehension such as working memory, inference making and comprehension monitoring (Cain et al. 2004). It appears that reading comprehension relies on a wide range of abilities including “lower-level” skills such as word recognition, as well as higher-order “supra-lexical” abilities such as semantics and syntax and high-level cognitive skills.

Consistent with these observations, a number of researchers have proposed that word recognition is dissociable from those higher-order abilities involved in comprehension processes (Hoover and Gough 1990). This approach is typified by Stanovich’s (1990) extension of Fodor’s (1985) theory of modularity, in which (skilled) word recognition is characterized as a modular autonomous process dependent primarily on sub-lexical information sources, and largely unaffected by higher-order processes. Evidence for cognitive autonomy of the word recognition process derives from the twin phenomena of hyperlexia and dyslexia. Hyperlexia is distinguished by proficient word recognition yet poor comprehension among persons with below average intelligence such as mental retardation or autism (Nation 1999). In contrast, dyslexia is characterized by impaired word recognition skills in the presence of spoken language competence and normal levels of intelligence (Stanovich 1991).

Some researchers, however, have disputed a strong version of the modularity hypothesis and argued that additional lexical (i.e., morphology and word-level meaning) and supra-lexical contextual information such as syntax and higher-order cognitive processes such as working memory and general intelligence, may also play an important role in word recognition (see, for reviews, Bowey 2005; Swanson and Alexander 1997).

The current state of our knowledge about reading is largely based on reading research on speakers of English. However, the underlying processes that predict word recognition may vary depending on the complexity or depth of the script. Share (2008) proposed that the degree of word recognition modularity is a function of orthographic transparency. According to Share's hypothesis of a "transparency-by-modularity" interaction, the relative contributions of lexical (word-level) and supra-lexical information (in alphabetic orthographies) depend on script transparency. This notion is also consistent with the Orthographic Depth Hypothesis (Katz and Frost 1992), which suggests that word recognition in a phonologically opaque script requires a greater degree of "top-down" lexical support compared to a less opaque script. Consistent with Share's modularity-by-transparency hypothesis and the ODH, several English language studies have demonstrated a significant role for oral vocabulary and syntactic skills in word recognition, particularly for irregular words and in readers with poor decoding ability (Bowey 2005; Ricketts et al. 2007). In addition, several English-language studies have demonstrated an association between higher-order cognitive processes such as working memory and word recognition (Siegel and Ryan 1989).

The contribution of lexical and supra-lexical factors in transparent scripts is less apparent. In a longitudinal study of early reading acquisition in Hebrew's regular pointed script, Shatil and Share (2003) showed that Grade 1 word recognition (a composite of speed and accuracy) was predicted by kindergarten sub-lexical measures such as phoneme awareness, phonological processing, early literacy measures and visual processing; neither oral vocabulary nor syntax made a significant contribution. In contrast, reading comprehension was well predicted by broader domain-general measures such as general intelligence, oral language (assessed by measures of syntactic awareness and listening comprehension), reasoning and meta-cognitive abilities. The findings supported Shatil's (1997) hypothesis of "cognitive modularity" in early reading in a highly regular orthography.

Regardless of the depth of an orthography, substantial research evidence has converged on two main sub-lexical antecedents of word recognition—phonological awareness (e.g., Adams 1990; Ehri et al. 2001; Goswami and Bryant 1990; Saiegh-Haddad 2003; Shatil and Share 2003) and letter knowledge (Adams 1990; Byrne et al. 2000; Treiman and Kessler 2003; Saiegh-Haddad 2005; Shatil et al. 2000; Snow et al. 1998). These two so-called "alphabetic" skills—phonemic awareness and letter knowledge—have been labeled "co-requisites" to alphabetic literacy (Share 1995) or, more recently, "co-determinants" (Bowey 2005).

However, despite the pervasive importance of alphabetic skills, the strength of these associations appears to vary depending on the nature of the script. Whereas studies of English reading have demonstrated that phonological awareness and letter knowledge are typically the strongest predictors of early reading (Share et al. 1984; Snowling 2000), studies of more transparent orthographies such as German and Dutch have revealed that the acquisition of phonemic awareness and decoding accuracy is acquired more rapidly and the reading-phonological awareness (PA) correlation is weaker (de Jong and van der Leij 2003; Landerl and Wimmer 2000; Wimmer et al. 2000).

It is important to stress that alphabetic skills are not the only predictors of early reading ability. A somewhat different line of evidence suggesting that visual (or visual-orthographic) processing may be important in word recognition emerges from a study by Van den Bosch et al. (1994). These researchers developed a two-dimensional measure of orthographic complexity representing the intersection of (i) the complexity of letter-phoneme alignment (graphemic parsing) and (ii) the complexity of grapheme-phoneme correspondence in each of three languages, English, French and Dutch. In terms of grapheme-to-phoneme mappings, English was shown to be by far the most complex (i.e., irregular), but somewhat less complex than French and similar to Dutch in the complexity of graphemic parsing. Studies of Hebrew (Meyler and Breznitz 1998; Shatil and Share 2003), Arabic (Abu-Rabia et al. 2003; Ibrahim et al. 2002; Eviatar et al. 2004) and Urdu (Rao et al. 2011) suggest that the link between graphemic complexity and reading ability is an important topic for future research especially in the case of Arabic given its cursive components.

An additional lexical or word-level factor likely to be important in word recognition is morphological awareness. Studies in English have pointed to a positive relationship between morphological awareness and reading (and spelling) development (Carlisle 2000; Deacon and Kirby 2004; Singson et al. 2000; Treiman and Cassar 1996). This relationship has not only been extended to non-concatenative orthographies such as Hebrew and Arabic which combine morphemes in a non-linear fashion and are also characterized by high morphological density (Abu-Rabia 2007; Abu-Rabia et al. 2003; Ben-Dror et al. 1995; Levin et al. 1999; Ravid and Schiff 2004; Saiegh-Haddad and Geva 2008), but the strength of this relationship may be even greater owing to the exceptionally rich morphology of Semitic languages (Abu-Rabia et al. 2003).

