Reading and spelling error analysis of native Arabic dyslexic readers

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Abstract. This study was an investigation of reading and spelling errors of dyslexic Arabic readers ($n = 20$) compared with two groups of normal readers: a young readers group, matched with the dyslexics by reading level ($n = 20$) and an age-matched group ($n = 20$). They were tested on reading and spelling of texts, isolated words and pseudowords. Two research questions were the focus of this study: What are the reading and spelling profile errors of dyslexic native Arabic speakers? What is the effect of the Arabic orthography on these types of errors? The results of the reading error analysis revealed a clear contribution of the uniqueness of the Arabic orthography to the types of errors made by the three different groups. In addition, the error profiles of the dyslexic readers were similar to the error profiles made by the younger reading-level-matched group in percentages and in quality. The most prominent types of errors were morphological and semiphonetic, which highlighted the contribution of the Arabic orthography to these types of errors. Consistently, the profile of the spelling errors was similar in percentages and quality among the dyslexics and the reading-level-matched group but different from the age-matched group on the spelling measures. The analysis of the spelling errors revealed that the dominant type of error was mostly phonetic due to the limited orthographic lexicon. In addition, the Arabic orthography also contributed to these types of errors because many spelling mistakes were made due to poor knowledge of the spelling rules. The results of the reading and spelling errors are discussed from a reading development point of view. Further, two models are suggested, one for reading and one for spelling, to illustrate the cognitive processes that underlie the reading and spelling mistakes in this type of orthography.

Key words: Arabic morphology, Arabic orthography, Arabic reading disabilities, Morphological errors, Spelling and reading errors

Introduction

The process of reading involves different strategies and skills that are all based on phonological decoding (Muter, 1998). The decoding process demands breaking the words down into phonemes, the shortest sound units in the language, and blending them in a systematic sequence to determine the correct pronunciation for each written word (Passenger, Stuart & Terrell, 2000). Reading and spelling error analysis

contributes essential knowledge to understanding the cognitive strategies that children use in doing reading and spelling assignments.

Further, it is important to learn more about the reading development process and the sources involved in reading and spelling processes (Moats, 1993; Worthy, 1990). Different writing systems show different and unique linguistic characteristics that affect the reading and spelling process in different languages (Abu-Rabia, 1997a, 2001, 2002). Thus, testing the reading and spelling errors in Arabic among dyslexic native Arabic readers compared with reading-level-matched and age-matched groups will enhance the understanding of the reading process in this type of orthography, particularly because reading and spelling error analysis among native Arabic children has not yet been investigated.

Reading acquisition

There is almost a consensus that in reading acquisition at least two abilities must develop: the linguistic mental lexicon and the phonological decoding ability (Snowling, Defty & Goulandris, 1994). The latter is essential for developing good reading skills (Share, 1995, 1999). Children who demonstrate delays in mastering reading skills have poor phonological decoding skills, which negatively affects their word recognition process (Abu-Rabia, 1995; Share, 1995; Stanovich & Siegel, 1994).

Snowling et al. (1994) suggest that the development of phonological strategies is critical in the reading acquisition process in order to help the regular development of mental lexical representations, because without them written word recognition will always be poor. The development of phonological reading strategies occurs during the visual–orthographic reading stage. Acquiring fluent reading strategies depends on the transition from the stage of reliance on visual–orthographic reading to phonological decoding, and then rapid transition from the phonological stage (Frith, 1985; Marshall, Friedman, Welch, & Desberg, 1983; Morton, 1989). Seymour (1990) suggests that the specific orthographic mental lexicon of the skilled reader relies on an interactive process of logographic knowledge represented in his/her mental lexicon, which is partially specific, with knowledge that is derived from application of phonological reading that relies on the natural development of the phonemic awareness. According to Seymour's model (1990), the beginner-reader may begin with visual reading or phonological reading, but ultimately both strategies are needed for logographic lexical development. Once this lexicon is completed, tackling words and nonwords is processed via two different channels. Perfetti (1992) also suggests that while

reading is developing, the quality of the lexical logographic representations are developing too. Frith (1985) suggested three stages of reading development. Children start with the visual stage, learning to associate words with pictures or situations. She calls it the logographic stage. The second is the alphabetic stage when children start to use more of the grapheme–phoneme correspondence (GPC) rules. In this stage children start to tackle unfamiliar words by applying GPC rules. Finally, they reach the orthographic stage when they automatically recognize spelling units while reading.

Martin, Pratt, and Fraser (2000) conducted a study with results that support Frith's model (1985). Three groups of participants were investigated in the study, one group with developmental dyslexia, an age-matched group and a reading-level-matched group. The participants were presented with words: orally or visually. In the visual mission they were asked to omit the initial sound of the word and say the new word that remains or to omit the first letter of the word and write the new word that remains. In the oral mission participants hear the word rather than see it and follow the same instructions as with the visual words. The results indicated that the normal age-matched readers succeeded in both missions: the phonological and the orthographic. The younger normal readers of the reading-level-matched group succeeded in the phonological and failed in the orthographic, whereas dyslexics failed in the phonological missions especially when words were presented orally.

Reading acquisition and spelling

There are shared representations that underlie reading and spelling skills (Holmes & Carruthers, 1998). Katz (1989) suggested that the spelling process demands mapping phonological units into orthographic units, which is the opposite of the reading process. However, Curtin, Manis, and Seidenberg (2001) suggest that the spelling process involves shared efforts of some sources that also motivate the readers' reading skills. The spelling process is a complicated process at a higher level than reading, because there is always one way to pronounce one phoneme, but there are sometimes more than one phonological representation for a phoneme. Thus, spellers need their orthographic lexical knowledge to ensure correct spelling. Readers may also rely on partial orthographic knowledge of those words in the text while reading, i.e., context of text, in order to reach exact pronunciation of phonemes (Lennox & Siegel, 1993).

Accordingly, the spelling process demands awareness of orthographic units more than the reading process itself. According to Holmes and Carruthers (1998), the unskilled speller faces problems in retrieving the specific orthographic unit of the specific word. According to Steffler (2001), retrieving the specific orthographic unit is a matter of implicit memory skill that develops as a result of exposure to written verbal messages that constitute the basis of acquiring and developing the orthographic units of words in the memory. According to these reading models, the textual stimulus, orthographic units trigger the stored orthographic lexicon (Ellis, 1993).

According to the reviewed literature, the spelling skill is well developed if reading has developed naturally. This enables readers to acquire orthographic knowledge about words. Lennox and Siegel (1998) explain the spelling process through the dual route model. They argue that the spelling process is developed through two different channels. First, the phonological where children learn how to represent sounds of words in letters, how to translate the phonemic codes to graphemic codes; the second involves direct lexical access without phonological intervention. The main conclusion of Lennox and Siegel (1998) is that children learn to spell using phonological and orthographic strategies, namely skilled spellers use phonological as well as visual codes effectively in the process of spelling. Consistently, Snowling (1987) assumes that there is a compensation process between different sources of orthographic knowledge, reading and spelling. Dyslexic children who suffer from low phonemic awareness fail to make it to the orthographic stage (Frith, 1985) and tend to develop dysgraphia in spite of their ability to acquire some alphabetical spelling skill. Temple (1986) distinguishes between two types of dysgraphia. In the first type, phonological dysgraphia, children spell real words correctly and fail to spell pseudowords correctly. The explanation for this type of dysgraphia is the natural conservation of the lexical access while the spelling phonological route is deficient. The second type is surface dysgraphia in which children write phonetically but with the incorrect orthographic structures, the failure to write homophonic words. According to Temple (1986), the explanation for this type of dysgraphia is natural phonological development while the spelling lexical access is deficient.

Many researchers argue that the morphology of the language plays an essential role in reading and spelling, especially in the Semitic languages: Arabic and Hebrew (Abu-Rabia, 2001; Abu-Rabia, Share & Mansour, 2003; Beland & Mimouni, 2001; Ravid, 2001). Ravid (2001) argues that the morphology of Hebrew plays a major role in determining what letters are acquired first among children. She continues that

beginners rely on morphological cues of their familiar spoken language and look for those cues in the written language while learning spelling. Furthermore, Somech (2001) investigated the role of morphology in the decoding and the orthographic learning of new words. She found that children pronounced words according to morphological structures expected from the context of the story. Likewise, Beland and Mimouni (2001) assume that Arabic is a morphological language that heavily affects the reading strategy of the readers.

The developmental lag of dyslexia

Many scholars attribute the developmental lag of dyslexic readers to a gap between their expected phonological processing level and their general intelligence (Stanovich, 1988). This developmental lag is specific to reading and phonological processing and certainly not related to other types of disorders (Aaron, 1987). This delay in phonological processing is attributed to slow maturation of certain areas in the central nervous system that are responsible for the phonological process ability (Satz & Fletcher, 1980). However, the dual route model of reading acquisition (Castles & Coltheart, 1993) considers two types of dyslexia, phonological dyslexia and surface dyslexia. The first show failure in pseudoword reading and unfamiliar words, and the latter do not show special difficulty in reading pseudowords or new words, but their failure is manifested in reading irregular words. The lexical access to the lexicon enables retrieval of whole phonological representation of irregular words relying on their specific orthographic–visual structure while sublexical processes operate to match the letters to the sounds of the specific word. The correct mapping enables correct pronunciation of words. Accordingly, the phonological dyslexia in the lexical processing continues to develop naturally along with some lag in sound to letters mapping skills. However, according to Snowling (2001), the only explanation for dyslexia and its subtypes is embedded in deficits in the phonological representation aspect of reading. She argues that the different symptoms of dyslexia are related to failure of dyslexics in phonological processing and its integration with other aspects of language processing, while both mechanisms constitute the best prediction of children's ability in reading and spelling.

