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The Role of Phonological versus Morphological Skills in the Development of Arabic Spelling: An Intervention Study

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Abstract The current study investigated the contribution of two linguistic intervention programs, phonological and morphological to the development of word spelling among skilled and poor native Arabic readers, in three grades: second, fourth and sixth. The participants were assigned to three experimental groups: morphological intervention, phonological intervention and a non-intervention control group. Phonological awareness, morphological awareness, and spelling abilities were tested before and after the intervention. Participants from both linguistic intervention programs and in all grades made significant progress in linguistic awareness and spelling after the intervention. The results showed that both intervention programs were successful in promoting children's spelling skills in both groups. Also, older poor readers showed a stronger response to the morphological intervention than the older skilled readers. A transfer effect was found with the phonological training contributing to the morphological skills and vice versa. The results of the current study were discussed in the light of developmental and psycholinguistic views of spelling acquisition as well as the characteristics of Arabic language and orthography.

Keywords Phonological intervention · Morphological intervention · Spelling · Arabic orthography · Literacy

Introduction

Research has shown that the acquisition of word spelling and reading, in different alphabetic orthographies, requires the development of basic linguistic awareness skills, in particular phonological and morphological awareness. This is because those different alphabetic

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orthographies are morpho-phonemic and they map two layers of language: phonological and morphological, (Adams 1990; Goswami and Bryant 1990; Nunes and Bryant 2009). Research has also shown that training children in phonological and morphological awareness results in significant gains in word-level reading and spelling performance (For review about phonological awareness and reading, see Bus and van IJzendoorn 1999; Carlisle et al. 2010; Goodwin and Ahn 2010, for morphological awareness).

Stage models of spelling capture the phonological and the morphological mechanisms utilized by children in spelling acquisition. Such models (e.g.,Hendrson 1985; Ehri and Snowling 2005; Frith 1985) conceptualize the development of spelling to proceed in qualitatively different stages that vary in the nature of the linguistic information used in spelling. These stages largely coincide with those proposed to capture reading acquisition in children (e.g., Ehri and Snowling 2005). This should not come at a surprise for both reading and spelling require the mapping of linguistic units (phonemes and morpheme) onto orthographic representations, as well as an understanding of the relationship between sounds and their written graphemic representations. As such, in the reading of unfamiliar words, the reader is required to recover the phonemes from the graphemes: i.e. phonological recoding. In spelling, a similar process is utilized but in a reversed order- phonological encoding (Coltheart 2005; Ziegler and Goswami 2005). Because both processes utilize phonemes, they heavily depend on phonological awareness; awareness of and access to the phonological structure of spoken words (Caravolas et al. 2005; Elbro and Pallesen 2002; Perfetti 1992).

It follows from the above that a normal development of phonological awareness should lead to a normal acquisition of basic word-level reading and spelling abilities, because phonological awareness facilitates the acquisition of phonological recoding and encoding. Phonological skills should also contribute to the acquisition of skilled reading because repeated exposure to written words enhances the development of the orthographic lexicon (Share 1995). An orthographic lexicon allows the efficient identification and reproduction of words in accordance with the orthographic patterns stored in memory (Coltheart 2005; Frith 1985). Accordingly, and a direct result of deficit in the phonological domain of language is the failure in the normal development of word decoding (Snowling 2000, 2001), which in turn, results in less exposure to and experience with written words and, hence, to less effective storage of these words in memory and to an inefficient development of the orthographic lexicon (Ehri 2000; Ellis 1993; Frith 1985; Steffler 2001; Treiman and Bourassa 2000). An inefficient orthographic lexicon may be the main reason of slow and inaccurate reading and spelling (Abu-Rabia and Taha 2004, 2006; Bourassa and Treiman 2003). In this context, it has been proposed that the poor quality of the orthographic lexicon among readers with reading difficulties is grounded in their core phonological deficit (Landerl et al. 1996, 1997; Lennox and Siegel 1998; Vellutino et al. 2004). In other words, phonological and orthographic processing skills are reciprocally related, with efficient phonological processing enhancing the construction of accurate orthographic representations and with high-quality orthographic representations enhancing spelling (Dixon et al. 2002; Share 1995; Sprenger-Charolles et al. 2003). Cross-linguistic research has recently addressed the relevance of phonological awareness to spelling in alphabetic orthographies besides English (Jongejan et al. 2007), and in typologically different languages (Al-Mannai and Everatt 2005; Goswami et al. 2005; Sprenger-Charolles et al. 2003).

Besides the phonological mapping into orthography, different alphabetic orthographies map the morphological structure of the languages they represent, yet to variable degrees of consistency and transparency (Ravid 2012). Given that morphology is an important component of the linguistic and orthographic representation of words in different alphabetical languages, different researchers assume that awareness of the morphological structure of

words should enhance reading and spelling development, especially when the orthography is more loyal to the morphographic than to the phonographic principle, as is the case in English as an example (Carlisle 2003; Saiegh-Haddad and Geva 2008; Singson et al. 2000). Recent research has endorsed this prediction and demonstrated the importance of morphological awareness and morphological processing in reading and spelling development in children (Abu-Rabia 2007; Ben-Dror et al. 1995; Levin et al. 2001; Ravid 2001; Nunes et al. 1997; Saiegh-Haddad, submitted 2012; Sénéchal 2000; Treiman and Bourassa 2000). Research has also shown that morphological knowledge helps readers store the morpho-orthographic patterns of written words more effectively and enhances the ability to spell new words by morpho-orthographic analogy with familiar morphologically related words already stored in the mental lexicon (Berninger et al. 2010; Deacon and Kirby 2004; Elbro and Arnbak 1996; Ravid and Schiff 2006; Roman et al. 2009; Sénéchal et al. 2006).

Unlike phonological awareness which has been shown to contribute to reading and spelling very early on and to remain strong in predicting reading in all orthographies (Ziegler et al. 2010) and even among adult and more skilled readers (Bruck 1992), the role of morphological awareness in spelling acquisition was argued to be probably more developmental in nature. For instance, Nunes et al. (1997) report a longitudinal study and show that when children first spell words, they do so with little regard to their morphological structure. Then, they begin to use morphology but might overgeneralize spelling patterns to grammatically inappropriate targets (e.g., sofed for soft). Later, these generalizations become confined to the right grammatical category, such as verbs (e.g., keped for kept) and finally to the right group of words (e.g., regular verbs). Others suggest that morphological awareness and derivational knowledge may be in a linear relationship with reading age (Tsesmeli and Seymour 2006). This assumption about the developmental nature of the morphological awareness and the mutual relationship with literacy acquisition was supported also by the findings of Berninger et al. (2010). Within their research, Berninger et. al. found that morphological awareness has main contribution to the development of reading and spelling in English beside the phonological awareness. This morphological awareness continues to grow up during the primary grades and after the fourth grade.

Considering this contribution of morphological awareness to spelling, this contribution has been reported among non-typical readers as well. However, their ability to do so was found to be constrained by their poor morphological awareness skills (Tsesmeli and Seymour 2006). For instance, Bourassa et al. (2006) used a spelling-level match design to examine the extent to which children with dyslexia and younger typical children make a similar use of morphology. They found that both groups of children utilized morphological knowledge in their spelling. It was also found that the spellings produced by older children with dyslexia were similar in their morphological characteristics to those produced by younger normal children.

However, other orthographic systems, rather than English are characterized by their unique morphological structures, where the contribution of the awareness to those morphological aspects to literacy acquisition, among children within those orthographies, was evidenced. Semitic Arabic and Hebrew are particularly interesting and can be extremely informative to theories of morphological processes in spelling and reading development. This is because of their non-linear root-word pattern morphological structure, with the resultant fact that almost every content word has an internal morphological structure (Frost 2006; Ravid 2012; Velan and Frost 2011). Another interesting morphological property is the rather regular morpho-orthographic structure of Semitic words (Ravid 2012). This explains previously published reports of an early emergence of morphological awareness and processing in Hebrew-speaking children (Berman 1999) and of a strong role of morphological aware-

ness in reading and spelling development in these languages (Gillis and Ravid 2006; Ravid 2012; Ravid and Tolchinsky 2002; Saiegh-Haddad, submitted; Taha and Saiegh-Haddad, In preparation 2012).

Due to the abovementioned contribution of the phonological and morphological awareness to literacy acquisition within different Alphabetic orthographies, different Intervention studies provide the best insight into the relationship between those linguistic processing skills and literacy development (Zhang et al. 2010). Literacy intervention studies have devoted particular attention to fostering the phonological and morphological skills and demonstrated evidence in support of the importance of both to the acquisition of reading and spelling (For reviews, see Bus and van IJzendoorn (1999) on phonological intervention and Carlisle et al. (2010) and Goodwin and Ahn (2010) on morphological intervention). For instance, Borstrøm and Elbro (1997) examined the impact of a phonological intervention program on spelling among 36 Danish speaking children at risk for developing reading difficulties during the pre-school age. The intervention program focused on training children in letter names, phoneme-grapheme correspondence rules, phoneme identification, and phonological analysis skills. The results showed that the reading and spelling scores obtained at the beginning of the second grade for those who had participated in the intervention program were significantly higher than those obtained by the control group.

