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Effects of Morphological Awareness Training on Reading Accuracy in Children with Dyslexia and its Transfer Effect on Phonological Awareness

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Abstract

We examined the effects of a morphological awareness (MA) training program on the enhancement of word and pseudo-word reading and phonological awareness in Arabic-speaking children with dyslexia. We compared two groups of children with dyslexia from Grade 3, an experimental group ($n = 12$; mean age = 112.4 months) with a control group ($n = 13$; mean age = 111.61 months). The training program focused on morphological analysis, derivational morphology and inflexional morphology. Results revealed that the experimental group outperformed controls on all post-training measures for MA, reading words and pseudo-words as well as phonological awareness. Also, the post-training measures were better achieved in the experimental group than pre-training ones, which confirm the efficacy of the morphological training program. We discuss these findings in light of the relationship between morphological awareness and word reading and phonological awareness, and the Arabic orthographic features as a morphological based language.

Key Words: morphological awareness, morphological training, developmental dyslexia, Arabic morphology.

Research has long been focused on a phonological awareness (PA) deficit as a potential cause for reading disabilities in dyslexia (Arnbak & Elbro, 2000; Joanisse et al., 2000; Siegel, 2008). However, morphological awareness (MA) is a relatively new topic on the causality of developmental dyslexia, although associated with reading acquisition in a growing number of studies (Arnbak & Elbro, 2000; Casalis et al., 2004; De Freitas et al., 2018; Siegel, 2008) including Arabic (Saiegh-Haddad & Taha, 2017; Tibi & Kirby, 2017). It follows that MA training should have a positive effect on reading skills of children with dyslexia. We report the results of an experimental study on how MA training can affect word and pseudo-word reading with a transfer effect on PA ability in Arabic speaking children with dyslexia.

As a part of metalinguistic skills, MA refers to children's awareness of the morphological structure of words and their ability to reflect on and manipulate morphemes (Carlisle, 2000), the smallest linguistic unit to convey semantic meaning in the word. To learn word reading efficiently, children need to apply phonological and morphological knowledge (Kirby et al., 2012), especially in morpho-phonemic languages where the combination of morphemic and phonemic principles is the basis of the creation /recognition of words in English (Li & Chen, 2016) and Arabic (Saiegh-Haddad & Geva, 2008). In addition to phonological knowledge, it has been reported that children who have awareness of morphological knowledge are able to process morphemes efficiently to facilitate reading of morphologically complex words (Carlisle & Stone, 2005).

The role of MA has been associated with real and pseudo-word reading performances of multi-morphemic words in studies of different languages (Frost et al., 2005; Nagy et al., 2006; Nunes & Bryant, 2011). In their longitudinal study, Pittas and Nunes (2014) examined the

contribution of morphological awareness to the prediction of reading and spelling in Greek children aged 6-9 years. The results showed that MA predicted performance in reading eight months later, even after partialling out grade level, verbal intelligence, phonological awareness and initial scores in reading and spelling. This study shows the long-term relation of MA with reading which could be established in intervention-based studies. It was suggested that because morphemes carry semantic information, the notion of MA is more salient and broader than the notion of PA as sensitivity to morphemes is easier to acquire (Casalis et al., 2004; Fowler & Liberman, 1995).Therefore, MA training could present advantages over a PA one for both students with and without dyslexia (Coutu-Fleury, 2015).