Snowling et al. (1994), in a longitudinal study, compared performance of dyslexic readers on reading tasks to age-matched groups and to children who were matched in their reading level. The progress of the dyslexics was very slow compared to the reading-level-matched group, and compared to the age-matched group, some specific difficul-

ties were observed in reading nonwords and repeating them. This latter group also showed a dysphonetic error type in spelling, namely problems in phoneme–grapheme matching. Snowling et al. (1994) explained these results in terms of the lag of phonological processing development of those dyslexics causing the delay in reading and spelling skills. Snowling et al. (1994) further assert that this developmental lag observed in this longitudinal study of these children in certain points in time later becomes a developmental disorder. Further, this phonological disorder differs in its severity among dyslexic readers, causing heterogeneity and variance among the subtypes of dyslexia. Despite this phonological processing lag, adult dyslexics manage to master reading and show progress in their reading skills. However, they fail in reading pseudowords, unfamiliar and irregular words, which indicates that the difficulty of phonological processing still exists and hinders phonological decoding ability (Bruck, 1998; Felton, 1998; Morton & Frith, 1995; Penington, van Orden, Smith, Green & Haith, 1992; Stanovich, 1994).

Reading and spelling errors of dyslexics

The importance of error analysis is that it sheds light on the reading and spelling strategies that children use. Goulandris and Snowling (1995) suggested subtypes of these reading errors:

1. Errors as a result of visual similarities, i.e., *money = morning*, which indicates that children adopt lexical reading strategies in reading and certainly not phonological decoding strategies.
2. Failure in correct pronunciation, which stems from the inability to decompose letters of words before applying grapheme–phoneme rules, deficient knowledge about letters-sound rules and inability to blend phonemes.
3. Regularization effect: Readers may read irregular words as analogous to regular words that sound similar, such as *flood* rhyming with *food*, which indicates that readers in this case use phonological decoding strategies and do not use specific lexical strategies.
4. Refusals: A non-reaction of beginning readers who fail to tackle new and unfamiliar words and resort to guessing strategies.

In addition, dyslexics make consistent spelling errors in addition to the reading errors and phonological decoding (Lennox & Siegel, 1993; Moats, 1993; Nelson, 1980). Analyzing the spelling errors of children enables us to learn about the development of the ability to read and the way these children acquire the rules of the language they read (Worthy, 1990). Moats (1993) argues that analysis of spelling errors of

dyslexic children enables us to learn about the subtypes of reading disabilities. Further, the use of this analysis may become a good feedback in evaluation of reading disabled intervention programs. Moats (1993) continues that English dyslexics who acquired the English orthography demonstrate problems in identification of orthographic units and in monitoring their own errors. However, Sawyer, Wade and Kim (1999) argue that the spelling error patterns of dyslexic readers are still missing, especially the phonological dyslexics. Pennington et al. (1986) conducted a study comparing spelling errors of adult dyslexics to their reading-level peers and to a young chronological age group. They analyzed spelling errors in two conditions of difficulty: phonological and orthographic. The main result was that the adult dyslexics made similar errors to the reading-level-matched readers in the phonological condition but fewer errors than the age-matched readers, while their performance on the orthographic task was similar to the reading-level-matched group. These results indicate that specific cognitive processes are responsible for accuracy on all aspects of performance, orthographic as well as phonological.

Nelson (1980) found that dyslexics made similar spelling errors, in rate and type, to subjects who were matched for reading level. Their errors were characterized by inadequate orthographic representations and many inaccurate phonological representations and errors of letter order in words. Likewise, Moats (1993) found that spelling errors of dyslexics were similar to those of reading-level-matched readers.

Boder (1973) was one of the first to analyze spelling errors among dyslexics indicating two types: dysphonetic and dyseidetic dyslexics. The first indicated inadequate phonological representation in familiar and in unfamiliar words, whereas the latter indicated accurate phonological representations; however, their difficulty was manifest in irregular orthographic patterns. Consistently, Manis, Szeszulski, Holt, and Graves (1990) divided dyslexic subjects into three major groups based on phonological and orthographic accuracy measures: the phonological group deficit, the orthographic group deficit, the group of both deficits, as opposed to the regular reading-level-matched group. The results indicated that the phonological deficit group demonstrated difficulty in spelling pseudowords as compared to spelling irregular words. The orthographic deficit group managed to spell pseudowords and failed to spell irregular words. The dyslexic group, compared with the reading-level-matched group, did not differ in its pseudoword and irregular word spelling error mistakes. The authors believed that these results enhanced the existing claim that there is high similarity between the processes underlying the reading processes and the spelling processes.

Snowling, Goulandris, and Defty (1996) investigated the development of reading among dyslexics. Their spelling errors were analyzed and three subtypes were observed; first, phonetic errors, i.e., cigarette – sigaret. Words were written according to their sounds and not according to their specific orthographic patterns. Second, semiphonetic errors based on isolated specific phonemes: omission of initial phoneme, addition of phoneme, substitution of one phoneme with another based on its similar sound, and dysphonetic errors including errors when the written orthographic units did not represent the right phonemic representation of the target word. The authors concluded that the dysphonetic errors were highly frequent among dyslexic readers and attributed this to a phonological delay.

The reviewed literature basically includes reading developmental studies among dyslexic readers in the English language. Although researchers think that the basis of dyslexia in alphabetic languages shares the same causes, namely a deficit in phonological decoding (Aaron, 1989), still other researchers think that studying dyslexia in different orthographies may contribute substantially to understanding the reading process in these languages and dyslexia in general (Abu-Rabia, 2001; Abu-Rabia et al., 2003). This attracts researchers to study different orthographies in order to learn more about the reading and spelling processes in these languages as compared to the known results of the literature (Abu-Rabia, 1997a, 1997b, 1997c, 1998, 2001, 2002).

Arabic orthography

Arabic is a language written in an alphabetic system of 28 letters, all consonants except three, the long vowels. Most Arabic letters have more than one written form, depending on the letter's place in a word: beginning, middle, or end. However, the essential shape of the letter is maintained in all cases (Abd El-Minem, 1987). In addition, the letters are divided into categories according to basic letter shapes, and the difference between them is the number of dots on, in or under the letter. Dots appear with 15 letters, of which 10 have one dot, three have two dots, and two have three dots. In addition to the dots, there are diacritical marks that contribute phonology to the Arabic alphabet (Abu-Rabia, 2001). Arabic words are a combination of consonants and vowels. Skilled and adult readers are expected to read texts without short vowels, but this demands heavy reliance on context and other resources. Beginners and poor readers read texts with short vowels. Vowelized Arabic is considered shallow orthography, and unvowelized

Arabic is considered deep orthography. Reading accuracy in Arabic requires vowelizing word endings according to their grammatical function in the sentence, which is an advanced phonological and syntactical ability (Abu-Rabia, 2001). Silent reading comprehension is less strict, because the reader can rely on orthography, morphology, and other resources (Abu-Rabia, 2002).

Arabic morphology
Arabic morphology is built of two types of structures: derivational and inflectional.

Derivational morphology. All words in Arabic are based on phonological patterns built on roots that are consonantal patterns. Roots are triliteral or quadriliteral, that is, with three or four consonants. This is not a phonological unit but an abstract entity. The phonological pattern is constructed of

(a) short vowels built onto roots. The phonological process does not break the orthographic order of the consonantal root;
(b) patterns that include vowel letters, which are inserted between the root consonants. Here the phonological pattern of the infixes breaks the orthographic order of the consonantal root;
(c) additional patterns with vowel letters that may come as prefixes or suffixes. The root conveys the initial lexical access and the combination of roots and phonological patterns conveys specific semantics (Frost, Forster & Deutsch, 1997).

The derivational morphology has two types of word patterns: verbal word patterns and nominal word patterns. There are 15 very frequent verbal word patterns in Arabic. Each verbal word pattern determines the inflectional pattern of the word (Abd El-Minem, 1987; Al-Dahdah, 1989; Wright, 1967). The verb pattern conveys basic semantics via verb roots, and it can change the meaning of a new word based on that root; different verb patterns built on the same root may convey different semantics (Abd El-Minem, 1987). There are nine nominal word patterns. There is semantic consistency in all these different nominal word patterns (Bentin & Frost, 1995), some of which are more common than others. The derivations of nouns are constructed in two ways, one by addition of nominal patterns of the base roots and one by changing the past tense to the present tense by applying a phonological pattern to the latter (Abd El-Minem, 1987; Al-Dahdah, 1989; Wright, 1967).

Inflectional morphology. In contrast to the derivational process, in which the basic constituents are roots and word patterns, the inflectional morphological system in Arabic is constructed by attaching prefixes and suffixes to real words. The system of inflectional morphology of verbs is systematic and considers person, number, gender and time. In the past tense inflectional morphology shows person, number, and gender through the addition of suffixes to the basic verb pattern (third person masculine singular). In future and present tenses of verbs the inflectional morphology is also according to person, number, and gender, indicated by prefixes and sometimes suffixes. The imperative mood is formed for person, number, and gender by the addition of prefixes and suffixes (Abd El-Minem, 1987; Al-Dahdah, 1989; Wright, 1967). The inflectional morphological system of nouns considers gender, masculine/feminine; number, singular/plural, masculine and feminine; and pairs, masculine/feminine.

Most verbs and the majority of nouns are constructed out of roots of three consonants, occasionally two or four. Roots are built in phonological patterns to create specific words; these patterns may be a series of consonants or a series of vowels and consonants. As for roots and morphemic word patterns, most words in Arabic are constructed of two morphemes: the combination of a root and a word pattern creates a certain word. Different morphemes convey different types of information: the root conveys more information than the phonological pattern, which leads to the core meaning of the word (Abu-Rabia, 2001, 2002), whereas the word patterns usually convey information on word class.