Phonological intervention programs were also found to enhance the literacy skills of reading disabled readers and young poor spellers (Amtmann et al. 2008). For instance, Blachman et al. (2004) used an intensive training program that emphasized the phonological and orthographic connections in written words. The results of the posttest revealed that the children who participate within the training program showed significantly greater gains than the control children in real word and nonword reading and spelling. These gains were maintained even in a one year follow-up examination.

Morphological intervention has also been shown to be effective in enhancing spelling development. For instance, Arnbak and Elbro (2000) conducted an intervention study which focused on morphological training to dyslexic readers in the fourth and fifth grades. The intervention program focused on learning the semantic aspects of morphemes and derivational morphology. The results revealed significant gains in spelling as a result of the intervention. Similarly, Kirk and Gillon (2009) found that training in the morphological structure of words among children with spelling difficulties contributed significantly to their spelling ability. Besides they found that leaning about the morpho-orthographic rules enable the children to generalize their knowledge to new words.

Another question that has been addressed by research on linguistic intervention was the relative efficacy of different linguistic training programs: phonological versus morphological in producing gains in spelling and reading. The results in this domain have been mixed. Some researchers report an equal contribution of both programs to the acquisition of literacy abilities (Lyster 2002; Nunes et al. 2003), where others have shown that, given the poor phonological processing skills, morphological intervention is particularly efficacious for poor readers (Nunes and Bryant 2009).

Another strand of research has suggested an interaction between development and the relative efficacy of phonological versus morphological programs with phonological abilities contributing more strongly to the acquisition of reading and spelling at an earlier stage while morphological awareness making a greater impact among older children (Tsesmeli and Seymour 2006). This is because in the early stages of reading and spelling the reader relies on phonological decoding and encoding (Blachman et al. 2004; Ehri and Snowling 2005), while in the later stages there is a heavier reliance on morpho-orthographic knowledge (Ehri and Snowling 2005).

In line with the previous review, the aim of the current study is to probe the impact of two linguistic intervention programs: phonological and morphological, on the development of spelling among skilled and poor readers with permanent spelling difficulties in second, fourth and sixth grades. A second objective is to compare the relative contribution of the two intervention programs to gains in spelling in the different groups and grades. This is because of the developmental nature of the both linguistic skills, and particularly the morphological one, as was reviewed earlier; hence we are interested to test whether this fact has an impact on the contribution of various ages intervention programs to spelling. Accordingly, the study addresses the following questions: (a) Do the two linguistic intervention programs (phonological vs. morphological) contribute to spelling ability among children; and (b) Are there differences in the relative efficacy of the two intervention programs (phonological vs. morphological) in producing gains in spelling in the two reader groups (poor versus skilled) and in the different grades (second, fourth, and sixth grades).

Spelling Arabic: Linguistic and Orthographic Factors

Researchers argue that the Arabic orthography may be best described as an "abjad" (Daniels 1996) or a consonantal orthography. The Arabic abjad consists of 28 letters that map the consonants of Standard Arabic. Three of these letters (ا, و, ي) also represent the long vowels of Standard Arabic while short vowels, as well as null vowelization and consonantal germination[1] are represented through a system of superscripted diacritics. Hence, Arabic orthography has two scripts: vowelized when all diacritic information is present and unvowelized when only letters are used. Vowelized written Arabic words are compatible to highly transparent orthographic patterns because the word's spelling provides a complete and highly regular account of its phonology. In contrast, unvowelized Arabic is an opaque orthography and is rich with homography. Though opaque, the unvowelized script is yet highly consistent. This is because the root morpheme which inheres in the linguistic representation of almost all content words is consonantal and is, thus, always represented via the letters even when the orthography is unvowelized. Further, the word-pattern, the second bound morpheme that inheres in all content words, consists of long vowels and consonants, and these are represented by letters and are, hence, always part of orthographic representation of Arabic words even when presented unvowelized. It follows from this that an important source of knowledge that might help readers restore the missing phonological information from unvowelized words is the word's internal morphological structure, in particular recognition of the root and the prosodic word-pattern. Because the missing short vowels may be reliably recovered when the reader has identified the root and the word-pattern, becoming aware of the morphological structure of the word should assist readers in their decoding of unvowelized words.

As explicated earlier, though traditionally regarded an alphabet, Arabic differs from other alphabetic orthographies, notably English, in orthographic architecture and in morphological structure. Unlike English, Arabic utilizes two types of morphological procedures: linear and non-linear. Also, these two morphological procedures fulfill two different functions in the language. Linear morphology is primarily inflectional. In contrast, non-linear morphology is derivational. Hence, almost all content words in Arabic are complex and minimally bi-morphemic comprising at least two morphological units: a consonantal root (e.g. KTB),

[1] It is noteworthy that the diacritic system also includes diacritics representing word-final vowels and *nunation* which are used to mark case as well as the grammatical function of words. This phonological information, and unlike word- internal diacritics, is only rarely needed for word identification (Holes 2004).

"a skeleton of consonants" (Bentin and Forst 1995, pp. 273) that provides the core semantic information, and a word-pattern (e.g. Ca:CeC or maCCu:C), a fixed prosodic template which specifies the surface phonological structure and the morpho-syntactic properties of the resultant lexical item. This implies that in Arabic, and unlike English, almost all content words have an internal morphological structure. (Velan and Frost 2011; Frost 2006). This contributes to a heightened awareness, on the part of even young speakers, to the derivational morphological structure of words. Indeed, Taha and Saiegh-Haddad (In preparation a, Taha and Saiegh-Haddad 2012) tested awareness of these two derivational morphemes in Arabic: the root and the word-pattern among young school age Arabic native speaking children. The study showed that root awareness was evident among young children and reached ceiling levels in the second grade. Word-pattern awareness was also found to develop early. Yet, it was shown to have a longer developmental trajectory. Similar findings had been reported for Hebrew (Ravid and Malenky 2001).

Given strong evidence for the role of the root and word-pattern morphological structure in Arabic, the pending question relates to the role of these morphological units in lexical representation, word recognition and spelling. Boudelaa and Marslen-Wilson (2001; 2004; 2005) tested whether Arabic native speakers use these two abstract morphemes (root and word-pattern) in the representation and processing of Arabic words. Their research shows that both the root and the word-pattern play a crucial role in lexical representation and processing in Arabic. Convergent evidence for morphological processing has also been reported in the reading of normal and reading disabled Arabic speakers (Abu-Rabia and Awwad 2004; Abu-Rabia et al. 2003). For instance, Taha and Saiegh-Haddad 2012) showed that dyslexic children were deficient in morphological awareness and that intervention in morphological awareness resulted in gains in reading in both normal and disabled readers. Likewise, recent research has offered evidence for root mediation in early plural formation in Palestinian Arabic (Ravid 2001; Ravid and Farah 1999; Saiegh-Haddad et al. 2012). In the same way, the evidence available from Hebrew, a Semitic language with a similar non-concatenative morphology, shows that root-awareness is an important correlate of reading and spelling development in Hebrew, and is particularly deficient in reading disabled children (Ben-Dror et al. 1995; Ravid and Schiff 2006; Schiff and Ravid 2004).

A second unique feature of Arabic is its diglossic context (Ferguson 1959) and the use of two linguistic systems: one for writing; Standard Arabic, and other formal settings and another for everyday conversation and is the one that is acquired naturally by children; Spoken Arabic (Saiegh-Haddad & Joshi, in preparation, 2012). The spoken language has different vernaculars that differ from one geographical region to another (Taha 2013). The linguistic distance between Standard Arabic and Spoken Arabic vernaculars traverses all linguistic domains and is probably the greatest in the phonological domain (Abu-Rabia and Taha 2006; Levin 1994). For example and considering the phonological domain, it could be found that within one specific vernacular in a particular geographical area there is an existence of certain phonemes, when in turn, those phonemes could be absent in another vernacular of another geographical region. Anyway, the phonological system of the standard Arabic is not identical to any of the spoken vernaculars of Arabic. This phonological distance was found to affect the phonological representation of the standard Arabic words among native Arab children. This distance is considered as a real challenge that the children encountered by during their phonological awareness development. Usually, the first time that Arabic-speaking children are exposed to the standard Arabic is when they begin to read and write. Within this situation, and specifically at the point in time of learning about the Arabic alphabetic system and letter-sound correspondences, the children may find themselves exposed to a new linguistic system

featured by phonological and syllabic structures which are different from those of their own spoken vernacular linguistic system.

In support of that, Saiegh-Haddad & Ali (in preparation 2012) investigated the spoken lexicon of five year-old Arabic native speaking children in Israel and found that paired lexical items (cognates) made up over 40 % of the children's lexicon. These phonologically related cognates are used in both Spoken and Standard Arabic. However, they have different phonological forms in the two varieties. These forms are largely related through transformational processes. Yet, research has shown that children are mostly unaware of the linguistic relatedness between the two forms and fail to reconstruct one from the other (Saiegh-Haddad 2011a). Such a phonological distance was found to adversely affect the acquisition of basic reading skills in Arabic, including phonological awareness and word decoding (Saiegh-Haddad 2003, 2004, 2005, 2007, 2011a, b; Saiegh-Haddad et al. 2011c).