To sum up, the literature documented thus far indicates that, although there is much in common, the antecedents of early word recognition may vary somewhat across languages and/or orthographies depending on the complexity or depth of the orthography. The present study aimed to explore the underpinnings of early reading acquisition in the Arabic language among native Arabic speakers. This appears to be the first longitudinal study to address the relationship between cognitive processes in kindergarten and early reading ability in Arabic. Although early reading acquisition in Arabic takes place within the orthographic context of fully vowelized script, which is conventionally considered to be a highly transparent orthography, this script has numerous complexities that are likely to pose a challenge to the novice reader. These include diglossia, multiple graphemic complexities such as letter shapes, morphological density (multiple morphemes in a single letter string) and morpho-phonological rules which in the case of Arabic lead to orthographic opacity. (For a discussion of the structure of Arabic language and orthography, see Saiegh-Haddad and Henkin-Roitfarb, Chap. 1).

8.2 The Arabic Language

Several studies carried out by Saiegh-Haddad (2003, 2004, 2005, 2007a) and recently Saiegh-Haddad et al. (2011) examined the effect of the phonological distance between spoken Arabic vernacular (SAV) and Modern Standard Arabic (MSA) on the acquisition of phonemic awareness in children. Results showed that

MSA phonemes, even when accurately articulated, were significantly more difficult for both kindergarten and first grade children to isolate (identify) and to recognize. Also children's performance in pseudo-word decoding was lower when the items included MSA phonemes that are not present in their SAV. These results were interpreted as reflecting low-quality phonological representations, which may be associated with a deficiency in the phonological encoding of words in long-term memory (Saiegh-Haddad et al. 2011). The phonological awareness performance of Arabic-speaking children has also consistently shown that CV sub-syllabic units were more accessible to children's metalinguistic awareness than the phoneme or any other sub-syllabic unit in Semitic Arabic (Saiegh-Haddad 2007a). Similar findings have also been reported for Semitic Hebrew (Ben-Dror et al. 1995; Saiegh-Haddad 2007b; Share and Blum 2005). Nonetheless, it is worth remarking that the outcomes of most studies of the acquisition of reading in Arabic agree that phonological skills are an important factor in reading development in fully-voweled Arabic script (Abu-Rabia et al. 2003; Saiegh-Haddad 2003, 2005) and unvoweled Arabic alike (Elbeheri and Everatt 2007).

Besides diglossia and the phonological distance between the spoken and written forms of words, the Arabic orthography introduces a set of additional challenges for the novice reader and makes the script functionally opaque for reasons other than transparency (see Saiegh-Haddad and Henkin-Roitfarb, Chap. 1). These relate to the graphemes of Arabic which embody a system of fully-fledged graphemes (letters) and a system of diacritics. Further, some (though few) graphemes are encoded but not pronounced, as in the case of plural marking ?Alif on verbs, and others have multiple spellings (like *hamza*). Another important aspect of Arabic orthography is the visual/graphemic complexity of the letters. In line with the graphemic complexity, researchers have suggested that basic visual perceptual and memory processes may be especially important for reading Arabic script (Abu-Rabia et al. 2003; Ibrahim et al. 2002; Eviatar et al. 2004).

Finally, an additional unique feature of Arabic concerns morphology. Arabic morphology is non-concatenative, morphemically dense and has a rich inflectional and derivational structure. These features as well as evidence from empirical studies in Arabic suggest that lexical information such as morphological knowledge may be an important contributor to early reading development in Arabic (Abu-Rabia 2007; Elbeheri and Everatt 2007; Saiegh-Haddad 2013; Saiegh-Haddad and Geva 2008). For a detailed discussion of the structure of Arabic language and orthography see Saiegh-Haddad and Henkin-Roitfarb, in this volume.

To sum up, although voweled Arabic orthography is considered a transparent script in terms of grapheme-phoneme correspondence, the features briefly described above create considerable complexity for the beginning reader. This leads to the prediction that vowelized Arabic word recognition might oblige the reader to rely on information beyond the word level, namely, "supra-lexical" or "extra-lexical" information. A cross-linguistic study of Arabic-English bilinguals reading voweled words and pseudo-words revealed that deficits in syntactic awareness in addition to phonological processing and working memory, are characteristic of poor Arab readers (Abu-Rabia and Siegel 2002). Abu-Rabia et al. (2003) also found deficits among fifth grade Arabic-speaking dyslexics in a wide range of cognitive processes including phonology, morphology, working memory, syntax and visual memory. Both these studies, therefore, suggest that individual differences in reading vowelized Arabic (transparent script) may be related to a variety of factors reflecting not only sub-lexical or intra-lexical processing (e.g., phonological and visual-orthographic aspects of print), but also lexical (morphology and word-meaning) and supra-lexical (syntax and working memory) abilities.

The present longitudinal study focused on the extent to which intra-lexical and supra-lexical factors, assessed in kindergarten, predict individual differences in later word recognition and reading comprehension. Specifically, to what extent can word recognition in Arabic be characterized as "modular"?

Four hypotheses were tested.

1. Based on the traditional notion of orthographic transparency, we hypothesized that the main predictors of early fully-vowelized word recognition in Arabic would be "intra-lexical" precursors such as phoneme awareness, phonological processing, early literacy measures and morphological awareness.
2. In view of the unique graphemic complexity of Arabic letters: visual similarity of the letters, letter-shape (allographic) variants and ligaturing, we hypothesized that visual-orthographic processing would play a significant role in word recognition.
3. The combined effects of graphemic complexity, diglossic phenomenon and morphological density were expected to increase reliance on supra-lexical factors in word recognition.
4. Reading comprehension is expected to depend on both intra-lexical and supra-lexical measures.

8.3 Method

194 native Arabic speakers living in Israel were tested two times: once in the final months of kindergarten (mean age: 5.9 years, SD: 3.6 months) and again at the beginning of Grade 2 ($n=177$). In kindergarten, children were administered a battery of tests assessing a variety of intra-lexical factors (phonemic awareness, phonological processing, visual-orthographic processing, pre-school print concepts and morphological awareness) and supra-lexical factors (general non-verbal ability, receptive vocabulary, syntactic awareness and working memory) . There were at least two individual measures in each block (a group of tasks designed to tap the same basic construct). Word recognition and reading comprehension were assessed in Grade 2.