In sum, the combination of morphological units in Arabic is not linear, but it relies on intertwining between two independent morphemes (the root and the word pattern). The order of root letters is dependent upon the word pattern and its way of intertwining with the root. The word pattern can be built of prefixes, suffixes and infixes, whose intertwining with the root can break the actual order of the root letters.

Research questions

(1) What type of reading and spelling errors characterize native Arabic readers?
(2) Is there a special reading and spelling error pattern among Arabic dyslexics that differs from reading-level-matched groups and age-matched group? Or from dyslexics in other languages?

Research hypotheses

(1) Different rates and error types will differ between dyslexics and the other groups.
(2) Dyslexics and their reading-level-matched group will tend to show similar reading and spelling errors.
(3) The reading and spelling errors will reflect the uniqueness and complexity of the Arabic language.

Method

Participants

Sixty students were screened from a total of 105 students who participated in this study. Twenty dyslexic students from grade 5, who had been professionally diagnosed as dyslexics; 20 normal 5th grade readers (who were matched to the dyslexic group according to their age) and 20 young normal readers, who were matched to the dyslexic group according to their reading level.

The two control groups, the age-matched and the reading-level-matched, were also screened according to, gender, socio-economic status and general ability.

Screening tests

General ability
The Raven-R (Raven, 1959) tests the nonverbal thinking level: the ability to create comparisons, analogies, inductions and deductions.

The Wechsler (Wechsler 1974) is a subtest of the Wechsler for children aged 6–16. It consists of 16 items, each item has a pair of words, the participant has to figure out the shared characteristics between the two words. The goal of this subtest is to learn about the ability of the participants to think and to reach abstraction while reading and thinking about words.

The goal of the general ability tests is to match the control groups to the experiment group: to match the age group on general ability and to confirm that the general ability of the participants falls within the norm.

Visual perception
Motor Free Visual Perception Test-Revised (*MVPT-R*) (Colarusso & Hammill, 1996) for children of age range 4–11.6 years. The goal is to

test visual perception. The test addresses spatial relations, figure determination, image and background, visual meaning, series completion and directions.

Reading tests

Text reading

Reading accuracy of the participants was measured in texts from the basal readers of grade 5. This was to determine the reading level of the participants.

Reading isolated words

A 20-word reading list from the basal reader of the participants, grade 5, was presented to them in order to determine the reading level of the participants by testing their reading accuracy.

The dyslexic group

The dyslexic students were diagnosed by the professional staff of the Ministry of Education as dyslexics and were studying in a special class. (Their age suits grade 5.) Other dyslexic students were diagnosed and treated in a local center for learning disabilities. All the dyslexic participants were native speakers of Arabic who came from a middle socio-economic status. Thirty-nine dyslexic students participated in the study. Twenty students were screened (mean age 11.19 and standard deviation 0.30). Their reading level was grade 2 according to their reading level in texts and isolated words from their grade 5 basal reader (see Tables 3 and 5). The additional criterion for the screened participants was the general ability tests.

The 20 dyslexic participants demonstrated acceptable ability on the Raven (1959) and the subtest of the Wechsler (1974), MVPT-R (Colarusso & Hammill, 1996) (see Table 3).

The control groups

Reading-level-matched

The reading level of the dyslexic participants was determined according to their reading level in texts and isolated words. Therefore, grade 2 teachers were asked to prepare a list of grade 2 pupils who were considered good readers in grade 2. Out of 30 screened pupils, 20 pupils were selected for this study. Their mean age was 8.04 and standard deviation 0.37. These young pupils matched the dyslexic students' reading level and their results on the general ability tests were as expected for their

chronological age. All the participants were from the middle socio-economic status, and they were native Arabic speakers from northern Israel.

Age-matched
Arabic language teachers of grade 5 were asked to prepare a list of skilled readers from grade 5. A list of 36 students was prepared and 20 of them were chosen to participate in this study. Their mean age was 11.10 and standard deviation 0.36. Their reading level reached 95% on reading texts and isolated words and their results on the general ability tests were as expected from their age. They were all native speakers of Arabic.

As seen in Table 1, there was no significant difference between the dyslexics and the age-matched on the general abilities tests. However, the differences on the reading accuracy tests were statistically significant. The age-matched group demonstrated skilled reading in texts and in isolated words appropriate for their age. Although the reading level of the dyslexics did not match their chronological age, it did, however, match the group reading level of young readers of grade 2. The age-matched group

Table 1. Means and standard deviations of all groups on the general ability tests.

Tests		Dyslexics	Reading-level-matched	Age-matched
Raven	M	45.20	31.15*	45.60
	SD	2.73	2.13	2.37
MVPT-R	M	39.90	33.55*	39.85
	SD	0.31	1.14	0.37
Wechsler	M	11.40	8.15*	11.40
sub-test	SD	1.27	1.30	1.19
Reading	M	76.25	–	98.05*
accuracy grade	SD	2.24	–	1.23
5 level (text)				
Reading	M	98.30	98.10	–
accuracy grade	SD	1.17	1.25	–
2 level (text)				
Reading	M	60.70	–	96.20*
accuracy isolated	SD	1.72	–	1.26
words grade 5 level				
Reading	M	96.75	96.15	–
accuracy of isolated	SD	1.21	1.10	–
words grade 2 level				

*$p < 0.001$

differed from the reading-level-matched group on the general ability tests. Thus, we can determine that the dyslexic group matched the age-matched group on all measures, except for the reading measures, and matched the reading-level-matched group only on reading level.

Testing tools

Reading tests

Vowelized isolated words. The list of words was built specially for this study. It consisted of 56 words with gradually increasing difficulty. We considered low/high frequency, regular and irregular words and words that represent all the characteristics of the Arabic language writing. The words were chosen from the basal reader of the participants to match the age of the experimental group.

Vowelized pseudowords. The list of pseudowords was built specially for this study. It consisted of 21 pseudowords. The pseudowords were built by changing a letter or a phoneme in a regular word which should change the regular word to a pseudoword. In addition, blending phonemes together according to a more frequent word pattern or a less frequent word pattern. The words were chosen from the basal reader of the participants to match the age of the experimental group.

Vowelized text reading. The text consisted of 208 words. The text was chosen from the basal reader of the participants to match the age of the experimental group.

Spelling tests

Vowelized isolated words. A list of 51 real words was chosen for spelling. It was built in the same way as the reading list. The words were chosen from the basal reader of the children to match the age of the experimental group.

Vowelized pseudowords. The list consisted of 20 pseudowords. It was built specially for this study. It was built the same way as the pseudoword reading list. Words were chosen from the basal reader of the participants to match the age of the experimental group.

Vowelized spelling test. The text was chosen from the basal reader of the children. It consisted of 175 words.

Procedure

The testing procedures were conducted at the schools in a quiet room dedicated specially for the purpose of this study. Testing took place during the regular school days of the week. All tests were conducted in a one-on-one method. The order of the tests was changed for each participant for counterbalancing purposes.

Results

Reading and spelling error analysis is the focus of this section. The following are classifications of reading and spelling errors among the dyslexic Arabic readers as compared with the normal readers.

Reading errors

1) *Nonsemantic semiphonetic* (Snowling et al. 1994): Errors as a result of mispronunciation of words, resulting in a nonword. In this case the readers are unable to master strings with short vowels on and under the letters. This caused reliance on the orthography. For example سُوقْ /market was read as سَوَقْ/nonword. However, both words share the same letters but not the same short vowels.

2) *Semantic and nonmorphological semiphonetic* (Beland & Miomouni, 2001): These are errors as a result of mispronunciation of the word; however, the target word is read as another word visually and orthographically similar to the target word, but the short vowels are posted on different letters. For example, the word ذَهَبَ /went was read as ذَهَبْ /gold; the word يُؤْمِنْ /believes was read as تُؤَمِّنْ /to keep safe.

3) *Semantic dysphonetic* (Boder, 1973; Snowling et al., 1996): These errors are a result of a phoneme substitution with other phonemes or as a result of substitution of number of phonemes. The result is reading the target word wrong and substituting a totally different word for it. For example: ألأيّامْ /the days was read as ألأيتام /the orphans.

4) *Nonsemantic dysphonetic* (Snowling et al., 1996): These errors are a result of mispronunciation of the orthographic units of words, which occurs when the reader substitutes phonemes while relying on visual–orthographic guessing. The result is usually reading

nonwords. For example, the word سَنَواتٍ / *years* was read as سَوْنَوَاتْ/*sawnawat*, a nonword.

5) *Morphological errors* (Beland & Mimouni, 2001): These are reading errors that still relate morphologically and semantically to the target word. For example: The word تَنْتَظِرْ / *waiting* was read as يَنْظُرْ/ *looking*; and the word وَلَد / *boy* was read as أولاد / *boys*. The morphological error is actually a phonological representation that relates to the morphology of the target word.

6) *Addition of functional words:* These errors occur when readers add unnecessary function words; في / *in,* إلى / *to,* and مِن / *from,* and أل / *the* was also considered a function word.

7) *Visual letter confusion:* These errors are made as a result of confusion of letter-shape similarities. A mismatch between graphemes and phonemes is the result.

8) *Irregular pronunciation rules:* These errors are made when readers pronounce letters that are silent. For example, the rules of أل / *the* before the sun or moon letters/ألصباح، البضائع

9) *Semantic sentence guessing:* This type of error is made as a result of semantic guessing of the sentence based on the visual–orthographic structure of the sentence. For example: في أحد الأيام / *once upon a time,* was read as في يوم الأحد / *on Sunday.*

10) *Semantic errors* (Beland & Mimouni, 2001): This type of error is made by substituting the target word with another word related semantically to the target word. For example, the word لِبَيْتَها / *to her house,* was read as لدارها / *to her home* which carries the same meaning.