It follows from the above discussion that non-linear root-word pattern morphological structure of Arabic and the consistent representation of this structure in the Arabic orthography may result in a unique contribution of morphological training to Arabic spelling development (Abu-Rabia and Taha 2006; Ibrahim et al. 2002; Saiegh-Haddad and Geva 2008). At the same time, the remarkable phonological distance between Spoken and Standard Arabic might result in a unique contribution of phonological abilities to the development of spelling in children especially as the written language maps the standard representation of words. Hence, one prediction of the study was that both intervention programs: the phonological and the morphological will contribute to enhancing the spelling abilities of children among the skilled and the poor readers groups and significantly differently from the no-intervention control group. The relative efficacy of the two intervention programs is expected to depend on the level of reading tuition with young children benefiting more from the phonological intervention while with older children showing greater gains from the morphological intervention. Due to their impaired phonological skills, poor readers were expected to benefit more from the morphological intervention than from the phonological, especially given the rich morphological structure of Arabic and the consistency of morphological representation in the Arabic orthography. We assume that the morphological intervention can provide an alternative route of orthographic and linguistic knowledge in case of poor phonological skills. More specifically, we assume that the morpho-orthographic knowledge (the knowledge about the orthographic representations of the morphemes) will enable the correct spelling of the words in case of presence difficulty in phonological processing (Arnbak and Elbro 2000; Taha 2013). Also, and in light of the developmental feature of the morphological awareness and its mutual relation with reading development (Berninger et al. 2010), it was proposed that older skilled readers will make a significant benefit from the morphological intervention compared to the younger skilled readers. This assumption is postulated due to the fact that the mature morphological knowledge of the skilled readers will constitutes a solid basis to contain the contents of the morphological intervention and can immediately promote the spelling ability. These predictions were tested in the current study.

Method

Participants

The study tested a total of 289 children in three age-groups: second grade ($N = 96$), fourth grade ($N = 98$) and sixth grade ($N = 95$). Participants were sampled from 22 different

Arab schools in north of Israel. All participants were speakers of the northern Palestinian vernacular of Arabic. Each age-group (or grade-level) included an equal number of skilled and poor readers. The participants within each grade were divided into the different intervention groups (see appendix table for further details about the number and the mean of age of the participants within each intervention group separately by grade and reading group).

Screening for the poor readers was based on "Low achievement models" (Fletcher and Denton 2003; Jiměnez et al. 2003; Lyon et al. 2002). Low achievement models as they described by Lyon et al. 2002 are those models based on the use of achievement markers can be shown to have a great deal of validity. accordingly, If groups are formed such that the participants do not meet criteria for mental retardation and have achievement scores below the 25th percentile, a variety of comparisons show that the subgroups of low achievers that emerge can be validly differentiated on external variables and help demonstrate the viability of the construct of reading difficulties or reading disabilities. Based on this way of screening, the first step in the screening procedure was administering a spelling test to each age-group with the aim of identifying students with spelling difficulties. The spelling difficulties are a significant predictor of reading difficulties in the absence of other difficulties like emotional, socio-economical and sensory ones (Jiměnez et al. 2003; Fletcher and Denton 2003; Lyon et al. 2002). Accordingly, at first the spelling skills of the subjects were tested for identifying the poor spellers, while the second step was testing their reading abilities to ensure that their spelling difficulties are a result of comorbidity with poor reading skills. This way of screening by starting with identifying the qualification of the target skill, i.e. spelling, and testing the reading skills out then is assumed to be useful for identifying a target group directly and may be savings in terms of time than testing the reading skills at first. For testing the spelling skills, different spelling tests were used. The spelling test for each grade was adopted from Abu-Rabia and Taha (2006) and was demonstrated to each grade-level, namely, spelling test for the second grade ($\alpha = 0.88$)[2], fourth grade ($\alpha = 0.94$), and sixth grade ($\alpha = 0.82$). Students falling below the 25th percentile on the spelling test were selected as having a risk for spelling difficulties. The students falling above the 90th percentile on the spelling test were selected as candidates of skilled spelling abilities. As it was mentioned above, the quality of the spelling skills could predict the reading skills of the participants. Accordingly, the next step in the selection procedure was testing the reading abilities within each of the two former groups.

Two reading tasks were used: (1) reading a list of words that were selected from the students' textbooks to ensure familiarity and suitability to the children's reading and language level. Three lists were developed for each grade: one for the second grade ($\alpha = 0.82$), the fourth grade ($\alpha = 0.89$) and the sixth grade ($\alpha = 0.79$). Each list consisted of 30 words. Each list of words targeted six different aspects of Arabic phonology and morphology. Each category consisted of five words. A total of thirty words was presented within each list as follows: (a) Five words with diglossic phonemes: words containing Standard Arabic phonemes that are not within the spoken vernacular of the participants; (b) Five words with emphatic phonemes: words containing velarized phonemes which differ from non-velarized phonemes in one secondary phonetic feature (velarization) but share with it all three main phonetic features (voicing, place of articulation, and manner of articulation): both velarized and non-velarized phoneme pairs exist in Arabic and they are represented in Arabic orthography using different letters; (c) Five words with a diglossic syllabic structure. Words that have a standard syllabic structure that is not frequent in the spoken vernacular of the participants (e.g., CVCC); (d) Five morphologically transparent regular words. Words with a transparent

[2] The values of the Alpha of Chronbach are as reported in Abu-Rabia and Taha (2006).

morphological structure (no homophonic letters) and a regular mapping between their sounds and reading; (e) Five morphological transparent irregular words: words with a transparent morphological structure but which are irregular. Reading these words requires the use of morphological cues. (2) Reading a text aloud. Three texts were selected, one for each level of grade. A number of candidate texts were presented to three elementary school teachers of Arabic and they were asked to judge the suitability of the texts to each grade-level. The texts were used were those that at least 2 out of the three judges had judged as suitable for a given grade-level. The text for the second grade consists of 89 words while the texts for the fourth and the sixth grades consist of 112 and 145 words respectively.

Normal performance in reading of the different tasks was suggested by the teachers who judged the level of texts according to their teaching experience. Accordingly, it was suggested that normal reading for each age level could be considered when having above 75 % accuracy of reading each reading task, while the skilled reading was suggested when the accuracy level was above 90 %. Therefore, a cut point below 70 % accuracy in reading both tasks (i.e. Reading the list of words and the text) was determined to screen the student as having a difficulty in reading. Also, a cut point of above 90 % accuracy in both reading tasks was determined to identify the student as a skilled reader. Readers who fared below 70 % accuracy on one test and above 70 % on the other were excluded. In addition to testing, pedagogical, familial, and developmental information was gathered about each participant to ensure that their reading difficulty is not a result of sensory disability or emotional disturbances.

Materials

With the aim of testing the performances of the participants on the phonological, morphological and spelling skills in the two points of pre and post intervention, the participants within the different groups and grades were tested with different tasks for assessing the abovementioned skills. The participants within the different groups and grades were tested with the same tasks. These tasks include items that match the different levels of grades and they are described as follows:

Phonological Awareness

Four measures of phonological awareness were used:

(a) Full phoneme segmentation of words. This task consisted of 20 Standard Arabic words that ranged in length from 4 to 5 phonemes and 1 to 2 syllables. Participants were asked to segment each word into all of its internal phonemes ($\alpha = 0.92$).
(b) Full phoneme segmentation of pseudo words. This task consists of 20 pseudo words that ranged in length from 4 to 5 phonemes and 1 to 2 syllables. Participants were asked to segment each pseudo word to its separated phonemes ($\alpha = 0.93$).
(c) Initial phoneme deletion from words. This task consisted of 20 items. Participants were asked to delete the initial phoneme from a heard word and were asked to pronounce the remaining part of the word. The task consisted of 20 Standard Arabic words that ranged in length from 4 to 5 phonemes and 1 to 2 syllables ($\alpha = 0.85$).
(d) Initial phoneme deletion from pseudo words. This task consisted of 20 items. Participants asked to delete the initial phoneme from a heard pseudo word and were asked to pronounce the remaining part of the pseudo word. The tasks consist of 20 pseudo words that ranged in length from 4 to 5 phonemes and 1 to 2 syllables ($\alpha = 0.88$).