It is important to note that in the kindergartens participating in the present study there was no explicit reading/literacy instruction. While some kindergartens emphasize exposure to MSA by story reading, others focus on structured literacy activities such as learning the letter names and writing letters. Nevertheless, it should be remarked that the Arabic language curriculum has undergone considerable changes since 2008 when reforms focused greater attention on phoneme awareness and letter knowledge.

With respect to phonological awareness, the new pre-school curriculum designates specific goals for each age: for instance, a child is expected to become aware of rhyme, syllables, sub-syllabic units such as the body (CV) and coda and singleton phonemes within the context of various activities such as comparison, isolation, segmentation, blending and deletion. ([al–bunyah al/asa| siyah lilqira|/a walkita|bah fil–lughah al– |arabiy–yah] Ministry of Education, Pre-school Curriculum 2008). Letter knowledge includes knowing standard letter names, their alphabetic order, their shapes (and position-dependent variants) and grapheme-phoneme correspondences.

Arabic reading instruction in Israel normally starts in the first grade and rarely employs phonics (phoneme-level instruction) or a phonemic awareness component in code instruction, only blending and segmenting at the syllable level. Letter recognition is also emphasized, including both the standard and colloquial names of the letters and not the letter "sounds" (i.e., isolated phonemes) (Levin et al. 2008), with special emphasis on the ability to write the different shapes of each letter. The most popular first grade reading scheme for Israeli Arabic-speakers at the time of testing is ?Al RA?id (1991). This method uses short texts to introduce letters and sometimes additional vowels or orthographic signs. Some letters, particularly those representing MSA phonemes which are not present in the present sample's SAV such as (/θ/-/ ð/-/ð̣/), and superscript orthographic signs such as *tAnwi:n*, the definite article and *maddeh*, are introduced only at the very end of the school year. As a result, Arabic-speaking children living in Israel often do not attain proficiency in decoding at the end of Grade 1. Nevertheless, it should be remarked that the Arabic reading acquisition curriculum has also undergone considerable changes since 2008 which include specific recommendations to teach words analytically via sub-lexical units and not as whole word patterns ([at–tarbiyah al–lughawiy–yah] Ministry of Education, Elementary School Curriculum for 2008).

In the current study, it was not possible to assess reading achievement at the end of Grade 1 because new letters and some superscript orthographic signs were still being introduced in the final days of the school year. Consequently, reading ability was assessed at the beginning of Grade 2 (October/November, 2007). Word recognition and reading comprehension measures were administered to the whole class in a fixed 60-minute time slot.

8.3.1 Measures

Kindergarten intra-lexical blocks
Visual orthographic processing

VMI Developmental Test of Visual Perception (Beery and Beery 2004). In this test, the child is required to select one of three geometric figures which matches a test figure. Following three demonstration items, an additional 24 items are presented for completion within a three minute time interval. Internal consistency was 0.69 after excluding two items with poor item reliabilities.

Short-term symbol memory. This task was developed especially for this study. The children were presented with ten cards printed with symbols from different scripts with which they were unlikely to be familiar, such as Chinese or Gargish. The child was encouraged to look closely at each card for 5 s and then try to memorize the exact order and position of the symbols. The card was then removed from view, three test cards were presented, and the child was asked to select the card that exactly matched the previewed string. The three alternatives included the following items: the identical symbol string, the same symbols but in a different order, and a sequence of symbols each of which differed from the original symbols. Internal consistency was 0.44.

8.3.2 Phonological Awareness

Initial consonant isolation. The child heard sixteen monosyllabic pseudo-words and was asked to pronounce the initial phoneme of each pseudo-word. For example, the examiner said “Say su:k”, the child first repeated the word and then was asked what the beginning sound/phoneme was. One point was given for each correct response. All the initial sounds were consonantal (š -j-m-n-f-s-r-z) and common phonemes in the spoken vernacular of this sample. There were six training items to ensure that the participants understood the task, with feedback provided by the examiner. If the child’s response was a CV sub-syllabic unit which has been found more accessible than isolated phonemes in Arabic (Saiegh-Haddad 2003, 2004, 2007), the examiner explained that */su:/* includes two sounds and they should only pronounce the first sound. Internal consistency for this task was 0.88.

Initial and final phoneme identity. This task was also adapted to Arabic from Bowey’s (2001) final phoneme identity task. Ten items tested final phonemes and ten initial phonemes. For each item, children saw a test picture (e.g., the picture of a house) and three additional pictures (*a strawberry, a mouse, and a banana*). It was then explained that the word *da:r* ‘house’ ends with the sound /*r*/. They were then asked, “Which of these three pictures below ends with /*r*/?” The alternatives were pronounced by the investigator to avoid retrieval difficulties. Three practice trials preceded the test items and no feedback was provided for test items. The first subtest contained the final phoneme items. Following this, three examples were given of initial phoneme items. In each of the two sub-tests, five items were monosyllabic words and five were disyllabic words. The phoneme identity test was found to have internal consistency of 0.78.

8.3.3 Phonological Memory

Rapid serial naming (RAN objects and colors), adapted from Shatil and Share (2003). In the serial naming of objects, the child was presented with a sheet containing five familiar pictures (*flower, house, dog, tree and table*). All pictures were named in the spoken Arabic vernacular of the sample. There were a total of 21 items arranged in seven rows of three. The child was asked to name these items as quickly as possible. In the serial naming of colors, children were presented with a series of 21 circles painted in five colors: red, yellow, blue, green, and black arranged in seven rows of three. Naming times in seconds and number of errors were recorded. The naming speed of objects and colors combined evinced satisfactory internal consistency (alpha = 0.75).

Pseudo-word repetition (adapted from Baddeley et al. 1998). Children were asked to repeat 40 pseudo-words adhering to Modern Standard Arabic phonology varying in length and syllabic structure. These items ranged from one to five syllables. The child heard each pseudo-word spoken by the investigator and was asked to repeat the item. Internal consistency was 0.84. This task has also proven to be a good kindergarten predictor of reading ability in Grade 1 (e.g., Gathercole and Baddeley 1993).