11) *Omitting functional words:* Errors that are made by omitting necessary Arabic functional words.

Spelling errors

1) *Phonetic errors* (Snowing et al., 1996): These types of spelling errors are made when the writer is unable to translate specific phonemes of a certain word to graphemes. This mismatch between orthography and phonology is made when the writer cannot rely on lexical writing. For example, the word يحضّر / *to attend* has the letter ض which represents the sound of *d* while there is another similar representation to this letter which is د /*d,* which ultimately leads to a different and incorrect word. Further, some phonetic errors are also made as a confusion between the short vowels and long vowels:بَ / *BA* confused with با / *BAH*.

Some of these errors occur in the end of words when writers have to vowelize the end of words. Usually they confuse the short vowel with the long vowel: The word مَدْرَسّة / *school* with a short phoneme *tun*. It was written with the long vowel مَدْرَسُّن / *school*, which is pronounced *madrasatoon* with long *oon*. In addition, the intervention of the local spoken Arabic into the process of spelling where children hear the literary word, but they write it the way they speak it in their daily life.

2) *Semiphonetic errors* (Snowling et al., 1996): This is when the orthography of a word does not represent the target word phonologically because of lack of internal specific representation. However, the major orthographical-phonological chuck of the word is preserved. These errors are caused by omitting, adding and substituting phonemes. For example, the word وَظِيفه / *job*, was written as وظّفه / *gave him a job*.

3) *Dysphonetic errors* (Boder, 1973; Snowling et al., 1996): This type of error occurs when the words are spelled incorrectly in more than one phoneme and when the spelled orthographic chunk does not represent most of the phonemes of the target words. Namely, there is no correct grapheme-phoneme correspondence and no internal lexical representation. For example, the word فكره / *idea* was read as رفرت, pronounced *Rifrat*, a nonword. It is more of a pseudohomophone but does not carry any meaning in Arabic.

4) *Visual letter-confusion errors:* The spelling errors were caused because children were confused between the similar visual shapes of letters: // س، ش /ض// ، صّ // ب، ث، ث، ن، //. For example, the word تَذْكَرَت / *she remembered* was spelled ندكرت, which is a nonword, because of substituting the letter ت / *t* with the letter ن / *n*, two visually similar letters, with different sounds.

5) *Irregular spelling rules:* These errors are caused because of lack of mastery of the spelling rules of Arabic. For example, أل/ *the* is not pronounced when it precedes the "sun" letters; however, it is represented in writing. Further, the consonant ء is presented in a word according to the vowel and letter that preceded it. Thus, there are different ways of spelling a consonant in a word:

سائل / *liquid*, مسؤول / *responsible*, and أين / *where*.

6) *Word omission:* Errors where children omitted whole words.
7) *Functional words omission:* Errors where children omitted functional words that preceded words.

Statistical analysis

Reading

Error analysis in text reading. The dyslexic readers made significantly more mistakes than the other two groups: Dyslexics (M = 39.85, SD = 7.20); age-matched group (M = 3.3, SD = 2.1) and the young reading-level-matched group (M = 30.50, SD = 8.62). These differences were statistically significant ($t(38) = 3.724$, $P < 0.05$), ($t(38) = 21.80$, $P < 0.05$), respectively.

Table 2. Means and standard deviations of types of errors of the three groups on reading texts.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Nonsemantic semiphonetic	2.50 (6.63%)	1.63 (4.62%)	0.05 (0.62%)	0.22 (4.63%)	3.40 (11.42%)	1.85 (6.62%)
Semantic and nonmorphological semiphonetic	2.70 (6.66%)	2.04 (4.29%)	0.686 (14.75%)	0.45 (22.62%)	2.20 (7.22%)	1.36 (3.87%)
Semantic dysphenetic	3.30 (8.01%)	2.08 (3.89%)	0.70 (16.75%)	0.87 (19.31%)	1.30 (4.38%)	1.20 (3.97%)
Nonsemantic dysphonetic	1.90 (4.68%)	1.55 (3.89%)	0.05 (0.83%)	0.22 (3.70%)	0.70 (2.54%)	1.03 (4.43%)
Morphological errors	22.25 (56.38%)	1.55 (10.14%)	1.55 (41.12%)	1.14 (24.02%)	17.85 (57.43%)	7.32 (13.19%)
Addition of functional words	2.3 (5.83%)	1.26 (3.35%)	0.12 (2.91%)	0.37 (9.07%)	1.5 (4.83%)	1.5 (4.99%)
Visual letter confusion	0.3 (0.79%)	0.66 (1.70%)	–	–	0.05 (0.14%)	0.22 (0.64%)
Irregular pronunciation rules	1.40 (3.40%)	1.76 (4.37%)	–		1.20 (4.30%)	1.44 (5.60%)
Semantic sentence guessing	1.05 (2.48%)	0.50 (2.32%)	0.15 (2.66%)	0.37 (6.54%)	0.50 (1.55%)	0.82 (2.67%)
Semantic errors	0.55 (1.23%)	1.05 (2.40%)	0.15 (3.50%)	0.34 (8.5%)	0.50 (1.97%)	1.00 (3.90%)
Omitting functional words	1.55 (5.84%)	1.31 (3.30%)	0.10 (2.90%)	0.30 (9.10%)	1.30 (4.83%)	2.47 (4.99%)
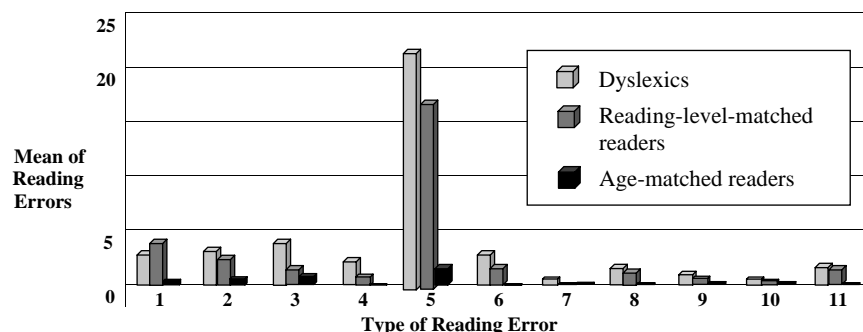
1 – Nonsemantic semiphonetic
2 – Semantic and nonmorphological semiphonetic
3 – Semantic dysphonetic
4 – Nonsemantic dysphonetic
5 – Morphological
6 – Addition of functional words
7 – Visual-letter confusion
8 – Irregular pronunciation rules
9 – Semantic-sentence guessing
10 – Semantic
11 – Omitting functional words

Figure 1. Mean errors of all groups in reading texts.

Table 3 presents means and standard deviations of the groups' error types. The dyslexic group made significantly more morphological errors than the other two groups. The morphological type of error was the highest among all groups as compared with the other types of errors (see Table *2* and Figure 1).

The MANOVA procedures indicated significant effects for all error categories at the significance level of $P < 0.05$, except for the semantic error type that did not reach statistical significance.

The Tukey post-hoc comparisons between the dyslexic readers and their reading-level-matched peers on text reading indicated a nonsignificant effect on all types of errors except for semantic dysphonetic, non-semantic dysphonetic and morphological errors ($P < 0.05$ for all significant differences). However, the differences were statistically significant ($P < 0.05$) when the dyslexic readers were compared with their age peers, on all types of errors except for the semantic errors.

Error analysis of isolated words. The dyslexic readers (M = 22.90, SD = 7.44) and the reading-level-matched group (M = 25.05, SD = 5.75) made more errors than the age-matched group (M = 3.45, SD = 1.66). The differences between the errors made by the dyslexic readers and the

Table 3. Means and standard deviations of types of errors on reading isolated words of the three groups.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Nonsemantic semiphonetic	5.15 (23.19%)	2.40 (11.4%)	0.05 (0.84%)	0.22 (3.72%)	7.35 (29.94%)	2.27 (8.52%)
Semantic and nonmorphological semiphonetic	3.65 (16.91%)	1.78) (9.29%)	0.45 (13.05%)	0.69 (22.74%)	5.35 (21.03%)	2.36 (6.94%)
Semantic dysphenetic	1.85 (8.03%)	1.63 (3.89%)	0.40 (14.91%)	0.50 (24.95%)	1.30 (4.75%)	1.20 (4.10%)
Nonsemantic dysphonetic	2.75 (11.35%)	2.09 (7.74%)	0.25 (10.71%)	0.44 (24.77%)	2.85 (11.05%)	2.18 (7.92%)
Morphological errors	8.02 (35.05%)	3.46 (8.63%)	2.30 (59.99%)	1.72 (36.96%)	6.70 (27.37%)	2.29 (9.22%)
Addition of functional words	0.30 (10.16%)	0.73 (S.68%)	–	–	0.15 (6.62%)	0.49 (7.05%)
Visual letter confusion	0.30 (1.37%)	0.47 (2.14%)	–	–	0.55 (2.14%)	0.89 (3.40%)
Irregular pronunciation rules	0.75 (3.01%)	0.97 (4.17%)	–	–	0.60 (2.30%)	0.69 (2.64%)
Semantic sentence guessing	–	–	–	–	–	–
Semantic errors	–	–	–	–	–	–
Omitting functional words	0.15 (0.86%)	0.37 (2.27%)			0.20 (0.74%)	0.53 (1.94%)

young reading-level-matched group were not significant. However, the difference was statistically significant between the dyslexic readers and the age-matched group: $t(38) = 11.7$, $P < 0.05$. Table 3 presents means and standard deviations of the group's error types (see Table 3 and Figure 2). The MANOVA procedures showed significant effects for all error categories at the significance level of $P < 0.05$, except for two categories: Addition of functional words and omitting functional words.