Given that the linguistic and orthographic representation of words in different alphabetical languages is mainly related to the morpho-graphic components as in English and Arabic (Carlisle, 2003; Saiegh-Haddad & Geva, 2008), different researchers assumed that reading performance should be enhanced when individuals receive morphological awareness instruction related to the structure of words. For children with reading disabilities, it appears that an explicit intervention approach, which focuses on stimulating children to reflect actively on the meaning of words and their structure (root and affixes) is most effective in improving reading skills (Bowers et al., 2010; Goodwin & Ahn, 2010; Goodwin et al., 2012). MA can indeed facilitate word decoding for both students with and without dyslexia by segmenting words into smaller meaningful units of speech that can be recognized more accurately (Siegel, 2008). Prior studies have investigated the relative effectiveness of MA training on word reading in shallow orthographies (Casalis & Cole, 2009; Lyster, 2002) and deep orthographies such as English (Nunes et al., 2003). MA training has been shown to improve word reading (Kirk & Gillon, 2009; Nunes & Bryant, 2011) with diverging amounts of effects. For example, Lyster (2002) found that Norwegian 4-year-old kindergarten children performed better in post-test word reading after morphological training than control and PA groups, and that the impact lasted even to the end of the first grade. Similarly, Arnbak and Elbro (2000) compared an experimental group of young students with dyslexia aged between 10 and 12 years old to an age-matched control group of typical readers. The training program was based only on oral instruction and on the semantic meaning associated with morphemes. The students with dyslexia made significant gains in reading ability according to their results on the comprehension test. The results from Arnbak and Elbro's (2000) study suggest that MA training has an impact on the reading and spelling abilities of young students with dyslexia. More recently, Bar-Kochva and Hasselhorn (2017) examined the effects of a morpheme-based training on reading and spelling in fifth and sixth graders with poor literacy skills. A computerized training program was designed to encourage fast morphological analysis in word processing based on a visual lexical decision task. The group receiving the morpheme-based program improved more in terms of word reading fluency, suggesting that the morpheme-based training contributed to the integration of morphological decomposition into the process of word recognition.

In recent meta-analyses and systematic reviews research, MA instruction has recurrently been found to improve literacy outcomes for children with literacy deficits in elementary school (Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2010, 2013; Goodwin et al., 2012). In a review of 22 studies, Bowers et al. (2010) found strongest effect sizes for MA training for readers in early elementary school struggling with literacy. In a similar meta-analysis of 17 studies, Goodwin and Ahn (2010) found MA instruction to be particularly effective for children with language and/or literacy deficits. School-age children who received explicit MA training appeared not only to improve significantly in the linguistic areas of PA, MA, and vocabulary but also in related literacy areas of reading and spelling (Wolter & Green, 2013). More recently, in a meta-analysis of MA intervention studies, Goodwin and Ahn (2013) investigated the moderators of MA intervention across a broad range of students and outcomes. The overall effect size for MA intervention across studies was small ($d = .32$), with different literacy outcomes ranging in effect sizes from non-significant (reading comprehension and fluency) to moderate (PA, MA, and decoding). Interventions administered to preschool and early elementary students yielded significantly greater gains than those administered to older students, with the largest reported for long-lasting interventions (e.g. 20 hours). These results suggest that one way to increase a broad range of literacy skills for young students with, or at risk for, developing reading difficulties is to provide a MA program, either alone or as part of a wide-ranging literacy intervention program (Goodwin & Ahn, 2013).

Some orthographic systems are characterized by their unique morphological structures, where the contribution of MA to reading development was evidenced. In this regard, Semitic languages, such as Arabic and Hebrew, are particularly characterised by their non-linear root-word pattern structures as principal features of internal morphological structure (Frost, 2006; Velan & Frost, 2011). Therefore, it could be interesting to study the potential effects of MA on reading in such languages, which can be extremely informative to the role of morphological processing in reading development theory.

Arabic differs from other alphabetic orthographies in orthographic architecture and in morphological structure. Unlike English, Arabic utilizes two types of morphological procedures: linear and non-linear, accomplishing different

functions (Saiegh-Haddad, & Schiff, 2016). While linear morphology is primarily inflectional, 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, carrying the meaning of "writing") that provides the core semantic information, and a word-pattern, a phonological template which specifies the surface phonological structure and the morpho-syntactic properties of the resultant lexical item (e.g. Ca:CeC "writer"). Such an internal morphological structure applies for all content words in Arabic (Velan & Frost, 2011).