Morphological Awareness

Five measures of morphological (oral) and morpho-orthographic awareness (written) were used. Given strong evidence for the role of the root and word-pattern morphological structure in Arabic, as it was mentioned and explained through the introduction, four of the morphological awareness tasks were designed for testing the participants' awareness for roots (tasks a, c, and e) and the awareness for words' patterns (task b). Task "d" is designed for assessing the participants' awareness for the morpho-syntactic structure of words in Arabic. Also, and as it was mentioned within the introduction, the almost all content words in Arabic are complex and have morpho-syntactic properties of the resultant lexical item. The task "d" is designed to assess the participants ability for analyze the word into the stem and the clitics that made it up. The tasks are described as follows:

(a) Word-relatedness by root. This task consisted of 20 pairs of words. Half of the word pairs were morphologically related words by root having the same root e.g., (عامِل – معمل) (workshop- worker), and half were semantically related but not morphologically related words by root or pattern (طبيب-مريض) (physician-sick). Items were presented orally and participants were asked to judge if each pair of words were morphologically related by having the same root relatedness or not. Before the practice items were presented, a short explanation about the root relatedness was given for each participant while root related and unrelated pairs of words were presented during the explanation session as examples. After this explanation session, each participant was practiced with two examples before starting the test and immediate feedback was given after each response of the subject. It was important to make sure that the participants understood the instructions before starting with the testing. ($\alpha = 0.84$).

(b) Word relatedness by pattern. This task consisted of 20 pairs of words. Half of the word pairs were morphologically related words by word-pattern, (shared the same pattern, e.g.,مزرعة- مدرسة–) (school- farm), and half were semantically related but not morphologically related words by pattern or root, e.g. (طبيب-مريض) (physician-sick). Items were presented orally and participants were asked to judge if each pair of words were morphologically related by having the same pattern or not. As in the root relatedness task, also within this task, a short explanation about the pattern relatedness was given for each participant before the practice items were presented, while pattern related and unrelated pairs of words were presented during the explanation session as examples. After this explanation session, each participant was practiced with two examples before starting the test and immediate feedback was given after each response of the subject. Also within the current task, it was important to make sure that the participants understood the instructions before starting with the testing ($\alpha = 0.68$).

(c) Morphological decomposition into clitics. This task consists of 20 items. Each item was a morphologically dense word that consisted of a stem (root and pattern) as well as a number of clitics attaching linearly (e.g., بسيارتنا "in our car"). Participants were asked to analyze the word into the stem and the clitics that made it up ($\alpha = 0.96$).

(d) Morphological production. Participants were presented with a simple verb stem and were asked to produce within 30 seconds as many root morphologically related words as possible ($\alpha = 0.97$).

(e) Morphological odd word out. The task consists of 15 items. Each item consisted of 4 word sets. Three words within each set were morphologically related (e.g., يخَبِّر، بخار، بخور، يبخِّر) and one was only phonologically similar to the other words in the set (e.g., يخَبِّر.) Partici-

pants were asked to read the words silently and to identify the item within each set that was not morphologically related to the other words ($\alpha = 0.84$).

Spelling Tasks

(a) Spelling Production of real words. The task consisted of 30 words. Each word was embedded within a short context and was read out loud to the participant three times before s/he was asked to write it down. The words used in this task targeted six different aspects of Arabic phonology and morphology: (a) word with diglossic phonemes: words containing Standard Arabic phonemes that are not within the spoken vernacular of the participants; (b) words with emphatic phonemes: words containing velarized phonemes which differ from non-velarized phonemes in one secondary phonetic feature (velarization) but share with it all three main phonetic features (voicing, place of articulation, and manner of articulation), both velarized and non-velarized phoneme pairs exist in Arabic and they are represented in the Arabic orthography using different letters; (c) words with a diglossic syllabic structure. Words that have a Standard syllabic structure that is not frequent in the spoken vernacular of the participants (e.g., CVCC); (d) morphologically transparent regular words. Words that have a transparent morphological structure (no homophonic letters) and a regular mapping between their sounds and spelling; (e) Morphological transparent irregular words: words that have a transparent morphological structure but which are irregular. Spelling these words requires the use of morphological cues ($\alpha = 0.88$).

(b) Spelling Production of pseudo words. The task consisted of pseudo words that embodied the six categories followed in the selection of real words in the previous task. Pseudo words were constructed by changing a phoneme or more from real words ($\alpha = 0.9$).

(c) Spelling Recognition Task. The subject was asked to choose the correct orthographic pattern of a written word from three suggested patterns. The task consists of 10 items. Each item contained three homophonic words that had a high transparent morphological pattern, for example: إستصعب، إصتصعب، إسطصعب "had a difficulty" ($\alpha = 0.7$).

Procedure

Children within each reading group in each grade level (poor and skilled) were randomly assigned to one of three experimental conditions: phonological intervention, morphological intervention, and control.

Phonological intervention. this intervention focused mainly on three phonological features: (a) phonological awareness (e.g., phonemic blending and segmentation); (b) phonological representations (e.g., phoneme articulation, auditory phoneme discrimination) especially for Standard words and Standard phonological units that are only within Standard Arabic and are not familiar to children from their spoken language, and (c) phoneme-grapheme correspondence rules especially for emphatic or velarized phonemes which are phonetically very similar to their non-emphatic phoneme neighbors. This part of the intervention contained different tasks of spelling for strengthen the phoneme-grapheme correspondence skills of the participants. When the participants demonstrated progress in internalizing the phoneme-grapheme correspondences, the second step was practicing the phonological segmentation and spelling of words and pseudowords. This part of the intervention was practiced intensively for strengthen grapheme-phoneme correspondences skills during spelling in the different grades.

Each intervention meeting with the participants was divided into four parts that addressed the following contents of the phonological intervention:

(a) Training the phonological segmentation of words and pseudowords: The main objective of this training content was to strengthen the phonological processing skills of the participants. This training consists of several exercises during which the participants were trained to segment different words and pseudowords into syllables and phonemes. For each new intervention meeting, five new words and pseudowords were practiced.
(b) Phonological blending and word formation: The main objective of this content was to strengthen the phonological awareness and blending skills. The participants were trained to compose words according to given syllables and phonemes. For example the participant heard the following syllables /RiA'=رع/ and /Sha=شا/ while the participant was supposed to say <SHARiA′> <شارع> (street) as a result of the formation process. The participants were trained with five words in such formation task in each meeting.
(c) Phoneme-grapheme correspondences: this training aimed to strengthen the phoneme mapping into the suitable graphemes. In the earlier meetings of the intervention this training began with training the spelling of syllables only. Those syllables were composed from consonant letters and short vowels (Cv) and syllables that were composed from consonants and long vowels (CV). Once the progress in the syllables spelling was revealed, we started in training the phoneme-grapheme correspondences by using pseudowords spelling training. For each new intervention meeting, five new pseudowords were practiced. Special consideration was given to the training of the diglossic and the emphatic phonemes mappings into the specific graphemes.
(d) Spelling of real words: the phoneme-grapheme correspondences were trained also by training the spelling of different real words in each meeting. For each new intervention meeting, five new words were practiced.

Morphological intervention. this intervention focused on three morphological features: (a) the derivational root-pattern morphological structure of Arabic words and on the morpho-syntactic information encoded in the morphological structure of words (e.g., morphological analogy, morphological decomposition, word building); (b) the morpho-orthographic representations of written words according to different verbal and nominal word patterns; and (c) morphological decomposition into inflectional morphemes and clitics. (e.g., "بسيارتنا in our car"). The participants practiced different writing tasks for strengthen the morpho-orthographic representations of the different morphological elements of the different words (roots, suffixes and prefixes of patterns, and morpho-syntactic morphemes). This part was practiced intensively in the different grades.

Each intervention meeting with the participants was divided into four parts that addressed the following contents of the morphological intervention:

(a) Analysis of root morphemes: as it was explained before, words in Arabic are derived from composition of roots and patterns. In each intervention meeting, an analysis of the root morphemes training was implemented. The main objective of the current training content was to strengthen the participants' awareness for the basic morphemes of the different roots. This training was demonstrated by using pencil and paper activities and oral activities as well. For each new intervention meeting, five new words were practiced.
(b) Derivational morphology (roots and patterns): The main objective of this training task was strengthening the linguistic derivational skills of composing words using specific root and pattern. Also during this training content, the participants learnt how to derive new words from the same root by manipulating the pattern of the word. The participants were practiced also in spelling down those words and were trained with writing down

the letters of the root in different colors than the letters of pattern for each word. This activity aimed to strengthen the morpho-orthographic representations of the words. Also here, five new words were practiced for each practice meeting.

(c) Inflectional morphology and morpho-syntactic analysis: during this part of the training, the participants were trained how to inflect words according to number, pronoun, gender and verb tense. in addition, participants were practiced by morpho-syntactic analysis tasks. Within those morpho-syntactic analysis tasks, the participants were asked to decompose words that were inflected by pronouns and gender into the stem word and the basic pronoun for each words (for example the word بيتي "my home" into two morphemes <mine=لي> and <home=بيت>). For each word, the participant was trained to make the decomposition orally and by writing. Five new words were practiced for each practice meeting.

(d) Morphological analogy in spelling: within each meeting, part of the training was devoted for morphological analogy in spelling. The objective of this training was to strengthen the spelling of real words using analogy with the morph-orthographic patterns of similar words. We used also pseudowords that were constructed according to exist morpho-orthographic patterns. Accordingly the participants were trained to spell those pseudowords by analogy with real words with the same patterns (for example= for spelling the pseudoword <مَفْبَلة> the participant was taught to that this pseudoword is composed according to the pattern <مَفعَلَة> and like the pattern of words that she/he already knows like <مَدْرَسَة> <SCHOOL>, for making the analogy and spell the "new word" correctly). Two words and pseudowords were practiced during each new meeting for this part.