The Tukey post-hoc comparisons between dyslexic readers and their reading-level- matched peers on reading isolated words indicated non-significant differences on all types of errors, except for the nonsemantic semiphonetic and the semantic and nonmorphological semiphonetic
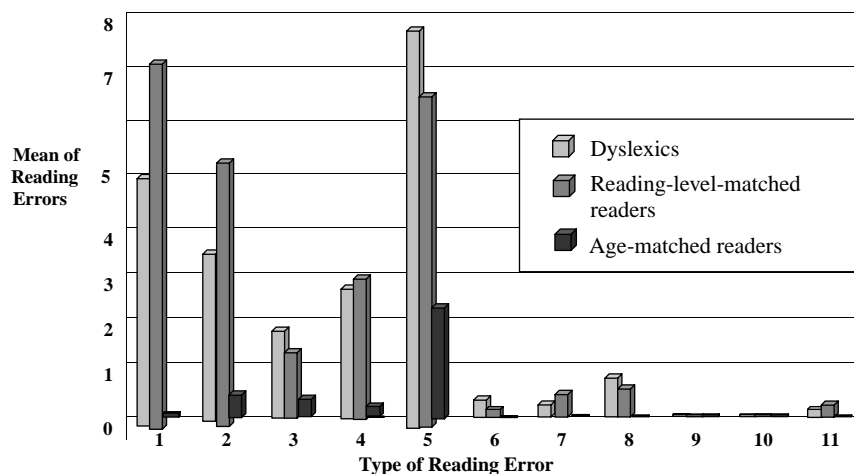
1 – Nonsemantic semiphonetic
2 – Semantic and nonmorphological semiphonetic
3 – Semantic dysphonetic
4 – Nonsemantic dysphonetic
5 – Morphological
6 – Addition of functional words
7 – Visual-letter confusion
8 – Irregular pronunciation rules
9 – Semantic-sentence guessing
10 – Semantic
11 – Omitting functional words

Figure 2. Means of scores of all readers in reading isolated words.

types of error ($P < 0.05$). The significant differences were clear when the dyslexic readers were compared with their age-matched peers ($P < 0.05$), except for the addition of functional words, visual letter confusion and omitting functional words, which did not reach statistical significance.

The most common error among all groups was the morphological, which constituted 35.05% of all errors among dyslexics, 27.37% among the reading-level-matched readers, and 59.99% among the age-matched readers. These differences were significant between dyslexics and age-matched readers and nonsignificant when dyslexics were compared with their age-matched peers.

Analysis of pseudoword reading

The dyslexic readers made more errors (M = 12.75, SD = 1.99) as compared with the other two groups: reading-level-matched (M = 12.65, SD = 3.20) and the age-matched (M = 3.80, SD = 2.37). However, the

Table 4. Means and standard deviations of pseudoword reading errors of all groups on all categories.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Nonsemantic semiphonetic	5.60 (44.63%)	1.90 (914.50%)	2.55 (67.98%)	1.57 (34.32%)	8.50 (68.32%)	2.25 (12.43%)
Semantic and nonmorphological semiphonetic	0.30 (2.31%)	0.57 (4.55%)	0.15 (2.08%)	0.37 (5.14%)	0.35 (2.72%)	0.49 (3.88%)
Semantic dysphenetic	0.40 (3.02%)	6.00 (4.47%)	0.20 (2.87%)	0.41 (5.80%)	0.25 (2.22%)	0.44 (4.50%)
Nonsemantic dysphonetic	4.50 (34.92%)	1.70 (11.33%)	0.90 (22.14%)	1.02 (29.65%)	1.80 (13.63%)	1.73 (12.85%)
Morphological errors	–	–	–	–	–	–
Addition of functional words	0.15 (1.19%)	0.49 (0.98%)	–	–	0.30 (2.29%)	0.92 (6.74%)
Visual letter confusion	0.45 (3.69%)	0.69 (5.91%)	–	–	0.35 (2.72%)	0.67 (S.47%)
Irregular pronunciation rules	1.15 (8.67%)	0.93 (6.81%)	–	–	1.00 (7.34%)	0.86 (6.58%)
Semantic sentence guessing	–	–	–	–	–	–
Semantic errors	–	–	–	–	–	–
Omitting functional words	0.20 (1.55%)	0.53 (4.18%)	–	–	0.10 (0.72%)	0.31 (2.22%)

difference between the dyslexics and the reading-level-matched readers was not statistically significant, but the difference between the mean errors was significant ($t(38) = 12.89$, $P < 0.05$) between the dyslexics and the age-matched group (see Table 4 and Figure 3). The Tukey post-hoc comparisons between the dyslexic readers and the reading-level-matched group on pseudoword reading indicated nonsignificant differences, except for the nonsemantic semiphonetic and the nonsemantic dysphonetic types of errors ($P < 0.05$). However, the results of the dyslexic readers vs. the age-matched peers comparison indicated nonsignificant differences for the semantic and the nonmorphological semiphonetic, semantic dysphonetic, addition of functional words and
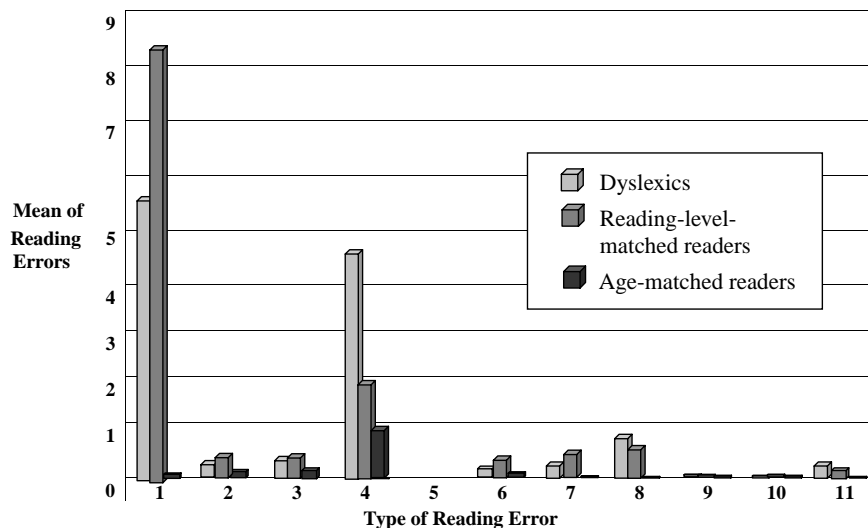
1 – Nonsemantic semiphonetic
2 – Semantic and nonmorphological semiphonetic
3 – Semantic dysphonetic
4 – Nonsemantic dysphonetic
5 – Morphological
6 – Addition of functional words
7 – Visual-letter confusion
8 – Irregular pronunciation rules
9 – Semantic-sentence guessing
10 – Semantic
11 – Omitting functional words

Figure 3. Means of errors of all readers in reading pseudowords.

omitting functional words, and significant differences ($P < 0.05$) for the rest of the categories (Table 4).

Spelling

Spelling errors of texts
The dyslexics made significantly more spelling errors (M = 27.65, SD = 11.52) than the other two groups, the reading-level-matched (M = 20.45, SD = 9.02) ($t(38) = 2.2$, $P < 0.05$) and the age-matched (M = 1.80, SD = 2.14) ($t(38) = 9.87$, $P < 0.05$) (see Table 5 and Figure 4).

Both groups, the dyslexics and the young reading-level-matched readers made more phonetic spelling errors than any other type of error: dyslexics 56.45% and reading-level-matched readers 65.32%. The differences between the two groups on the phonetic error type was not

Table 5. Means and standard deviations of text spelling errors among the three groups.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Phonetic	15.60	7.11	1.15	1.38	13.40	6.21
	(56.45%)	(.44%)	(47.99%)	(42.72%)	(65.32%)	(11.73)
Semiphonetic	2.75	1.74	0.15	0.49	2.00	1.41
	(10.31%)	(7.46%)	(2.92%)	(9.08%)	(10.03%)	(5.85%)
Dysphonetic	2.65	3.15	–	–	0.40	0.75
	(8.18%)	(7.07%)			(2.06%)	(3.87%)
Visual letter	0.65	0.87	0.10	0.31	0.90	0.96
confusion	(2.82%)	(4.36%)	(3.50%)	(11.82%)	(4.84%)	(5.45%)
Irregular	4.75	2.25	0.30	0.57	2.70	1.53
spelling rules	(17.7%)	(6.59%)	(8.51%)	(16.65%)	(13.83%)	(7.77%)
Word	0.60	0.94	–	–	0.35	0.67
omission	(1.99%)	(3.24%)			(1.85%)	(4.15%)
Functional	0.65	0.88	–	–	0.70	2.10
words omission	(2.53%)	(3.03%)			(2.05%)	(5.32%)

statistically significant. However, the age-matched readers made significantly fewer errors as compared to the dyslexics ($t(38) = 8.92$, $P < 0.05$). The MANOVA indicated significant effects for error categories at the 0.05 level of significance, but the omission of functional words did not reach significant significance. The Tukey post-hoc comparisons between the dyslexic readers and their reading-level-matched peers indicated nonsignificant effects almost for all types of errors, except for dysphonetic and irregular spelling rules ($P < 0.05$). However, the results of the comparison of the dyslexics and the age-matched peers indicated significant differences on almost all types of errors ($P < 0.05$), except for visual letter confusion and functional words omission.