While studies on morphological instruction have shown positive effects on reading in different languages (See Goodwin & Ahn (2013) for a review), few Arabic based studies on MA intervention for children with dyslexia have been carried out. Given the strong evidence for the role of the root and word-pattern morphological structure in Arabic, convergent evidence for morphological processing has been reported in the reading of Arabic speaking children with and without reading disability (Abu-Rabia & Awwad, 2004; Abu- Rabia et al., 2003). For instance, Taha and Saiegh-Haddad (2012) showed that children with dyslexia performed worse in MA and that MA intervention resulted in gains in reading skills for readers with and without dyslexia. Dallasheh-Khatib et al. (2014) examined the effects of MA and PA training on later reading skills in kindergarten children. Results showed that the MA and PA programs enhanced MA and PA in comparison to the control group, with a small advantage for the former. Morphological intervention improved in morphological tasks and also in a PA tasks. Other Arabic based experimental studies were devoted to the contribution of MA training on word spelling in Arabic cohorts (e.g., Taha & Saiegh-Haddad, 2016).

It appears that due to the central role of morphology on word recognition in both typical readers and children with dyslexia, and with regard to the fact that reading in Arabic is a morphemic (root) based process, there is increased need to explore the direct effects of MA training on the improvement of MA and word reading accuracy in Arabic children with dyslexia, and the potential gain in PA as a concurrent metalinguistic awareness skill of reading development. The aim of this study was to examine the effects of a MA training program on word and pseudo-word reading accuracy in Arabic-speaking children with dyslexia, and its potential effect on PA as well. The main prediction directing this study was: if MA represents a critical substrate for reading in Arabic, then training in MA should lead to measurable direct improvements in both MA and word reading performances. This potential positive effect may also reflect in PA improvement as a meta-linguistic concurrent factor of reading development.

METHOD

Participants

A sample of 217 native Arabic speaking children from separate schools were first screened in their classrooms in the initial phase of the screening process. Participants were screened with the help of the school administrations who facilitated the direct contact between researchers and teachers. Based on teachers' opinion about the main manifestation of children's reading behaviour, 43 children were considered as struggling readers and subsequently were administered word and pseudoword reading tests. The responses provided by the teachers are associated with dyslexic traits which indicate a higher likelihood of dyslexia. In a second step of the screening process, 18 out of 43 children in the initial group were eliminated for not meeting our inclusion criterion of scoring above the cut off score for the sample in word and pseudo-word reading as detailed below. The remaining group of 25 participants did not match the exclusive criteria including hearing, visual or language impairments history. All participants (N= 25) scored lower than (-1.5) *SD* below the mean on the test of word and pseudo word-reading compared to the initial sample.

The participants (18 male and 7 female) were divided into two groups after being diagnosed as having dyslexia on the basis of their word reading deficit. A control group ($n = 12$) with mean age of 111.61 months ($SD = 5.38$) and an experimental group (n=13) with mean age of 112.42 months ($SD = 5.56$). The two groups were matched by chronological age (t = - 0.37, $p > .05$), and did not significantly differ in IQ measured by the Raven test (t= -0.48, $p > .05$). The two groups were also matched on their reading performance in word and pseudoword reading test showing non-significant difference between the two groups (see Table 1). They were all right-handed with normal or corrected-to-normal vision and no history of neurological disorders. Participants provided parental consent and were informed of the objective of the study. Participants came from the same geographical area using Modern Standard Arabic in schools and shared a similar socio-economic and linguistic background. Children first accomplish the preschool class before they become first graders. All schools should comply with the academic program established by the Ministry of Education. All teachers are provided with a textbook, including specific educational guidelines about the use of books by students and the reading and writing teaching method, in order to ensure uniformity in educational system. Moreover, participants did not receive any special instruction at school or special program intervention.