The control group did not receive any special linguistic intervention throughout the study period. Instead, they received the ordinary reading and spelling instruction that all children in Israeli Arab schools usually receive without any specific emphasizing of phonological or morphological strategies or training.

Participants received a forty five minutes training session twice a week for a period of six months Each training session was administered within small groups of four or five participants. The two intervention programs began in November and ended in May of the same academic year. Each intervention process began immediately after the screening and the pre-test process. Each intervention was supervised by the first author and implemented by research assistants specializing in the identification and remediation of reading and spelling difficulties.

For the sake of uniformity within each intervention program administered by the different research assistants, each assistant trained one only during the entire intervention program. Each intervention team, the phonological and morphological team, met twice a week in two practice sessions, before and after the weekly intervention sessions. Each session lasted an hour and a half and aimed for preparing the next contented for the coming session. In those meetings, training, instructions and feedback on the relevant tasks was provided.

Each research assistant documented his/her training, as well as the progress that was made by the participants and comments on specific aspects that should be emphasized in future meetings within the intervention group. A weekly summary was submitted to the first author for feedback and follow-up.

Phonological awareness, morphological awareness, and word and pseudo word spelling abilities were tested in all readers across all experimental conditions (intervention and control) before and immediately after the intervention. The period of time between the pre and post testing is elapsed about six months which is the intervention duration period.

Results

As a means of data reduction, we created composite scores of phonological and morphological awareness. Each factor was computed as the average performance score on the different tasks used to measure phonological and morphological awareness. This procedure was possible because performance on the different tasks correlated significantly with correlation values above ($r = .6$) with each other and with the main factor (i.e., the phonological awareness factor and morphological awareness factor) after carrying out factor analysis. Correlations between the measurers and the main factor are computed using the factor analysis of the measures in each area,. Within this case of correlations above the value of ($r = .6$), the measures can be considered as sufficiently correlated between each other and with the main factor, theirfore all of those measures could be computed into one main factor. The computation was performed by computing the mean of the percent of accuracy of all the measures within each factor.

Table 1 provides means and standard deviations of the performance on the different spelling tasks by Intervention program (phonological, morphological, control), grade (second, fourth, and sixth), group (skilled vs. poor) and time of measurement (pre vs. post). Table 2 provides means and standard deviations of the performance on the linguistic processing factors by Intervention program (phonological, morphological, control), grade (second, fourth, and sixth), group (skilled vs. poor) and time of measurement (pre vs. post). All scores were converted into percent correct scores.

The first question which we addressed was related to the contribution of the linguistic intervention programs (phonological vs. morphological) to spelling ability, and also to linguistic awareness, among children. The differences between the pre-test and the post-test scores on all measures were computed using repeated measures analysis of variance within each group of readers in the different grades and intervention programs. The results showed that the differences between the pre-test and the post-test scores on all tasks within each reading group in the two intervention programs differed significantly across all grades. In contrast, no such significant differences between pre and post scores of the most tasks were observed in the control group. Excluded from this pattern was the significant difference observed among the second skilled readers from the second grade between the two points of testing on the spelling and phonological awareness tasks, and among the sixth skilled graders between the two points of testing the phonological awareness (see Tables 2 and 3).

The second question probed whether the impact of the two intervention programs (phonological versus morphological) on spelling development in the two reading groups (Skilled and disabled) was similar. To address this question, we used analysis of covariance (ANCOVA) that covaried the pretest measurement from the posttest measurements in each grade separately. In analyzing randomized experimental designs, this technique has been found to be more powerful than a repeated measures analysis of variance approach (Blachman et al. 2004; Maxwell 1998). The results from this analysis are presented below for each grade separately.

The results obtained from the performance of the second grade skilled readers on the word spelling task showed that the effect of the intervention was significant, $F(2, 44) = 7.92$, $p < .01$. Post hoc analysis did not show a significant difference in the gains that participants made in the phonological program compared with the morphological program. However, significant differences were found between the gains made in the phonological and control groups (mean difference = 6.97, $p < .05$) and also between the morphological and the control groups (mean difference = 8.98, $p < .05$). The same pattern was found on the pseudoword spelling task, as such, the results revealed a significant effect of intervention,

Table 1 Pre and posttests means and standard deviations of the spelling performance, according to intervention program, group, and grade, and F values

Intervention program	Group	Grade	Word spelling production pre-test	Word spelling production post-test	F value	Pseudoword spelling production pre-test	Pseudoword spelling production post-test	F value	Word spelling recognition pre-test	Word spelling recognition post-test	F value
Phonological	Skilled	2nd M(±SD)	84.51 (11.72)	94.12 (5.59)	12.43*	74.90 (17.68)	92.16 (6.66)	24.58*	61.76 (26.51)	88.24 (10.15)	23.27*
		4th M(±SD)	94.58 (7.08)	100.00 (.00)	9.35*	88.33 (8.34)	95.83 (5.09)	10.04*	88.13 (13.28)	98.75 (3.42)	9.36*
		6th M(±SD)	99.58 (1.14)	100.00 (1.81)	.31	95.42 (6.07)	100.00 (.00)	9.12*	98.75 (3.42)	99.38 (2.5)	.31.00
	Poor	2nd M(±SD)	66.89 (15.86)	80.22 (14.45)	9.18*	64.67 (11.32)	82.67 (12.86)	23.05*	51.33 (20.31)	70.00 (25.63)	3.39
		4th M(±SD)	67.4 (9.74)	85.74 (10.28)	36.08*	52.22 (14.51)	79.07 (13.03)	54.41*	46.11 (16.85)	81.11 (21.39)	32.73*
		6th M(±SD)	82.08 (6.87)	94.58 (4.37)	86.53*	72.08 (14.55)	91.46 (6.66)	54.62*	68.13 (10.47)	90.63 (10.63)	31.15*
Morphological	Skilled	2nd M(±SD)	89.58 (6.65)	96.67 (3.22)	17.55*	82.71 (11.5)	94.79 (4.38)	16.11*	75 (18.97)	95.63 (8.14)	33.00*
		4th M(±SD)	95.29 (6.57)	99.41 (6.57)	7.53*	86.86 (8.93)	96.67 (5.00)	19.45*	78.82 (16.91)	96.47 (8.62)	18.00*
		6th M(±SD)	99.38 (1.34)	99.79 (.83)	1.00	93.54 (4.47)	97.50 (3.33)	9.28*	97.50 (4.47)	100 (.00)	5.00*
	Poor	2nd M(±SD)	53.53 (23.02)	81.57 (10.61)	27.1*	48.43 (21.61)	79.02 (12.4)	34.47*	51.76 (24.3)	83.53 (11.69)	18.73*
		4th M(±SD)	68.13 (10.75)	87.50 (7.65)	39.66*	55.00 (14.14)	79.38 (10.9)	37.58*	55.00 (13.66)	80.63 (13.4)	28.71*
		6th M(±SD)	81.25 (5.43)	96.46 (3.75)	96.1*	70.63 (12.00)	91.04 (8.23)	77.78*	75.63 (16.72)	97.50 (5.77)	29.87*
Control	Skilled	2nd M(±SD)	84.22 (14.5)	87.11 (9.5)	.48	75.78 (23.59)	88.22 (6.02)	3.94	78 (7.75)	90 (14.64)	13.5*
		4th M(±SD)	95.11 (6.41)	93.56 (9.3)	1.44	86.67 (13.15)	85.33 (12.14)	.36	75.33 (21.34)	83.33 (17.18)	1.75
		6th M(±SD)	98.44 (3.53)	94.00 (14.81)	1.38	92.89 (4.86)	94.67 (5.01)	3.79	98.00 (4.14)	98.67 (3.52)	.19
	Poor	2nd M(±SD)	66.04 (13.94)	61.25 (6.76)	2.01	41.25 (21.5)	60.42 (17.6)	10.23*	48.75 (8.85)	56.25 (18.21)	1.95
		4th M(±SD)	70.63 (9.68)	66.88 (15.94)	1.92	60.42 (10.46)	56.67 (17.5)	.52	58.75 (17.46)	68.13 (22.57)	1.61
		6th M(±SD)	76.88 (6.72)	81.67 (11.35)	3.81	68.13 (11.42)	67.08 (10.6)	.51	63.75 (19.62)	70.00 (14.14)	1.96

*= F value is significant at a level of $p < .05$

Table 2 Means and standard deviations of the phonological the morphological factors outcomes at the pre and post test points and F values