Spelling error analysis of isolated words
The dyslexics made more errors (M = 7.40, SD = 17.30) than the control groups: reading-level-matched (M = 15.70, SD = 5.97) and age-matched (M = 2.30, SD = 2.18). The differences between the mean errors between the dyslexic readers and the reading-level-matched group did not reach statistical significance. However, the difference was significant when the dyslexics' mean error was compared with the age-matched group ($t(38) = 8.77$, $P < 0.05$).
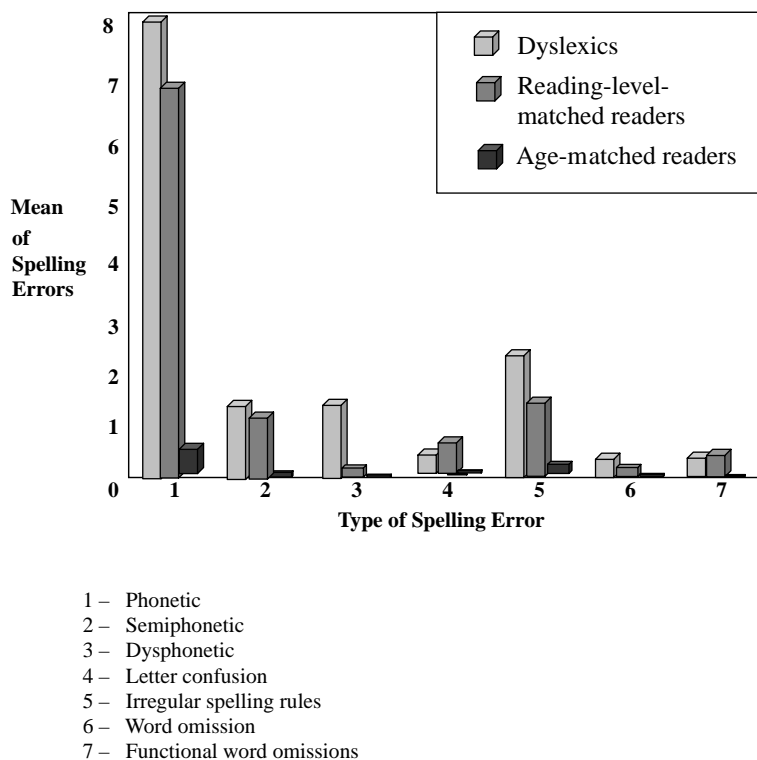
1 – Phonetic
2 – Semiphonetic
3 – Dysphonetic
4 – Letter confusion
5 – Irregular spelling rules
6 – Word omission
7 – Functional word omissions

Figure 4. Means of spelling errors of all groups in texts.

Four main types of error were observed among the dyslexics and the young reading-level-matched group: (for the dyslexics) phonetic 41.85%, semiphonetic 11.89%, dysphonetic 15.22% and irregular spelling rules 27.71%. Similar percentages and error types were found among the young reading-level-matched group. The differences between these means of error types between the two groups of readers were not statistically significant. However, the age-matched group made significantly fewer errors (see Table 6 and Figure 5). The MANOVAs of the spelling error types indicated significant effects for all types of error in Table 7, except for omission of words and functional word omission. The Tukey post-hoc comparisons between the dyslexics and the reading-level-matched peers indicated nonsignificant differences on all categories (Table 6). However, the results of the comparisons between the dyslexics and their age-matched peers revealed significant differences on all types of error ($P < 0.05$), except for the functional words omission type of error.

Table 6. Means and standard deviations of spelling errors of isolated words of all groups on all categories.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Phonetic	7.40	4.53	0.85	0.93	7.05	2.23
	(41.85%)	(13.21%)	(34.09%)	(39.49%)	(47.98%)	(12.87%)
Semiphonetic	2.05	1.39	0.45	0.83	2.15	1.75
	(11.89%)	(6.71%)	(11.64%)	(19.35%)	(12.52%)	(9.14%)
Dysphonetic	2.50	1.70	0.30	0.93	1.80	1.90
	(15.22%)	(9.76%)	(7.50%)	(19.09%)	(9.65%)	(9.42%)
Visual letter	0.40	0.68	–	–	0.30	0.57
confusion	(2.71%)	(4.91%)			(1.39%)	(2.65%)
Irregular	4.85	2.66	0.70	0.80	4.30	1.97
spelling rules	(27.71%)	(9.44%)	(21.76%)	(26.65%)	(27.97%)	(8.91%)
Word	0.05	0.22	–	–	–	–
omission	(0.29%)	(1.31%)				
Functional	0.05	0.22	–	–	0.10	0.31
words omission	(0.36%)	(1.62%)			(0.47%)	(1.50%)

Pseudoword spelling error analysis

The dyslexics made significantly more errors (M = 7.15, SD = 2.89) than the two control groups: young reading-level-matched group (M = 5.10, SD = 2.44) ($t(38) = 2.42$, $P < 0.05$), and age-matched group (M = 1.05, SD = 1.35) ($t(38) = 8.55$, $P < 0.05$). The MANOVA indicated significant effects for all error type categories (Table 7), except for the visual letter confusion category. The Tukey post-hoc test also showed nonsignificant differences between dyslexics and young reading-level-matched groups. However, these differences were significant when dyslexics were compared with the age-matched group ($P < 0.05$), except for the visual letter confusion.

Four common spelling error types were made by the dyslexics as compared with the age-matched group; (for dyslexics) phonetic 33.23%, semiphonetic 12.26%, dysphonetic 25.84% and irregular spelling rules 27.26%. A similar percentage of the same types of error were observed among the reading-level-matched group (see Table 7 and Figure 6).
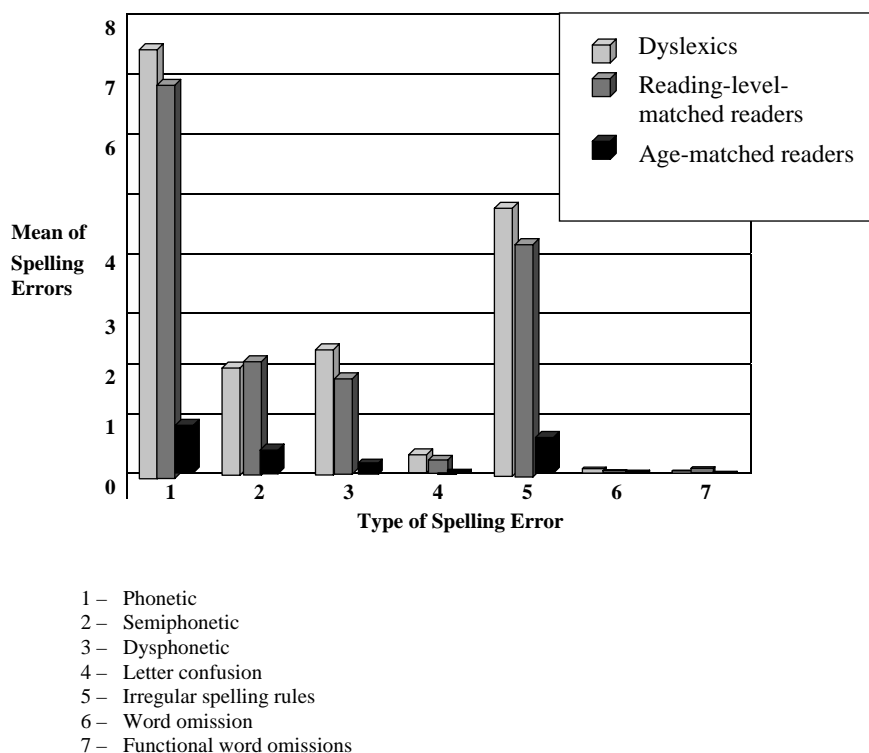
1 – Phonetic
2 – Semiphonetic
3 – Dysphonetic
4 – Letter confusion
5 – Irregular spelling rules
6 – Word omission
7 – Functional word omissions

Figure 5. Means of spelling errors of all groups in isolated words.

Summary of results

The dyslexic readers were characterized by some major reading errors: morphological, nonsemantic semiphonetic, semantic semiphonetic, and nonsemantic dysphonetic. The young reading-level-matched readers demonstrated similar rates and types of errors. Similarly, the main spelling errors of the dyslexic readers were: phonetic, irregular spelling rules, semiphonetic, and dysphonetic.

Discussion

The results of this study indicate that similar reading and spelling error profiles were observed among dyslexics and the reading-level-matched group, and these profiles were different from the age-matched group. This is in addition to the clear influence of the Arabic orthography and its morphology on reading and spelling. However, some performances

Table 7. Means and standard deviations of spelling errors of pseudowords among all groups on all categories.

Type of error	Dyslexic		Age-matched		Reading-level-matched	
	M	SD	M	SD	M	SD
Phonetic	2.35	1.18	0.25	0.44	1.95	1.23
	(33.23%)	(11.04%)	(16.66%)	(32.89%)	(42.34%)	(27.62%)
Semiphonetic	1.05	1.39	0.15	0.37	0.65	1.76
	(12.26%)	(11.12%)	(9.17%)	(25.05%)	(10.53%)	(12.56%)
Dysphonetic	1.70	0.86	0.40	1.14	1.10	1.16
	(25.84%)	(15.35%)	(14.15%)	(32.10%)	(21.53%)	(23.88%)
Visual letter	0.10	0.30	–	–	0.10	0.30
confusion	(1.39%)	(4.36%)			(2.25%)	(6.97%)
Irregular	1.95	1.09	0.25	0.55	1.30	1.17
spelling rules	(27.26%)	(14.50%)	(15.00%)	(33.29%)	(23.34%)	(19.15%)
Word omission	–	–	–	–	–	–
Functional words omission	–	–	–	–	–	–

of the dyslexic group and the reading-level-matched group were different and inconsistent. This can be attributed to the phonological lag that characterizes the reading disabled and not the normal reading-level-matched group (Snowling, 2001).