8.3.4 Pre-School Literacy

Letter naming. Children were asked to name 12 printed letters. All the letters were in their non-ligatured form. Either the standard (MSA) name of the letter or the colloquial name was accepted. Internal consistency was 0.91.

Concepts about print (Clay 1979). This test was adapted from the Shatil and Share (2003) task, which, in turn, was adapted from Clay's (1985) English test. Children are presented with a story book and required to answer 16 questions assessing knowledge of print conventions and text handling such as page, line, word, letter, writing and pictures. Two additional questions tested the awareness of the Arabic short vowels, namely, their location and shape. Cronbach's alpha for this test was 0.77.

Word-likeness. In this task, the child was presented with (10) real Arabic words or with (10) non-Arabic word-like symbol strings. The non-Arabic foils were real words in which the original Arabic letters were changed to symbols such as a question mark or a letter from another script such as Chinese. Some foils contained changes in the number or location of the dots in an Arabic letter (e.g., a letter with two dots written with four dots). The child was asked to look closely at the word and decide if this was a word in Arabic. Internal consistency was 0.78.

Morphological awareness (based on Shatil 2002). This test examined the awareness of the morphological structure of spoken Arabic words. It included twenty items, each consisting of a pair of pseudo-words designed to assess different aspects of inflectional morphology and knowledge of word structure such as gender, number, tense etc. For example, the tester asked which of two words (one with the plural suffix and one without) indicated that there is only one thing *(lu:d- lu:di:n*). The test used pseudo-words that adhere to the structure of the spoken Arabic vernacular of the sample. Two demonstration items were given before the test, and repeated if necessary. Internal consistency (alpha) was 0.65.

8.3.5 Kindergarten Supra-Lexical Blocks:

General ability

Raven's Colored Progressive Matrices (RCPM; Raven et al. 1995). This test of non-verbal reasoning consists of 36 items presented in a multiple-choice format with a matrix-like arrangement of figural symbols. Sets A, AB, and B were administered. Internal consistency was 0.71.

Peabody Picture Vocabulary Test-Revised (Form B, Dunn 1965). This test, which is widely considered to be a proxy measure for verbal IQ, was adapted to (MSA). The test was discontinued after 6 errors in 8 consecutive items. Split-half reliability was 0.85; $p<0.01$.

Working memory (based on Siegel and Ryan 1989). This test contains (spoken) sentences with missing words. The child had to supply the missing words orally and then recall all the missing words in the correct order. The test was divided into 3 sub-tests and each sub-test included two attempts at 2, 3 and 4 sentences respectively. The test was discontinued if the child failed both items in the two sets in a block; one point was awarded for each missing word supplied, with an additional point given if the participant recalled all the missing words in the correct order. This test was administered in the Spoken Arabic vernacular of the sample. Internal consistency was 0.65.

Syntactic awareness (based on the Test of Receptive Oral Grammar—TROG, Bishop 1982). In the TROG, the child is shown a page with four pictures, and must select the picture that matches a spoken sentence. There are 80 items divided into 20 blocks of four items. The test is discontinued after five consecutive blocks in which one or more errors are made. The test was translated into (SAV). It should be noted, however, that the complex sentence structures in this test were more characteristic of MSA than SAV. Split half reliability was 0.66.

8.3.6 Grade 2 Assessment of Reading Ability

Context-free oral word naming. This test consisted of 50 vowelized words in Arabic (MSA) divided into three sets of items of increasing difficulty in terms of syllabic structure and frequency. The first set contained twenty familiar words chosen from two first grade reading books, one of which was the instructional book for the present sample in Grade 1. The words in this set varied in length from one to four syllables. The words were considered to be highly familiar to Arabic-speaking Israeli children in Grade 2. The second set comprised 15 lower frequency words which also appeared in the children's first grade reading texts. These items varied in length from two to three syllables. The final set included words with lower frequency that did not appear in the reading books of Grade 1: these varied from one to three syllables. Children were required to read all the words aloud as quickly and accurately as possible. As well as accuracy and overall reading time, the number of words read in one minute was also recorded. One point was allocated for each word read correctly. Internal consistency (alpha) was 0.90.

Pseudo-word naming. A list of vowelized pseudo-words was specially developed in this study. It included 50 items varying in length and syllabic structure. Half the items were monosyllabic and half were disyllabic. Following five practice items, children were asked to read the list aloud as quickly and accurately as possible. Scoring procedures were the same as for the previous word naming task. Internal consistency (alpha) was 0.91.

Semantic categorization (adapted from Raviv 2002). In this test, 50 fully vowelized words were presented for semantic decision. Half of the items named edible foods and the other half named familiar objects or animals. The participants were asked to read the list silently and circle the words that indicated food items. Both accuracy and total time were measured. In addition, the number of items correctly read (i.e., categorized) in one minute ("*wpm*"—words-per-minute) was recorded too. Although no test-retest reliability was available for this task, adequate reliability is implicit in the high correlations observed between accuracy of semantic categorization and the two word naming tasks: the correlation with real word decoding accuracy was 0.81 and the correlation with pseudo-word naming accuracy was 0.80.

8.3.7 Reading Comprehension

All three reading comprehension tasks: sentence comprehension, reading comprehension of narrative text and the expository text were administered to whole classes in the course of a single 60 min lesson-period.

Sentence comprehension. (Metzav test for Grade 2 in Israel, 2005). Ten printed sentences (3–4 words long) were accompanied by four pictures arranged in a table of four boxes. The child was asked to read the sentence (silently) and to circle the appropriate picture. One point was given for each correct item. Internal consistency (alpha) was 0.80.

Reading comprehension: Narrative text. (Metzav test for Grade 2 in Israel, 2005). This test consisted of a passage of 61 words relating a story about a girl's birthday party. Ten multiple-choice questions followed the narrative passage, each containing three options. Five questions tested factual (text-explicit) comprehension and five tested inferential comprehension. Internal consistency (alpha) was 0.58 (two items were deleted).