Intervention	Reader	Grade	Phonological awareness pre-test	Phonological awareness post-test	F value	Morphological awareness pre-test	Morphological awareness post-test	F value
Phonological	Skilled	2nd M(±SD)	85.66 (13.07)	93.97 (7.82)	5.91*	59.95 (15.76)	65.17 (13.36)	6.35*
		4th M(±SD)	93.20 (7.26)	98.98 (1.84)	13.17*	72.52 (7.95)	76.90 (4.95)	15.04*
		6th M(±SD)	97.34 (5.04)	98.98 (1.89)	1.8	80.28 (.94)	80.93 (.07)	7.89*
	Poor	2nd M(±SD)	62.42 (14.26)	83.91 (6.9)	41.66*	42.52 (9.71)	50.77 (10.66)	8.31*
		4th M(±SD)	58.75 (13.65)	87.78 (8.57)	63.78*	42.53 (8.24)	61.44 (9.97)	63.34*
		6th M(±SD)	68.75 (10.93)	91.95 (4.42)	49.46*	51.62 (12.51)	64.80 (7.95)	27.55*
Morphological	Skilled	2nd M(±SD)	96.25 (5.04)	97.66 (5.42)	.6	58.42 (7.34)	71.83 (5.71)	32.56*
		4th M(±SD)	90.37 (8.5)	98.46 (2.28)	20.32*	63.12 (10.66)	76.26 (5.54)	16.61*
		6th M(±SD)	94.22 (5.64)	98.44 (3.08)	23.61*	77.23 (5.03)	80.81 (.42)	8.34*
	Poor	2nd M(±SD)	55.96 (18.37)	82.87 (7.2)	38.31*	43.34 (10.72)	62.64 (5.48)	48.65*
		4th M(±SD)	54.14 (8.7)	83.75 (12.01)	155.9*	50.70 (10.62)	67.12 (12.18)	31.75*
		6th M(±SD)	72.19 (9.59)	91.88 (6.42)	79.06*	54.40 (10.34)	77.99 (1.69)	86.24*
Control	Skilled	2nd M(±SD)	93.02 (5.68)	90.75 (7.6)	2.15	63.09 (8.85)	66.74 (9.33)	1.27
		4th M(±SD)	91.08 (8.59)	93.92 (6.88)	8.24*	73.18 (4.04)	71.07 (6.28)	2.01
		6th M(±SD)	94.67 (4.19)	98.00 (2.54)	16.35*	77.25 (5.88)	80.20 (.95)	3.74
	Poor	2nd M(±SD)	61.71 (16.33)	77.24 (11.9)	.15	40.81 (10.05)	51.42 (13.01)	5.58*
		4th M(±SD)	63.36 (15.23)	71.09 (11.08)	3.35	46.50 (9.84)	46.99 (5.15)	.03
		6th M(±SD)	68.59 (8.26)	74.61 (10.9)	3.59	49.66 (9.57)	52.70 (10.08)	1.89

*= F value is significant at a level of $p < .05$

Table 3 Means and standard deviations of improvement scores (z-scores) among the different readers within the different grade and within the different interventions

Grade	Intervention	Reader	Words spelling M (±SD)	Pseudowords spelling M (±SD)	Spelling recognition M (±SD)
2nd	Phonological intervention	Skilled	.35 (58)	.47 (.5)	.31 (.55)
		Poor	−.15 (1.21)	.09 (.98)	−.58 (1.77)
	Morphological intervention	Skilled	.36 (36)	.40 (.52)	.48 (.35)
		Poor	.54 (1.14)	.38 (1.05)	.23 (.98)
	Control	Skilled	−.27 (.97)	.13 (.96)	.08 (.81)
		Poor	−1.80 (.7)	−.84 (1.4)	−1.36 (1.14)
4th	Phonological intervention	Skilled	.44 (.3)	.29 (.48)	.40 (.35)
		Poor	.32 (.94)	.25 (.96)	.19 (1.3)
	Morphological intervention	Skilled	.36 (.27)	.40 (.45)	.46 (.55)
		Poor	.45 (.77)	.17 (.9)	−.01 (.86)
	Control	Skilled	−.16 (.61)	−.48 (.67)	−.26 (1)
		Poor	−1.50 (1.15)	−1.82 (1.45)	−.84 (1.43)
6th	Phonological intervention	Skilled	.17 (.14)	.36 (.22)	.23 (.17)
		Poor	.49 (.31)	.52 (.37)	.32 (.71)
	Morphological intervention	Skilled	.22 (.1)	.23 (.29)	.29 (.09)
		Poor	.69 (.38)	.54 (.5)	.58 (.41)
	Control	Skilled	−.26 (1.31)	.03 (.29)	.20 (.24)
		Poor	−.44 (.9)	−1.27 (.53)	−.83 (.75)

$F\,(2, 44) = 4.42,\ p < .05$. However, post hoc analysis showed that the source of this effect lied in the gains that were made only in the morphological versus the control group (mean difference = 5.97, $p < .05$) but not in the gains observed in the phonological as against the control. The spelling recognition task showed no significant main effect of intervention in this group of readers and at this early grade, $F\,(2, 44) = 1.66,\ p = 0.2$.

Similar to the pattern observed among the skilled reader from the second grade, the results from an analysis of the performance of poor readers from the second grade on the word spelling task showed that the gains made between the pre and the post tests revealed a significant effect of intervention, $F\,(2, 44) = 20.61,\ p < .01$. Post hoc analysis did not showed a significant difference between the gains of participants from the phonological program compared with the morphological program. However, significant differences were found between the gains made in the phonological versus the control groups (mean difference = 18.81, $p < .05$) and between the morphological and the control groups (mean difference = 22.68, $p < .05$). The same pattern of intervention effect was found for the gains on the pseudoword spelling task, with a significant effect of intervention, $F\,(2, 44) = 7.08,\ p < .01$. Post hoc analysis did not show a significant difference between the gains of participants in phonological program compared with the morphological program. However, significant differences were found between the gains of the participants in the phonological and control groups (mean difference = 17.42, $p < .05$) and between the morphological and the control groups (mean difference = 17.12, $p < .05$). Gains on the spelling recognition task showed a significant main effect of intervention program, $F(2, 44) = 9.77,\ p < .01$. Post hoc analysis did not show a significant difference between the phonological program and the morphological program either between the phonological program and the control group. The significant effect arises from the difference between the gains in the morphological program as against the control group (mean difference = 28.2, $p < .05$).

For the fourth grade, the performance of the skilled readers on the word spelling revealed a significant effect of intervention, $F(2, 44) = 9.25,\ p < .01$. Post hoc analysis did not show a significant difference between the gains made in the phonological versus the morphological program. However, significant differences were found between the gains of the phonological and control (mean difference = 6.64, $p < .05$) and between the morphological and the control (mean difference = 5.78, $p < .05$). The same pattern of intervention effect was found in the gains made on the pseudoword spelling task, with a significant effect of intervention, $F(2, 44) = 12.46,\ p < .01$. Post hoc analysis showed a significant difference between the gains of participants in phonological program versus the control (mean difference = 9.8, $p < .05$) and in the morphological versus the control (mean difference = 11.25, $p < .05$). Considering the gains on the spelling recognition task, the results showed a significant effect of intervention, $F(2, 44) = 7.12,\ p < .01$. Post hoc analysis showed a significant difference between the gains made in the phonological program versus control group (mean difference = 13.6, $p < .05$) and in the morphological versus control (mean difference = 12.64, $p < .05$).

The results obtained from the performance of the poor readers in the fourth grade on the word spelling revealed a significant effect of intervention, $F(2, 46) = 19.86,\ p < .01$. Post hoc analysis did not show a significant difference between the gains of participants in the phonological program as against the morphological program. However, significant differences were found between the gains of the phonological program and the control (mean difference = 20.34, $p < .05$) and between the morphological program and the control (mean difference = 21.77, $p < .05$). The same pattern of intervention effect was found for the gains on the pseudoword spelling task, with a significant effect of intervention, $F\,(2, 46) = 15,\ p < .01$. Post hoc analysis did not show a significant difference between the gains

of participants in the phonological program compared with the morphological program. However, significant differences were found between the gains of the phonological program and control (mean difference = 23.9, $p < .05$) and between the morphological program and the control (mean difference = 23.72, $p < .05$). The gains on the Spelling Recognition task did not showed a significant main effect of intervention group, $F\ (2, 46) = 2.13$, $p = .13$.

Unlike the pattern observed in the performance of the younger children in both the skilled and the poor readers groups, the performance of skilled readers on the sixth grade on the word spelling task did not reveal a significant effect of intervention, $F(2, 43) = 1.68$, $p = .19$. In contrast, performance on pseudoword spelling task did reveal a significant intervention effect, $F(2, 43) = 7.97$, $p < .01$. Post hoc analysis showed that the source of this effect rise only in the significant difference between the gains of participants in the phonological program compared with the control (mean difference = 4.7, $p < .05$). The spelling recognition task did not show a significant effect of intervention, $F\ (2, 43) = 1.069$, $p = .35$.