Our result indicates that the reading-level-matched group showed significantly more errors on the nonsemantic semiphonetic category than the dyslexic group. However, the dyslexics made significantly more semantic dysphonetic errors. The dysphonetic errors involve inaccurate pronunciation of words, the readers disregard short vowels posted on words causing the pronunciation to sound only partially like the expected sound according to the suggested orthographic pattern in reading texts, words and nonwords. It seems that due to a severe phonological deficit in applying grapheme–phoneme rules in decoding words, dyslexics tend more to rely on visual strategies in word recognition (Snowling, 1987). Thus, the dyslexic semantic dysphonetic errors are significantly greater than the errors of the reading-level-matched group, because the latter made more semiphonetic errors due to their reliance on phonological decoding strategies. The most prominent were the morphological errors across all groups.

It seems that because both literary Arabic and spoken Arabic are rich with morphological structures, and because when the similarity of
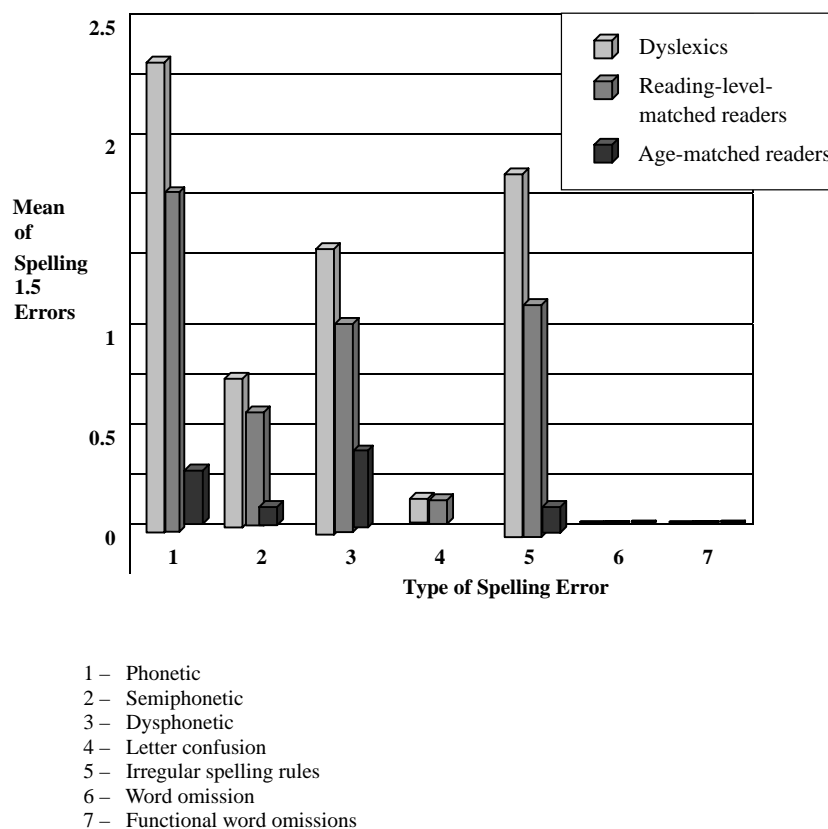
1 – Phonetic
2 – Semiphonetic
3 – Dysphonetic
4 – Letter confusion
5 – Irregular spelling rules
6 – Word omission
7 – Functional word omissions

Figure 6. Means of spelling errors of all groups in pseudowords.

words, visually and phonologically, usually relate to the same root (Beland & Mimouni, 2001), this causes morphological types of errors while reading regular words. This finding indicates that the reader of Arabic relies on word recognition strategies that involve phonological decoding skills, visual–orthographic recognition, and high morphological mapping.

The evidence lies in the profile of errors in reading. The age-matched group made more morphological errors, which can be attributed to their partial phonological decoding ability in reading and their over reliance on the visual–orthographic pattern of the word (Snowling, 1987, 2001). Further, when the phonological decoding skills are not fully mastered and the morphology of the specific language is essential in word recognition (Abu-Rabia et al., 2003), usually heavy reliance on the morphology may occur (Beland & Mimouni, 2001). The same principle was applied in the reading of the young reading-level-matched

group (Frith, 1985), because their orthographic acquisition was still in
its early stages. Our findings support this assumption among the young
reading-level-matched group, because although their morphological
errors were very high in relation to the other types of errors made in
reading isolated words, they also showed high semantic dysphonetic
errors due to over reliance on phonological decoding strategies and less
reliance on lexical processes (Frith, 1985; Marshall et al., 1983; Morton,
1989; Seymour, 1990). This can also explain the nonsemantic, semipho-
netic and nonsemantic dysphonetic errors in reading isolated words
among the reading-level-matched group. In other words, their limited
orthographic lexicon and their over reliance on phonological decoding
strategies in reading low frequency words, which they found difficult to
read, caused high nonsemantic phonetic and dysphonetic errors.

Similarly, the dyslexic readers made similar and high numbers of
morphological errors in reading text and isolated words. The dyslexics
and the reading-level-matched group showed a similar profile of errors.
In addition, the dyslexics made more nonsemantic, phonetic and dys-
phonetic errors in reading isolated words as compared with their read-
ing in text. In reading text, they seemed to benefit from the priming
effect to predict the meaning (Lennox & Siegel, 1993). The absence of
priming effect in reading isolated words caused higher nonsemantic,
phonetic and dysphonetic errors.

Consistently, when dyslexics read pseudowords, which demands high
phonological decoding skills, the nonsemantic semiphonetic and the
nonsemantic dysphonetic errors were higher, because pseudowords are
nonsemantic and are not related to any specific Arabic morphology,
which makes the probability of semantic phonological error very low.
It is known that the root in the Arabic morphology is the key for initial
lexical access (Abu-Rabia, 2001, 2002; Abu-Rabia & Awwad, 2004).

In addition, some error types were also observed as a result of the
specific Arabic orthography: for example, the irregular pronunciation
rules and visual letter confusion. It seems that the lack of GPC rules
mastery underlies the failure in acquiring lexical knowledge of words,
which resulted in a profile of errors that resembled the profile of the
young normal readers. It seems that accuracy as a result of Arabic
GPC rules mastery is a developmental matter that is related to lexical
knowledge. The profile of errors of this study enhances this claim, espe-
cially when these profiles were not observed among the age-matched
normal readers.

Furthermore, due to the high visual similarity between the letters,
mastering the GPC rules is highly correlated with success in accurate
reading; similar performance was observed between the dyslexics and

the reading-level-matched group. This is probably because the latter is still in the initial stages of reading and orthographic acquisition, which explains the inaccuracy of reading (Samuels & Flor, 1997). Likewise, the dyslexics are suffering from the lack of GPC rules manipulation ability, especially in an orthography like Arabic where letters change shapes according to their position in the word. Although these types of error were low in percentages as compared to direct phonological decoding and to the effect of morphology, still these types of error can be considered a direct result of the uniqueness of the written Arabic orthography. These errors characterized the dyslexics and the young reading-level-matched group because both suffer from poor phonological decoding skills, especially when these types of errors were not observed among the age-matched normal readers.

The semantic errors were low on average across all tasks as compared with other types of error. It is related to failure in phonological decoding and heavy reliance on visual–orthography, which resulted in
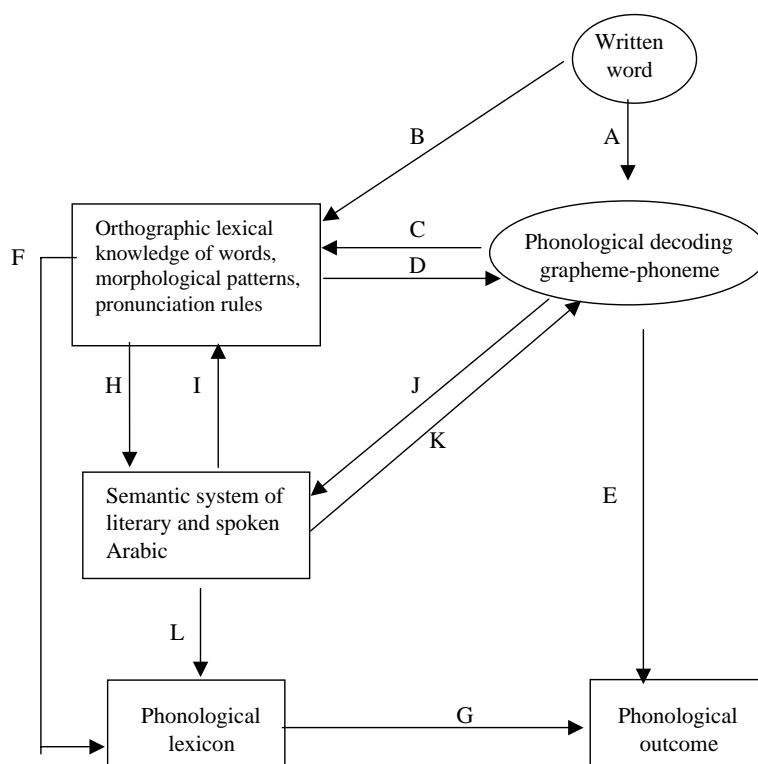

Figure 7. The suggested reading model illustrating morphological, semiphonetic and dysphonetic errors.

inaccurate phonological pronunciation that was semantically accept-
able. Further, there were no semantic errors in reading pseudowords,
which indicates that readers are always searching for meanings of
words that they read. When they read regular words, their semantic
phonetic and dysphonetic errors went up along with morphological
errors. But when reading pseudowords, the nonsemantic phonetic and
dysphonetic errors went up as compared with their errors in reading
regular words and text. Furthermore, the lack of semantic errors in
reading pseudowords is also related to the orthographic structure of the
target word that does not suit any verbal meaning, and in such a case
it does not convey direct access to the semantic lexicon. Further, these
pseudowords did not convey other important morphological clues for
lexical access, i.e., roots. Similarly, other semantic errors occurred while
reading sentences, which characterized dyslexics as well as the reading-
level-matched group. Their over reliance on context and guessing
resulted in semantic errors (Lennox & Siegel, 1993).