Reading comprehension: Expository text. (*Metzav* test for Grade 2 in Israel, 2005). The format of this test was the same as that of the narrative text. The text included six sentences (39 words long) describing an alligator. For this text, seven questions tested information explicitly provided by the text, and another three questions tested integration and interpretation. Internal consistency (alpha) was 0.73.

8.4 Results

The reliability indices were all moderate to high, with the exception of the short-term symbol memory task, which included relatively few items and was quite difficult for most children (see Table 8.1). It should be noted, however, that performance in this task was significantly above chance (33 %). The reliability of RAN accuracy (calculated as the average number of errors in naming objects and colors) was understandably low since more than half of the sample made no errors.

All the word recognition measures were combined into a single composite measure including accuracy and speed. Accordingly, a principal components analysis was undertaken. The results revealed that the first principal component accounted for 72 % of the variance with high positive weights for all six measures. Consequently, a single composite measure of word recognition was calculated as the mean of z scores of all these tasks. A principal components analysis of the three tests of reading comprehension produced a very similar outcome: the first measure principal component accounted for 68.5 % of the variance with high positive weights for all three measures. A single composite measure was therefore created for reading comprehension calculated as the mean of z scores of those three tasks.

To assess the unique contribution of each block to word recognition and reading comprehension, three separate types of multiple regression analyses were carried out. First, each set of intra-lexical variables, namely, phonemic awareness, phonological processing, visual processing and morphological awareness were entered set-wise, once with word recognition as the dependent variable and then with reading comprehension. The same analyses were conducted with the supra-lexical measures. Second, hierarchical regression was used to test the unique variance explained by each block after controlling general ability as measured by Raven and Peabody tasks and, in a final set of analyses, with all supra-lexical measures partialled out (Raven, Peabody, Working memory, and TROG). The results of these analyses are summarized in Table 8.2.

It can be seen that the intra-lexical sets each contributed significant and substantial variance to word identification and to reading comprehension. Phonemic awareness was the strongest predictor; phonological processing, pre-school literacy and morphological awareness all made similar contributions, with visual-orthographic processing making a more modest but still non-trivial contribution.

As predicted, supra-lexical factors also contributed non-trivial variance to word recognition although, as expected, this contribution was overshadowed by the contribution of intra-lexical factors. On the other hand, these same supra-lexical variables (with the exception of working memory) were more potent in predicting reading comprehension.

To illuminate the degree of modularity in early Arabic reading, separate multiple regression analyses were carried out on the intra-lexical sets and supra-lexical sets, respectively, with word recognition and reading comprehension as the dependent variables (see Table 8.3).

Table 8.1 Means, standard deviations, maximum and minimum scores and reliability coefficients for kindergarten predictors and Grade 2 reading measures

	M	SD	Max score	Min score	Reliability
	Kindergarten measures				
Phonemic awareness					
Initial consonant isolation	72.1%	29.04%	100%	0%	0.88
Initial/final phoneme identification	63.1%	20.36%	100%	25%	0.78
Phonological processing					
RAN (speed in secs)	32.0	9.85	64.9	16	0.75
RAN (errors)	0.6	0.93	5.0	0.0	
Pseudo-word repetition	82.8%	12.87%	100%	32.5%	0.84
Visual-orthographic processing					
Beery Visual Perception	13.7	3.10	21	4	0.69
Short-term symbol memory	47.9%	21.98%	100%	0%	0.44
Pre-school literacy					
Letter naming	42.6%	34.11%	100%	0%	0.91
Concepts about print	51.2%	20.39%	93.8%	0%	0.77
Word-likeness task	71.2%	19.59%	100%	10.5%	0.78
Oral language					
T.R.O.G (syntax)[b]	7.8	3.22	18	2	0.66
Morphological awareness	68.2%	18%	100%	18.8%	0.65
General ability					
Raven's matrices	40.9%	13.11%	80.6%	5.6%	0.71
Peabody picture vocabulary	42.9	9.55	65	13	0.85
Working memory	3.1	2.51	13	0	0.65
	Grade 2 reading measures				
Word recognition					
Word decoding (accuracy)	67.5%	21.16%	98%	8%	0.90
Word decoding (speed in secs)	251.9	271.66	2043	66	[c]
Pseudo-word decoding (accuracy)	62.9%	27.28%	100%	0%	0.91
Pseudo-word decoding (speed in secs)	200.3	142.33	922	67	[c]
Semantic categorization (accuracy)	91.6%	11.57%	100%	38%	[d]
Semantic categorization (speed in secs)	194.1	105.93	887	63	[c]
Reading comprehension					
Sentence comprehension	84.8%	20.42%	100%	0%	0.80
Narrative text comprehension	61.8%	22.60%	100%	0%	0.58
Expository text comprehension	56.6%	25.93%	100%	0%	0.73

Intra-lexical cognitive factors explained around one third of the variance in word recognition, and close to one half of the variance in reading comprehension. Supra-lexical factors explained a more modest but still significant 11% of the variance in word recognition, and just over one quarter of the variance in reading comprehension. It is especially noteworthy that intra-lexical factors explained over twice as much variance in reading comprehension as the supra-lexical factors.