Unlike the pattern observed among the skilled readers from the sixth grade, the performance of the sixth grade poor readers showed a significant effect of intervention on the word spelling task, $F\ (2, 44) = 14.32$, $p < .01$. Post hoc analysis did not show a significant difference between the gains of participants in the phonological program compared with the morphological program. However, significant differences were found between the gains of the phonological program and the control (mean difference = 10.34, $p < .05$) and between the morphological program and the control (mean difference = 12.6, $p < .05$). The same pattern of intervention effect was found for the gains made on the pseudoword spelling task, with a significant effect of intervention, $F(2, 44) = 74.4$, $p < .01$. Post hoc analysis did not show a significant difference between the gains of participants in phonological program compared with the morphological program. However, significant differences were found between the gains made in the phonological intervention and control (mean difference = 22.4, $p < .05$) and between the morphological program and the control (mean difference = 22.72, $p < .05$). Regarding performance on the spelling recognition task, the results show a significant effect of intervention, $F\ (2, 44) = 24.12$, $p < .01$. Post hoc analysis did not show a significant difference between the gains of participants in the phonological program compared with the morphological program. However, significant differences were found between the gains of the phonological program and control (mean difference = 19.81, $p < .05$) and between the morphological program and the control (mean difference = 25.3, $p < .05$).

The third question we addressed in this study asks whether there were differences in the amount of gain obtained between pre and post between the two groups of readers (skilled vs. poor readers) within each intervention program and in each grade separately. In order to address this question, we used regression analysis predicting post-intervention score from pre-intervention score, in order to obtain standardized residual scores. These residual scores were used as a measure of improvement or response-to-intervention score for each group of readers within each intervention program. Next, analysis of variance was used within each grade separately to compare improvements indicated in the residual scores between the disabled and the skilled readers. Table 3 summarizes the means and standard deviations of the computed improvement scores in the different groups of readers within the different grade and in the different intervention programs. The results reported below are presented for each grade separately.

We will begin with the second graders. In the phonological intervention program, the results showed no significant differences in response-to-intervention score between skilled and poor readers from second grade on any of the three spelling tasks used: Word spelling, $F\ (1, 30) = 2.21$, $p = .14$; pseudoword spelling, $F\ (1, 30) = 2.03$, $p = .16$; and spelling recognition, $F\ (1, 30) = 3.86$, $p = .059$. Similar results were obtained in the morphological

intervention program with no significant differences between the two groups of readers as a response to intervention on any of the spelling tasks used: Word spelling, F (1, 31) = .38, $p = .53$; pseudoword spelling, F (1, 31) = .08, $p = .93$; and spelling recognition, F (1, 31) = .97, $p = .33$.

Similar patterns were observed in the fourth grade. In the Phonological intervention no significant differences in response-to-intervention scores between the two groups were observed on any of the spelling tasks used: Word spelling, F (1, 32) = .22, $p = .63$; pseudoword spelling, F (1, 32) = .021, $p = .88$; and spelling recognition, F (1, 32) = .38, $p = .53$. Non-significant response scores were also observed in the *morphological intervention* on all tasks: Word spelling, F (1, 31) = .21, $p = .64$; psuedoword spelling, F (1, 31) = .89, $p = .35$; and spelling recognition, F (1, 31) = 3.55, $p = .07$.

Now we turn to sixth graders. In the Phonological intervention, the results showed a significant difference in response-to-intervention scores between the two groups of readers on word spelling: F (1, 30) = 13.9, $p < .01$. However, no such difference was observed on the other two spelling tasks: Pseudoword spelling, F (1, 30) = 2.14, $p = .15$, and spelling recognition, F (1, 30) = .27, $p = .6$. On the other hand, in the morphological intervention, there were significant differences between the two groups in response-to-intervention on all tasks used: Word spelling, F (1, 30) = 22.9, $p < .01$, pseudoword spelling, F (1, 30) = 4.47, $p < .05$, and spelling recognition, F (1, 30) = 7.8, $p < .01$, with the poor readers achieving higher scores of response than skilled readers.

The fourth and last question is developmental in nature and asked whether there were differences across grades within each group of reader in response to intervention. In order to address this question, we used analysis of variance in each intervention program separately and with grade as a between subject factors and with the residual scores indexing response-to-intervention as the depended variable. The analysis was split for each reading group within each intervention.

On the word spelling task, skilled readers did not show a significant difference between grades in response to intervention, neither phonological, F (2, 46) = 1.93, $p = .55$, nor morphological, F (2, 46) = 1.46, $p = .24$. The same pattern was observed among the poor readers: Phonological intervention, F (2, 46) = 2.08, $p = .13$; Morphological intervention, F (2, 46) = .34, $p = .7$.

Similar to the results reported above, the pseudoword spelling task, did not reveal any difference in response-to-intervention scores between the different grades, neither in the skilled readers: phonological intervention, F (2, 46) = .82, $p = .44$; Morphological intervention, F (2, 46) = .86, $p = .42$, nor in the poor readers: Phonological intervention, F (2, 46)= 1.09, $p = .34$; Morphological intervention, F (2, 46) = .73, $p = .48$.

The spelling recognition task showed exactly the same pattern with no differences between grades in response-to-intervention scores among skilled readers in any of the two intervention programs: Phonological program, F (2, 46) = .82, $p = .44$; Morphological program, F (2, 46) = 1.18, $p = .31$. Similar results were obtained among the poor readers in both programs: Phonological intervention, F (2, 46) = 2.12, $p = .13$; Morphological intervention, F (2, 46) = 2.29, $p = .11$.

Discussion

Three factors make the current study particularly informative: (a) the scarcity of intervention studies of spelling development in children, (b) the implicit assumption that because the

acquisition of basic reading skills in a shallow orthography is fast and easy, no direct or explicit training in the linguistic basis of reading or spelling might be required, especially among old and normally developing school children, and (c) the focus on spelling in Arabic with its unique non-linear morphological structure and consonantal orthographic system. Two main findings emerge from the current study. First, linguistic intervention, both the phonological intervention and the morphological were each found to make a significant contribution to spelling development, even among skilled readers and even among the oldest group tested (sixth grade). Second, skilled and poor young readers (second and fourth grade) made equal gains in spelling from both intervention programs; only in the sixth grade, were the poor readers found to produce more gains from the morphological intervention than the skilled readers. Below is a detailed discussion of the results of the study.

The first question we addressed related to the contribution of linguistic intervention (phonological and morphological) to spelling development in skilled and poor readers. We tested three grade-level groups (second, fourth, and sixth) in order to probe the developmental nature of the impact of intervention on spelling. This is important, given the fact that spellers may rely on different spelling strategies at different stages of spelling development: phonological first and morphological later (Berninger et al. 2010). We also used three different spelling tasks that require variable degrees of reliance on phonological versus morphological processes: a word spelling task, a pseudo word spelling task, and a spelling recognition task of morphologically-based pseudohomophones. We found that the spelling performance of children (on all spelling tasks) in both the phonological and the morphological intervention programs was significantly higher on the post-test as compared with the pretest; Only sixth grade skilled readers did not show a significant difference between pre and posttests on the majority of tasks. In contrast, in the control groups, the difference between children's spelling scores on the pretest and post-test was not significant on any single spelling task. These findings highlight the contribution of linguistic intervention: phonological and morphological to the development of spelling in Arabic among skilled and poor reading children, especially in the initial grades (until the fourth grade).

Next, we tested the relative contribution of type of intervention (phonological versus morphological) to spelling scores in the different grades and groups. Here, though both intervention programs were shown to result in significant gains in word spelling as against the performance of children in the control group, the results did not show a difference in the contribution of type of intervention (phonological versus morphological) in neither grade in the poor readers group, and in neither the second nor the fourth grade and in the skilled readers group. In contrast, in the sixth grade, the effect of both intervention programs on word spelling fell below satisfactory levels of significance when compared with the control in the skilled readers group. In other words, children's improvement in word spelling between pretest and post-test was different from the performance of the control group but equal in both intervention programs, the phonological focusing primarily on phonological segmentation skills and letter-sound knowledge, and the morphological focusing primarily on morphological root-pattern morphological structure and morpho-orthographic patterns, in all grades in the poor and skilled readers, with only the skilled sixth graders failing to show significant gains in spelling as against the control group in neither intervention program. Given the diglossic context of Arabic and the phonological distance between the phonological representation of words, even high-frequency (Saiegh-Haddad & Ali, in preparation Saiegh-Haddad and Ali 2012), in StA and SpA, and given the centrality of morphology in Semitic Arabic (Ravid 2012) these results make clear sense. In other words, the phonological distance between the spoken and standard representation of words together with the predominance of morphology results in equal gains in spelling from both the phonological and the morphological training.