Materials

Nonverbal intellectual ability (Raven Test). The Raven Standard Progressive Matrices is a test of nonverbal

Table 1
Comparison Between Experimental Group and Controls in the Pre-Training Measurements

Measures	Group	Pre-intervention Mean ± SD	t-test value, Sig.
Age	Experiment	112.42 ± 5.38	t= .37, p>.05
	Control	111.61 ± 5.38	
Raven	Experiment	32.23 ± 2.28	t= .48, p>.05
	Control	31.62 ± 3.95	
Frequent word	Experiment	5.75 ± 2.05	t= 1.30, p>.05
	Control	4.46 ± 2.78	
Infrequent word	Experiment	6.92 ± 2.10	t= .87, p>.05
	Control	6.08 ± 2.66	
Pseudo-word	Experiment	3.17 ± 1.52	t= .90, p>.05
	Control	2.62 ± 1.50	
Total read	Experiment	15.83 ± 3.76	t= 1.48, p>.05
	Control	13.15 ± 4.82	
Recognition of morphological patterns	Experiment	9.17 ± 1.94	t= -.07, p>.05
	Control	9.23 ± 2.55	
Morphological root production	Experiment	9.50 ± 2.90	t= - .41, p>.05
	Control	9.92 ± 2.17	
Phonological awareness	Experiment	7.33 ± 1.49	t= .44, p>.05
	Control	6.58 ± 2.41	

reasoning ability and general intelligence. We used the shortened form (Bouma et al., 1996) comprising 36 items (sets A, B, C).

Word and pseudo-word reading test. The word reading test was elaborated for children from ages 8 to 12 years (Layes et al., 2015a; Layes et al., 2015b). A set of 80 partially vowelized words (40 frequent and 40 infrequent words) varied in length (di-syllabic and tri-syllabic) and frequency of usage (high and low) in addition to a list of 20 pseudo-words (CVCV/CVCVC) varying in orthographic length was given. Participants were required to read each item aloud without any time limit. The number of correct responses was scored. The inter-consistency coefficient of this test was ($\alpha = .84$).

Morphological awareness test. This test ($\alpha = .78$) consisted of two tasks (Layes et al., 2017) that they are explained below.

Recognition of Morphological Patterns. To evaluate children's ability to recognize the morphological relationship between words (derivational morphology knowledge), twenty pairs of words were orally presented either related morphologically (example: /3amal/ [work] /3amel/ [worker]), or semantically (example: /mahkama/ [tribunal], /3adala/ [justice]). Participants were instructed to decide whether the two words were morphologically related (i.e., from the same family or not).

Morphological Root Production. This timed task elaborated to examine the participants' ability to generate morphologically related words. It is related to the frequency with which a particular root morpheme is involved in processing word formation (Boudelaa & Marslen-Wilson, 2011). Twenty vowelized verbs were presented to the examinee who was instructed to generate as quickly as possible four derived forms in three minutes. The expected responses follow various patterns commonly used in Arabic (e.g., /ka:teb/ [writer]; passive adjective /maktu:b/ [written], etc.).

Phonological awareness test. A syllable manipulation task was used as described by Layes, Lalonde and Rebaï (2019). The purpose of the phonological manipulation task was to measure the child's ability to blend syllables together to form a word when syllables were extracted from orally presented words. Twenty series of three words were each presented orally one by one, and participants were instructed to isolate the initial syllable from each word and pronounce the new combination, producing a new word. The examiner paused for one second between words. The child was to respond with the target word without pausing or altering the pronunciation or order of presentation of the syllables. Each child was given three practice items prior to administrating the test items. The child's score was based on the total number of correct responses on the test items only when giving the correct

target word. The test–retest reliability of this test was adequate ($r = .71$).

The MA Training Program

The main objective of the current training program was to strengthen the participants' awareness for the basic root morphemes in words. The training took place in the school and was implemented for the whole experimental group. An assistant trainer (the second author) attended each training session provided by the first author to ensure training quality, including time control, content delivery, and material presentations. Because MA requires both oral and written presentations, each participant was provided with a prepared material before executing the tasks of each training session (e.g. letter cards, pencils). We tested the children on all of the tasks listed below administered in random order. The training program content focuses on three axes:

(a) Analysis of root morphemes. Words in Arabic are derived from roots and patterns. In each intervention session, children were instructed to analyse the order of the presented letters, varying from three to four, and arrange them in order to identify the root morpheme of the word. This is a basic activity that was practiced at the beginning of each new session throughout the program. The instructor wrote on the whiteboard a in an unordered form, then child was instructed to arrange these letters in a correct order. For example, the instructor writes the root letters on the whiteboard in an unordered form, then the child has to arrange them in a correct order to give the targeted root.