Table 8.2 Variance in word recognition and reading comprehension explained by blocks of kindergarten predictors before and after controlling for general ability (Raven and Peabody) and after controlling all supra-lexical measures

	Adjusted R^2					
	Word recognition			Reading comprehension		
	Unpartialled (%)	Partialled[a] (%)	Partialled[b] (%)	Unpartialled (%)	Partialled[a] (%)	Partialled[b] (%)
Intra-lexical blocks						
Phonemic awareness	24	19	14	28	15	11
Phonological processing	18	13	9	26	12	10
Visual-orthographic processing	11	7	4	19	7	4
Pre-school literacy	17	13	10	23	11	8
Morphological awareness	17	12	9	24	11	9
Supra-lexical blocks						
Syntax	11	5		21	5	
Working memory	3	1[ns]		3	0.1[ns]	
Raven & Peabody	6			23		
All supra-lexical measures	11			27		

$p < 0.001$
[a] Raven and Peabody controlled for
[b] all supra-lexical measures controlled for
[c] non-significant (ns)

Table 8.3 Variance in word recognition and reading comprehension collectively explained by intra-lexical and supra-lexical sets (combining sets)

	Word recognition		Reading comprehension	
	Multiple R	Adj.R^2 (%)	Multiple R	Adj.R^2 (%)
Intra-lexical sets	0.61	33	0.70	45
Supra-lexical sets	0.36	11	0.54	27

$^* p < 0.001$

8.5 Discussion

The results confirmed the hypothesis that the main precursors of word recognition in fully vowelized Arabic, which is typically considered a transparent orthography, are intra-lexical factors such as phonemic awareness, phonological processing, early literacy and morphological awareness, rather than higher-order extra-lexical factors such as semantics, syntax, general cognitive abilities and working memory. It is worth noting, however, that the contribution of each intra-lexical set to word recognition declined substantially (by around half) after controlling for general non-verbal and verbal (vocabulary) ability. Nonetheless, even after partialling out supra-lexical sets, the combined contribution of all four intra-lexical sets remained substantial and significant, accounting for 25 % of the variance in word recognition. This finding confirms that early word recognition in Arabic is related first and foremost to the more word-specific, intra-lexical skills (alphabetic, visual-orthographic and morphological) that underpin identification of individual printed words. Converging evidence was reported by Saiegh-Haddad (2005) in a cross-sectional study where it was shown that RAN, working memory and letter recoding speed were the best predictors of reading fluency at the end of Grade 1, and where PA was found to be a strong indirect predictor of fluency and a direct predictor of letter recoding speed.

The strongest individual predictor of word recognition in the current study was phonemic awareness. This finding is at odds with earlier evidence reported in Hebrew by Shatil and Share (2003) in their longitudinal study of early pointed (fully-vowelized) Hebrew reading. They found that phonemic awareness plays a weak role in word recognition at the end of Grade 1, accounting for only 11 % of the variance in word recognition and, furthermore, failing to account for any unique variance after controlling for the variance explained by other domain-specific and domain-general measures. The results of Shatil and Share replicate earlier Hebrew studies such as Bentin and Leshem (1993) and Geva and Siegel (2000). This finding has also been obtained in other transparent orthographies such as Latvian (Sprugevica et al. 2006), Turkish (Oney and Durgunoglu 1997) and Finnish (Leppanen et al. 2006), prompting Share (2008) to propose that the phonological awareness (PA) -reading association is strongest when script *per se* is complex or when incomplete mastery of the code makes the script functionally opaque; once the learner has mastered the code, however, the PA-reading relation declines.

The present study revealed another important finding. The accuracy of Arabic word reading (67 %) and pseudo-word reading (63 %) at the beginning of Grade 2 was very low, implying that children are making around one error every three words. This means that Arabic-speaking children living in Israel have not yet mastered the alphabetic code at the beginning of Grade 2, thereby reinforcing the claim regarding script complexity. This finding contrasts sharply with studies with pointed Hebrew showing that a majority of Israeli beginners achieve proficient decoding by the end of Grade 1 (Feitelson 1989; Share and Levin 1999). In their cross-linguistic study of 14 European nations, Seymour et al. (2003) found that most children from a majority of (European) countries were reasonably accurate and fluent decoders by the end of the first school year, averaging 87 % accuracy. After English (34 %), the next lowest result was Danish (71 %). This places Arabic among the poorest performers, at least relative to European nations. A similar finding was recently reported by Saiegh-Haddad (2011), who found that even the good readers of Arabic do not reach these high levels of accuracy in Grade 1 and probably only in Grade 2.

To summarize, the prominent role of phonemic awareness in Arabic decoding and the low levels of decoding accuracy, suggest that reading acquisition in Arabic is a considerable challenge despite its spelling-sound consistency.

In addition to phonemic awareness, the other phonological measures including pseudo-word repetition and RAN also explained significant variance in word recognition. This finding was anticipated since a substantial body of research has repeatedly demonstrated that basic phonological processing abilities that develop prior to the start of schooling are essential for reading acquisition across orthographies (see, for example, Boets et al. 2007; Van Leeuwen et al. 2006). It is worth remarking that the contribution of phonological processing, particularly the RAN test, was lower than that of phonemic awareness. In this context Ziegler et al. (2010) argued that phonological awareness is important in all languages but that its impact is modulated by the transparency of the orthography; thus, phonological awareness might be a stronger predictor in opaque orthographies, whereas rapid automatized naming (RAN) is weaker and limited to decoding speed and the reverse in transparent orthographies. Like Danish and English, Arabic poses considerable challenges for the novice reader, hence, the contribution of phonological awareness is particularly salient.

As expected, morphological awareness was found to be an important additional contributor to early vowelized word recognition. This finding is in accordance with many studies reviewed in the introduction which point to a positive relationship between morphological awareness and reading development in different orthographies including English and Hebrew, as well as Arabic (see Saiegh-Haddad and Geva (2008).

The centrality of Arabic morphology in the spoken and written language has already been discussed above. Suffice it to note that the present study used a purely aural task that included pseudo-words adhering to the structure of the *spoken* vernacular of the sample. This task only assessed knowledge of inflectional morphology such as gender, number, tense etc. Yet, this single task accounted for unique variance in word recognition not only when phonemic awareness was controlled, but even when all supra-lexical abilities were partialled out. This finding suggests that, alongside intra-lexical abilities, reliance on word-level information such as inflectional morphology also contributes to decoding skill in Arabic. Future longitudinal research will need to address the predictive utility of additional morphological abilities such as root extraction and derivational knowledge.