The results from the pseudoword spelling task showed a rather consistent pattern in the poor readers group across all grades, children with poor reading skills showing equal improvement in spelling on the post-test in both intervention programs as against the controls. The same pattern was observed among the skilled readers from the fourth grade. In contrast, skilled second graders in the phonological program made significant gains compared to controls but not in the morphological program compared to controls. In the sixth grade, both intervention programs failed to produce significant gains in pseudo word spelling among children as against the control groups. Given the nature of the pseudo word spelling task and the processing mechanisms it requires, it is reasonable to expect the phonological intervention to produce significant gains in spelling pseudo words as against the control group. This finding was true of poor readers in all grades, and of skilled readers in the fourth grade. A less straightforward finding is the finding that the morphological intervention was equally conducive to pseudo word spelling as the phonological intervention in Arabic among reading disabled in all grades and also among skilled young readers in the second and fourth grade. Morphological intervention was the only intervention that produced significantly different gains from the control among skilled readers in the second grade. These findings should be interpreted within the morphological structure of Arabic. All Arabic content words are morphologically complex and have an internal morphological structure that combines a consonantal root and a consonantal-vocalic word pattern. Given the fact that spelling in Arabic requires the representation of letters only, it follows that creating pseudo words from real words will involve changing the letters of the root or those of the pattern. In turn, spelling pseudo words will also benefit from a morpho-phonological processing mechanism that makes use of morphological cues in the phonological encoding of words. Convergent evidence in support of the role of morphological processing in pseudo word spelling was recently demonstrated in a study that compared children spelling of morphologically transparent versus morphologically opaque Arabic words. This study showed that morphologically transparent pseudo words were easier to spell than morphologically opaque pseudo words in both skilled and poor readers in second, fourth, and sixth grade with the difference in the gains in spelling between the two conditions being larger in the disabled than the skilled group (Taha & Saiegh-Haddad, In preparation Taha and Saiegh-Haddad 2012). In another study, we showed that even young first graders use the internal root-pattern morphological structure in spelling Arabic words (Saiegh-Haddad, submitted Saiegh-Haddad 2012)

Using morphological processing in spelling requires morphological awareness. Research on young Arabic speakers showed that morphological awareness of the internal root-pattern structure develops relatively early in children given the predominance of derivational morphology in the language (Taha & Saiegh-Haddad, In preparation Taha and Saiegh-Haddad 2012). Thus, as we have explained, given the morphological structure of Arabic words, it does make sense that even second grade skilled readers make significant gains in spelling from the morphological intervention; another less straightforward finding is the finding that second graders in the phonological intervention did not make gains that are different from the controls. This finding may reflect the fact that the second grade controls were also being trained to spell in Arabic using phonological processing strategies and letter-sound correspondence rules, as this is the main reading and spelling instructional strategy emphasized in the first and second grades and recommended by the new curriculum for the teaching of the Arabic language in Israel (Ministry of Education 2009). The absence of any effect of intervention among sixth grade skilled readers against the control group might be due to the shallow orthography of Arabic, which despite the existence of some homographic letters and the use of an orthographic system of diacritics, is highly consistent. Indeed the spelling

scores among skilled sixth graders were found to reach a ceiling level of in both intervention and control groups (see Table 1).

Now we turn to the spelling recognition task which tapped into the recognition of the correctly spelt word that followed the conventional spelling from among a set of four homophones. These homophones utilized the predominant phonological assimilation process in Arabic involving velarized phonemes and operating across morphological boundaries (see examples in the method section).This task requires high morpho-orthographic knowledge of the consistent root-pattern representation in Arabic orthography. The results from the performance on the spelling recognition task show two patterns. First, as expected, the phonological intervention program failed to produce gains on this task as against the controls among the disabled young second graders; in this group, it was only the morphological program that resulted in significantly different scores than the controls. Among fourth grade poor readers, neither intervention program resulted in significantly different scores from the controls. This pattern was also found in the young second grade and old sixth grade skilled. The poor readers from the sixth grade and the skilled fourth graders showed equal gains in both programs as against the control. These findings shed light on the nature of the task and the mechanisms it requires. The task is a complex morph-orthographic task that requires not only morphological awareness but also an intricate knowledge of the consistent orthographic representation of morphemes that overrides phonological irregularity. It appears that disabled young second graders have not yet developed such a morph-orthographic knowledge (Ravid and Malenky 2001; Taha & Saiegh-Haddad, In preparation) and have thus benefited from an explicit, and intensive training of these rules, despite the fact that all Arabic content words integrate the two derivational morphemes (root and pattern) that this task has targeted and despite the fact that the tasks targeted high frequency verbal pattern and roots. This effect disappeared in the fourth grade.

As for skilled readers, not even young second graders appeared to need this explicit training in the morpho-orthographic structure and therefore were not different from controls. The same was true of the old sixth graders who, given the centrality of morphology both in the language and in the orthographic representation of words have implicitly acquired knowledge of how real word should look like in Arabic. For instance, they know that a work is more likely to begin with the letter sequence است than اصط even if they hear a sound that might correspond with the latter. This is because the former represents the first three letters of a productive word-pattern and is thus repeated in the orthographic representation of all verbs that derive from the same pattern and regardless of how they sound.

Considering the question of response-to-intervention in the different groups and grades, the results draw a rather consistent picture. Despite the centrality of morphology in Arabic and the consistent orthographic representation of morphemes, it was found that in the second, fourth, and sixth grades, both the skilled and the poor readers made equal gains from both intervention programs in their spelling of words and pseudo words and in their spelling recognition. Excluded from this was the finding that in the sixth grade the reading disabled made more gains from the morphological intervention than the phonological on all spelling tasks. Also, they made more gains from the phonological intervention than from the morphological in word spelling. All together, these findings support the effectiveness of early explicit and intensive training in the linguistic basis of spelling (both phonological and morphological) in Arabic and despite its rather shallow orthography. The results also support the importance of including explicit phonological and morphological training in spelling instruction in skilled readers too, rather than reducing it to a remediating tool necessary for poor readers only (Wolter et al. 2009). The centrality of morphology in Arabic and the consistent morpho-orthographic structure of Arabic appear to lie behind the efficacy that this study has shown

of morphological training in Arabic in both skilled and poor readers. Another finding of the study is that response to intervention was not different in neither the phonological nor the morphological program or in either group. This strengthens the previous argument of the importance of explicit training of the phonological and the morphological basis of Arabic spelling in all grades equally, young and old (For review about phonological awareness and reading, see Bus and van IJzendoorn 1999; Carlisle et al. 2010; Goodwin and Ahn 2010, for morphological awareness).

The contribution of the phonological training to spelling development, that was equal to the contribution of morphological intervention, even among sixth graders, may be explained by the diglossic nature of Arabic and the phonological distance between SpA and StA. In other words, because StA words encode StA phonemes and other phonological and lexical properties, spelling in StA does benefit from phonological training that focuses on the phonological distance between the two languages and on the orthographic representation of StA phonological units (Abu-Rabia and Taha 2004, 2006; Saiegh-Haddad 2003, 2004, 2005, 2007, 2011b, a).

One interesting result that emerged from the current study is the "indirect transfer from one program to another". The results showed a marked progress in morphological awareness among the participants from the phonological intervention program and vice versa. Two explanations are possible. One that both programs entailed raising awareness to the linguistic structure of words and this resulted in gains in awareness both at the phonological and at the morphological level. Second, because, of the morphological structure of Arabic is highly tight to its phonological one, (the root is a consonantal structure and the word-pattern is a prosodic template with slots for the consonantal root- the two levels of representation), the morphological and the phonological, are intertwined and an intervention in one indirectly results gains in the other. In the light of this, we can postulate that it is hard to construct pure morphological or phonological intervention in languages characterized by a strong overlap between phonology and morphology (Deacon and Kirby 2004), like the Arabic language.

To sum up, the current study endorses the contribution of phonological and morphological intervention to spelling development in Arabic in both children with skilled and poor reading skills and in young and old school grades. The rather equal contribution of the two programs to spelling development in Arabic reflects the effect of two competing forces. The first is the diglossic context of Arabic and the phonological between SpA and StA words (Saiegh-Haddad 2007; 2011a; 2011b). This distance makes a phonological intervention that draws attention to the phonological distance and focuses on the phonological and the orthographic representation of StA structures particularly conducive to Arabic spelling. The second is the centrality of morphology in Semitic Arabic (Ravid 2012) and the consistent representation of this morphological structure of the Arabic orthography (Saiegh-Haddad and Geva 2008). This makes a morphological intervention that draws attention to the internal morphological structure that inheres in almost all content words, and of the morpho-orthographic regularities in Arabic spelling particularly conducive to spelling Arabic words.

Appendix

See (Table 4).

Table 4 Total number of participants and mean age within each intervention group separately by grade and reading group

		Skilled readers			Poor readers		
Grade		Phonological intervention	Morphological intervention	Control	Phonological intervention	Morphological intervention	Control
2nd	*N*	17 (8.03, ±.28)	16 (8.17, ±.29)	15 (8.12, ±.35)	15 (7.97, ± .27)	17 (7.99, ±.26)	16 (7.95, ±.28)
4th	*N*	16 (10.02, ±.27)	17 17 (9.97, ±.3)	15 (9.96, ±.28)	18 (10.2, ±.31)	16 (10.04, ±.29)	16 (9.93, ±.36)
6th	*N*	16 (11.91, ±.33)	16 (12.01, ±.19)	15 (12.06, ±.25)	16 (12.11, ±.29)	16 (11.99, ±.3)	16 (11.86, ±.31)

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