The error patterns observed among the dyslexics and the reading-
level-matched group indicate that the Arabic orthography clearly
demands visual word recognition strategies, especially because most of
the error patterns were shared by all readers: dyslexics and reading-
level-matched. This indicates that the reading process in Arabic orthog-
raphy involves strong morphological dimensions along with decoding
processes based on phonological decoding (GPC rules), along with a
clear lexical dimension, which is also based on correct and precise pro-
nunciation of Arabic. The mastery of these reading dimensions is a
developmental issue that characterizes the Arabic reader. According to
the above, and to illustrate the occurrence of reading errors, especially
the morphological ones, a reading model is suggested (see the suggested
model, Figure 7).

Morphological errors occur when the phonological decoding process
is partially functioning, along with heavy reliance on visual–ortho-
graphic identification process, whereas according to Beland and
Mimouni (2001), in Arabic orthography words that are visually and
phonologically similar have a high potential of being related to the
same root. Further, spoken Arabic as well as literary Arabic are rich
with morphological structures, such structures are stored in the phono-
logical lexicon in regard to pronunciation and in the orthographic lexi-
con in regard to identification of root-consonants and their
combinations. When the phonological lexicon is activated via retrieved
orthographic knowledge from the orthographic lexicon after visual
identification of a word, and when the phonological decoding process-
ing is not applied or partially applied, the phonological lexicon is

activated according to the registered information that has been retrieved from the phonological lexicon. As a result, partial phonology and partial lexical orthography partially trigger the lexical phonology, which includes the phonological combinations of root pronunciations. Further, the retrieved inaccurate lexical phonology that was stimulated by partial orthographic and phonological sources of the printed word does not represent the exact pronunciation of the target word, raising the possibility for morphological, nonsemantic semiphonetic and dysphonetic errors. Similarly, Snowling (1987) argues that reliance on partial phonological and orthographic knowledge along with context guessing are strategies that characterize reading disabled and poor readers (see Figure 7).

The suggested model illustrates that the visual reading routes that are activated when morphological, semiphonetic, and dysphonetic errors occur are A, C, F and G, when the phonological knowledge that passes through route F from the orthographic lexicon is also partial, along with over reliance on the visual–orthographic knowledge of the written orthographic patterns that are conveyed through route B. In other words, morphological as well as dysphonetic errors occur due to poor phonological reading strategies and over reliance on visual–orthographic reading strategies. Further, the dysphonetic errors are a result of poor mastery of GPC rules in regard to the short vowels.

Furthermore, the most prominent type of spelling error among the dyslexics and the reading-level-matched controls was phonetic across all spelling tasks. This result indicates that the reliance on lexical orthographic knowledge was not sufficient to enable successful spelling. The young reading-level-matched group seems not to reach the orthographic phase (Frith, 1985). The very common error was confusing homophonetic letters in words that are highly frequent in the Arabic language.

Similarly, the dyslexic group faced difficulties in spelling, applying spelling rules that rely on lexical writing. According to Holmes and Carruthers (1998), the unskilled speller faces difficulty in retrieving the specific orthographic structure of the target word. Steffler (2001) argues that implicit memory is responsible for the retrieval of the specific orthographic unit and that such a procedure develops through the correct and adequate exposure of the reader to written messages, which constitutes the basis of perceiving the stored orthographic units in the human memory (Ellis, 1993). Good spellers rely on their orthographic lexicon as well as their phonological knowledge (Lennox & Siegel, 1998).

There was also an intervention of the spoken language into the spelling error patterns. Dyslexics and younger reading-level-matched readers tended to spell words according to their spoken forms and not
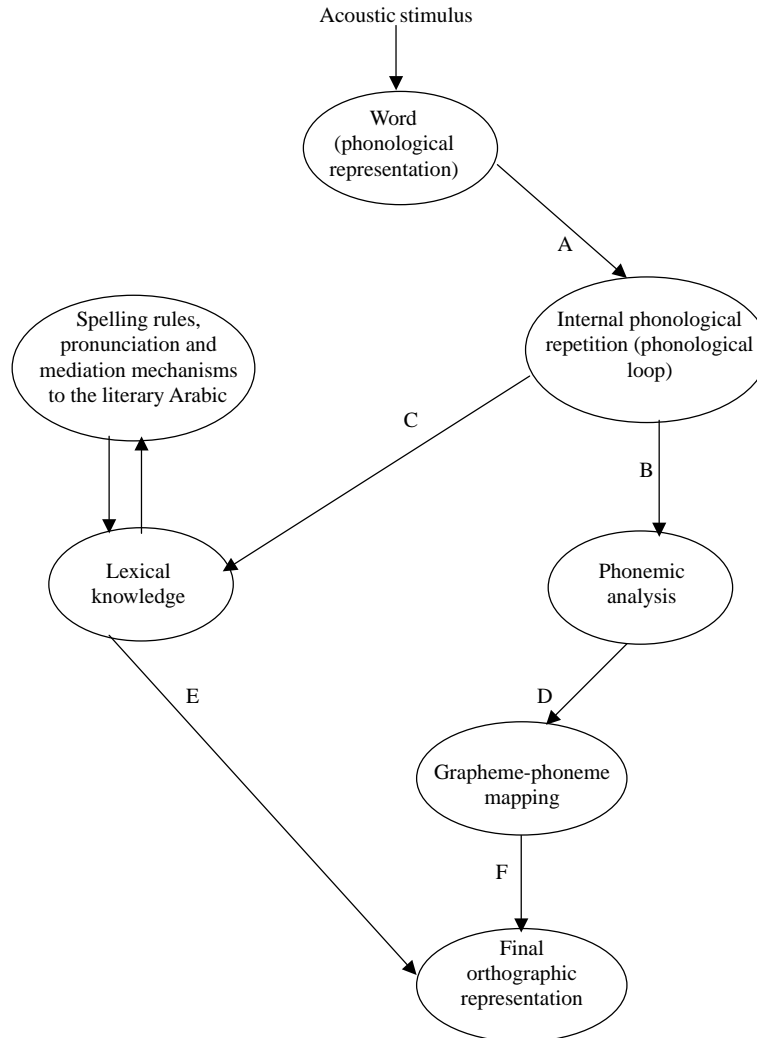
Figure 8. The suggested model of spelling errors.

according to their literary forms. It seems that the spelling process among these children involves a sound loop of the target word in which the sound of the spoken words interferes into the sound of the literary target. As noted, spoken Arabic is different from what is written and read in the literary language (Abu-Rabia, 2000; Ayari, 1996). When deficient lexical processes operate, the retrieval of exact orthographic units does not represent the orthographic units of the target word, which brings over reliance on phonological spelling (Frith, 1985). Among unskilled Arabic spellers, in this case, they rely more on the

phonology of their spoken words than their internal sound loop. Figure 8 is a suggested model intended to explain the spelling process among native speakers of Arabic.

For a reading-disabled speller, the internal phonological repetition of the acoustic stimulus will be mediated by the specific phonology of the spoken word and the reliance will be on the A, B, D and F routes as a result of deficient lexical processes; as marked on the model, C and E mediate between the spoken word phonology. As a result of weak lexical processes, the spoken language phonology interferes and prevails on the internal phonological repetition, which is manifest in final incorrect orthographic representation. Furthermore, the model explains the semiphonetic and dysphonetic errors: when there is no reliance on the lexical knowledge or, simultaneously, the phonological routes (A, B, D and F) are not developed enough due to a phonological lag of the reader, then it is assumed that the grapheme–phoneme mapping strategies will not be correctly applied, resulting in semiphonetic and dysphonetic errors. In this case we can consider that the lack of reliance on the lexical orthographic knowledge is compensated for by over reliance on phonetic spelling among the dyslexics and their young reading-level-matched peers (Frith, 1985).

The semiphonetic errors were similar among the disabled spellers and their reading-level-matched spellers. This indicates that the grapheme–phoneme mapping strategies are similar in both groups and the quality of the errors indicates that there is a developmental profile of these skills that is not developed enough among the dyslexic spellers and the reading-level-matched spellers as compared to the age-matched spellers.

Further, the same profile was also found among the two groups in spelling pseudowords: dysphonetic errors. It seems that in the nature of the Arabic orthography many letters are visually similar and phonemically different, which was evident in errors resulting from confusion in the graphemic representation of certain phonemes. This could be explained as a failure in retrieving the correct graphemes to the heard phonemes, due to visual similarities. This situation becomes cognitively loaded for the young speller and the dyslexic speller.

In other words, the effect of regular and irregular development spelling rules, and the effect of orthographic lexical development are major components to affect the spelling development of dyslexics and young spellers. This reciprocal relationship between these two spelling resources seems to be significant in this case (Ellis, 1993).

The conclusion of our study can be summed up in two points: 1) disabled readers revealed error profiles that resembled the error profiles of the reading-level-matched peers, which indicates a developmental profile

in reading and writing (Olson, 1994); 2) the nature of Arabic orthography contributed specific profiles of errors among the reading disabled and the reading-level-matched peers: the influence of diglossia, morphology, and phonology (vowels).

These error profiles enabled us to understand the developmental profile of reading and spelling among these native Arabic children and to understand the cognitive profiles that intervene in their process of reading and spelling. Our study has some implications for the field of Arabic reading and spelling acquisition: 1) early intervention in exposure to literary Arabic should help overcome the diglossia effect, 2) equip children from early ages with morphological knowledge of Arabic, 3) equip children from early ages with knowledge of vowelized reading and vowelized writing due to the heavy cognitive load required to process vowelized Arabic script.

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