Among the other significant predictors were pre-school literacy measures which were assessed with tasks of letter naming, concepts about print and word-likeness explained a similar portion of variance to morphological awareness—17 %. This finding adds to a long list of studies demonstrating a relationship between alphabetic and print knowledge in kindergarten and future reading achievement. It is worth remarking on the generally low performance on the letter naming task in kindergarten. Indeed, additional analyses revealed wide differences between kindergarten means in letter naming. For instance, the lowest average accuracy in one kindergarten was 7 % and the highest was 70 %, with the mean of the other kindergartens in the 38–53 % range. These data point to major differences in instruction. As already noted in the method section, Arabic-speaking kindergartens in Israel at the time of testing received no explicit literacy instruction. Some kindergartens emphasize story-reading and thereby exposure to MSA, others include systematic literacy activities such as learning letter names and writing letters, but ignore phonological awareness. Nevertheless, as already noted, the Arabic-sector curriculum has undergone considerable changes since 2008 when reforms focused attention on phoneme awareness and letter knowledge. Unfortunately, no systematic research has been carried out to determine the extent to which these reforms have been implemented *in situ*. Only this way can the influence of instruction be evaluated. This remains, therefore, a crucial question for future investigation because many of the key cognitive predictors in this study are likely to have their source in instructional factors that vary from site to site.

In addition to instructional factors, the poor performance on letter naming may be partly attributable to the visual complexity of the graphemes. Support for this assumption can be found in the significant correlation between the letter naming task and the two visual processing tests. Converging evidence was recently reported by Levin et al. (2008) which revealed that the visual similarity of the Arabic letters increased letter confusability among Israeli Palestinian kindergartners.

The second hypothesis proposed that visual/orthographic processing would play a significant role in word recognition (Abu-Rabia et al. 2003; Elbeheri and Everatt 2007; Ibrahim et al. 2002; Eviatar et al. 2004). Although visual perception and short-term visual memory contributed unique variance to word recognition, this contribution shrank considerably (to 4%) after controlling for the variance explained by all supra-lexical variables. Nevertheless, it is worth noting that the visual-orthographic memory test developed in this study had low reliability and relatively few items. In any case, future research will need to replicate the visual processing finding with more reliable tasks, and, above all, elucidate the locus of this effect. At least four factors will need to be investigated: graphemic similarity, short-vowel diacritics, ligatured letters and allographic variants of letters. In addition to the unique visual complexities of Arabic, there may also be a universal cross-linguistic visual component in learning to read, as visual processing has been found to contribute to word recognition in other Semitic languages such as Hebrew (Meyler and Breznitz 1998; Share and Levin 1999; Shatil and Share 2003) and, in some reports, even English (Badian 2005; Olson and Datta 2002; Pammer and Kevan 2007; Stein et al. 2001). The latter English-language studies attest to a renewed interest in the role of visual processing in reading ability which diminished considerably following the publication of Vellutino's (1979) authoritative book on dyslexia which provided compelling evidence against visual deficits as a cause of dyslexia.

The case of Arabic, however, presents an interesting argument for the role of visual factors. As discussed in the introduction, the complexity of letter-phoneme alignment (graphemic parsing) needs to be considered separately from issues of grapheme-phoneme correspondence. While English appears to be the most complex alphabetic orthography in terms of grapheme-phoneme correspondence, it seems less complex in terms of graphemic parsing than French for instance (Van den Bosch et al. 1994). Arabic appears to represent the inverse of English—visual/graphemic complexity co-occurring with grapheme-to-phoneme consistency. This 2-dimensional conception of orthographic complexity underscores the limitations of the dominant one-dimensional regularity-based or consistency-based taxonomy and offers a useful theoretical framework for future research into the predictors of reading in Arabic and cross-linguistic studies in general.

One of the most salient findings in the present study related to the third hypothesis which predicted a significant role for supra-lexical antecedents in word recognition due to the unique complexities of Arabic. Variables such as general verbal ability and syntax, in addition to working memory and non-verbal reasoning, all contributed significantly to Arabic word recognition. The most prominent variable in this set was syntactic awareness which explained a significant 11 % of the variance, and continued to account for significant variance (5 %) even when general ability (non-verbal ability and receptive vocabulary) was controlled. This suggests that the inexperienced reader must rely to a certain extent on contextual (supra-lexical) information to facilitate word recognition. This finding is in accordance with English-language studies showing syntactic involvement in the recognition of irregular words and among poor decoders (Bowey 2005; Strain and Herdman 1999).

Working memory accounted for only a few percentage points of the variance in word recognition. This finding converged with studies that showed an association between working memory deficits and poor word recognition (e.g., Siegel and Ryan 1989; Swanson and Alexander 1997). However, it is important to note that working memory no longer continued to contribute to word recognition once general ability was controlled. Some studies have found that a deficit in working memory is also characteristic of poor readers of Arabic (Abu-Rabia et al. 2003; Abu-Rabia and Siegel 2002). Additionally, Saiegh-Haddad (2005) showed that Arabic pseudoword reading fluency in first grade was primarily predicted by letter recoding speed (a composite measure of accuracy and speed of converting letter symbols into their corresponding phonemes), followed by working memory. In the current study, the contribution of working memory to word recognition was marginal, but this must be qualified by a methodological limitation: the present working memory task was very difficult for the kindergarteners and also had low reliability (0.65), hence future research will need to rectify this shortcoming.

Turning to the supra-lexical set of general ability measures adopted in the present study, these included non-verbal reasoning as assessed by Raven's matrices and receptive vocabulary as assessed by the Peabody Picture Vocabulary test (Dunn 1965). This pair accounted for modest variance in word recognition, but this finding should be treated with caution since the vocabulary test was adapted to MSA and not to the spoken vernacular. Thus, this contribution may partly reflect aspects of the literacy environment such as exposure to written Arabic and MSA vocabulary. Future research may need to assess both forms of vocabulary knowledge, namely, MSA and SAV in order to provide a clearer picture of the role of verbal (vocabulary) skills in word recognition in the initial phase of reading acquisition. It must also be acknowledged that despite the fact that the syntactic awareness task (TROG) was adapted to spoken Arabic, the complex sentence structures that make up many of the items in this test are more characteristic of MSA than SAV. Thus, it cannot be ruled out that these two supra-lexical abilities are partly tapping exposure to MSA.