Another recurring activity, "identification of the root in the word", consists of dismantling the complex word and separating the main morpheme in it (the root). For each word, the participant was trained to complete the decomposition activity orally and in writing. The participants also practiced spelling those words and writing down the letters of the root and the pattern for each word. This activity aimed to strengthen the morpho-orthographic representations of the words. Five new words were given for each session. Children were presented with a given word (/yarkab/ [he rides]) and were requested to give the minimal form of the word (/rakiba/) by taking away the additional element (/ya/).

(b) Derivational morphology (roots and patterns). The main objective was the strengthening of the linguistic derivational skills of word composition using specific roots and patterns. During this training content, the participants learned how to create (derive) new words from the same root by manipulating the pattern of the word. For example, from the root KTB, children could derive multiple words by applying different phonological patterns, such as [KuTiBa] (written) KaaTeB (writer) [KuTuB] (books). Hence, derivational modifications can transform an adjective to a noun, a verb to a noun, or a verb to an adjective.

(c) Inflectional morphology. During this part of the training program, the participants were trained how to transform (inflect) words according to the number, subject, gender and verb tense. Whereas derivational morphology changes the semantic roles played by words within sentences, inflectional morphemes modify number (singular-plural), tense, or aspect of the words (Wolter & Green, 2013). By converting the word to the singular ([ya3amel] "he works"), we asked the child to add adequate new letter(s) to the word to convert it to the plural ([ya3maloun] "they work"). In each session, children were trained to conjugate new verbs with the different pronouns and in various tenses.

Design and Procedure

Following a pre/post-test experimental design, we randomly assigned participants to the group that received the MA training program (experimental group) or to the comparison group that did not receive the training (control group) after collecting baseline assessment data.

All participants were tested individually on a word and pseudo-word reading test. This testing took place after consent was received from the participants' parents who were informed about the general aim of the study, and before participants were trained (or not). To evaluate the effectiveness of the program, a post-training measurement was applied for both groups within the same periods.

The MA program involved face-to-face interactive training carried out in a quiet room inside a school building but outside of regular classroom hours. The experimental group received a 45-minute training session twice a week for three months. The duration and frequency of training sessions was relevant to the age group (Griffiths & Morag, 2013). The intervention process began immediately after screening and pre-test. Both the control group and the experimental group received regular instruction in the classroom for the duration of the study. This school based ordinary instruction was provided for the same amount of time as the training in the experimental group.

The program was implemented collectively, and the activities to be mastered were executed successfully many times. The participants received a detailed description of each task session and then provided responses individually following the specific instruction of the task provided by the experimenter. We moved throughout the continuum of MA skills as indicated in the program content above.

RESULTS

Baseline Assessment

Due to the small sample size, the assumption of the normality of the distribution of the dependent variable (in the experimental group) for the pre-intervention measure of reading was checked with the Shapiro–Wilk test (W

(13) = .90), indicating a normal distribution ($p > .05$) with a skewness of - 0.67 (standard error (SE) = 0.71) and a kurtosis of –1.02 (SE = 1.40). As kurtosis is near 0, a normal distribution is assumed and parametric tests were applied. With regard to inclusion criteria, comparisons at baseline assessment between experimental and control groups are presented in Table 1, including age levels and Raven scores as well as word and pseudo-word reading, MA and PA measures.