This investigation also addressed a further question—the degree of modularity in early Arabic reading. The modularity-by-transparency interaction (Share 2008) predicts that an opaque script demands a greater degree of lexical and supra-lexical processing than a less opaque script. The finding that supra-lexical factors made a significant contribution to word recognition variance suggests that Arabic orthography may be considered only moderately transparent or semi-transparent among novice readers due to its complexity. This lack of transparency obliges the reader to resort to lexical and, wherever possible, supra-lexical or extra-lexical information. Thus, reading in Arabic may be a case of "semi-modularity". This finding is clearly very different from the conclusion reached by Shatil and Share (2003) regarding the cognitive modularity of pointed (full voweled) Hebrew. Their study showed that word recognition is highly dissociable from higher-order or supra-lexical abilities. This implies that the two linguistic cousins (Hebrew and Arabic) depend on somewhat different cognitive resources. However, it should be noted that the current study did not examine extrinsic/environmental factors (such as instruction) that are likely to distinguish between Arabic and Hebrew novice readers, so the question of teaching methods in Arabic remains to be pursued.

The designation of semi-modularity is corroborated by the finding that the contribution of intra-lexical abilities to word recognition (and reading comprehension) declined appreciably after we controlled for all supra-lexical measures (25 %). Furthermore, the current results revealed considerable overlap between intra- and supra-lexical abilities. A principal components analysis was undertaken for the four supra-lexical variables. Results showed that the first principal component accounted for 55.7 % of the variance with high positive weights on all four measures. Factor score coefficients for syntactic awareness, Raven, Peabody and working memory were 0.371, 0.344, 0.338, and 0.279 respectively. Using this principal component variable as the criterion variable in multiple regression, all intra-lexical abilities together explained a substantial proportion of the variance in supra-lexical abilities (multiple $R=0.70$, adjusted $R^2=0.45$). This finding confirms a high degree of overlap between intra-lexical and supra-lexical abilities in Arabic. Indeed, the combined set of intra-lexical abilities explained no less than 45 % of the variance in supra-lexical abilities when the latter was coalesced into a single composite measure based on the first principal component in this set. Two explanations for this overlap come to mind. The first concerns the complexities of Arabic script, the second relates to the diglossic context. It must be acknowledged that the current study did not address the diglossic issue directly, and some kindergarten measures included items tapping written Arabic (e.g., syntax (TROG) and vocabulary (Peabody). Future research will need to explicitly distinguish spoken and written aspects of Arabic-language processing.

The fourth hypothesis related to reading comprehension. As predicted, reading comprehension was explained by both intra-lexical and supra-lexical measures. This indicates that early reading comprehension in Arabic relies heavily on word recognition, hence the significant role of intra-lexical factors. In addition, extra-lexical factors such as higher-order thinking skills, vocabulary and sentence-level skills are necessary for the high-order reasoning processes required for reading comprehension.

Consistent with the cognitive breadth required for reading comprehension, supra-lexical abilities explained substantially higher unique variance in reading comprehension than in word recognition. Setting aside the problematic working memory task, it was found that general ability and syntactic awareness contributed unambiguously to individual differences in reading comprehension. This finding converges with earlier studies showing that reading comprehension is a global ability that depends on a wide range of precursor skills such as oral language proficiency and higher-level cognitive skills (Laurie and Hollis 2006; Nation et al. 2004).

The largest contributions to reading comprehension within the intra-lexical set of abilities were made by phonemic awareness and phonological processing. This reaffirms the crucial role of basic decoding ability (and its phonological foundations) in early reading comprehension in Arabic. However, it is important to note that all other intra-lexical abilities contributed significantly to reading comprehension even after partialling out general ability. The larger contribution of intra-lexical measures to reading comprehension than to word recognition replicates the finding reported by Shatil and Share (2003) in their Hebrew study. One possible explanation for this finding relies on the simple model of reading comprehension (LaBerge and Samuels 1974) which assumes that relatively weak lower-order or "bottom-up" skills impair comprehension not only because words are misidentified, but because fewer cognitive resources can be devoted to the processing of meaning. Consequently, word recognition difficulties in Arabic constitute a major stumbling block in comprehending written text in initial literacy learning. Support for this can be seen in the large inter-correlation between word recognition and reading comprehension ($r = 0.69$). The present results diverge from Shatil and Share (2003) who found a lower word recognition/comprehension correlation in Hebrew ($r = 0.46$).

8.6 Conclusion

To summarize, the present study provided some novel insights into the nature of the cognitive and psycholinguistic precursors of early reading acquisition in Arabic. Word recognition skill in the early grades depends mainly on sub-lexical and lexical abilities, most notably phonemic awareness and phonological processing, but also early literacy such as letter knowledge and print concepts, visual- orthographic processing and morphology awareness. Alongside these intra-lexical abilities, more general cognitive abilities and linguistic abilities such as syntactic awareness and vocabulary were shown to be significantly related to word recognition in Arabic, owing to the multiple complexities of the script as well as perhaps the diglossic context. This finding implies that word recognition in Arabic is only moderately autonomous or "semi-modular" in spite of the near perfect match between graphemic and phonemic units. Early reading acquisition in Arabic is slow and difficult—a fact that suggests that fully voweled Arabic is a relatively opaque Arabic orthography, although the uni-dimensional notion of transparent-opaque orthographies may not be the most adequate framework for conceptualizing the present findings. Overall, early Arabic reading comprehension skill relies heavily on decoding skill as well as higher-order linguistic and cognitive abilities.

An immediate implication of this study relates to initial reading instruction. The present results show that phonological awareness develops slowly in Arabic and is a strong predictor owing to the complexities of the orthography. It would, therefore, seem to make sense to include phonemic awareness instruction as an integral component of reading instruction from kindergarten onward.

Because the present results revealed a non-trivial contribution of supra-lexical abilities to word recognition, initial instruction may also need to emphasize the syntactic structures of MSA sentences and MSA vocabulary.

Finally, an interesting implication of this study relates to reading comprehension skill. The present results revealed a high correlation between decoding skill and reading comprehension, implying that a significant number of reading comprehension difficulties in the early grades may be related to decoding difficulties. Remediation programs will consequently need to focus on developing decoding skill in young children.

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