Intervention Effects

To examine whether the MA intervention improves word and pseudo-word reading in the experimental group and whether this improvement affected MA and PA, a one-way multivariate analysis of covariance (MANCOVA) controlling for pre-training measures was conducted to assess the main effect of the group variable (experimental/control) on multiple continuous dependent variables simultaneously (word and pseudo-word decoding, MA and PA) in the post-training measurement and the follow-up measurement separately. Statistics provided from Box's M-test of equality of covariance indicated that homogeneity of covariance was met (F (15) =.85, $p > .05$). The omnibus effect for 'group' was significant (Pillai's trace = .82, F (5.18) = 16.75, $p < .001$), partial η^2 = .82. Follow-up univariate analyses (ANOVAs) show significant differences on the group factor for real words (F (1.22) = 48.80, $p <$ .001, partial η^2 = .69), pseudo-words (F(1.22) = 14.00, p = .001, partial η^2 = .39), morphology pattern (F(1,22) = 9.64, p = .001, partial η^2 = .31), morphology root (F(1.22) = 22.58, $p < .001$, partial η^2 = .51), and PA (F(1.22) = 10.84, p =.003, partial η^2 =.33).

To examine further the potential impact of the intervention programme, paired t-tests were performed comparing pre- and post-intervention measures for the experimental group (Figure 1). Results show significant differences in the post-intervention scores for real word reading in pre- (M = 12.67, SD = 2.64) and post-intervention (M = 20.17, SD = 4.08, t (11) = -7.77, $p <$ .001), for pseudo-word decoding in pre- (M = 3.17, SD = 1.52) and post-intervention (M = 6.08, SD = 2.42, t (11) = -5.67, $p < .001$), for morphology pattern in pre- (M = 9.16, SD = 1.94) and post-intervention (M = 12.42, SD = 1.93, t (11) = 7.58, $p < .001$), for morphology root in pre- (M = 9.50, SD = 2.90) and post-intervention (M = 14.92, SD = 2.35, t (11) = -8.72, $p < .001$), and for PA in pre- (M = 7.33, SD = 1.49) and for post-intervention (M = 9.17, SD = 1.90, t (11) = - 4.33, $p < .01$).

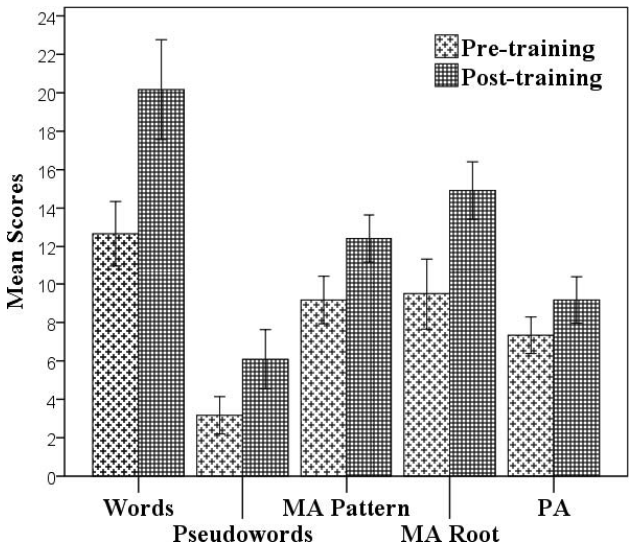

Figure 1: *Pre- and Post-Training Measures for the Experimental Group*

DISCUSSION

The aim of the current study was to investigate the effects of a MA training program on word and pseudo-word reading accuracy in Arabic-speaking children with dyslexia, and potentially on PA as a second metalinguistic skill besides MA. The study revealed positive effects of the training program, replicating previous findings in children with reading disabilities in other alphabetic orthographies (Arnbak & Elbro, 2000; Lyster, 2002). Moreover, the results of post-tests obtained in the current study showed that the MA training program enhanced both metalinguistic abilities, MA, and PA, to a greater extent in the experimental group. Similar to previous studies, our finding may constitute an empirical source of evidence regarding the connection between MA and reading acquisition (Carlisle, 2003; Carlisle & Stone, 2005; Deacon & Kirby, 2004) and the resulting benefits of instruction of MA on reading (e.g., Lyster et al., 2016; Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2010, 2013).

Our findings showing significant improvement of both word and pseudo-word reading indicate that the morpheme-based training contributed to the integration of morphological decomposition in word recognition. These results suggest that the morpheme-based training is effective in enhancing word reading skills and for orthographic representations acquisition (Bar-Kochva & Hasselhorn, 2017), consistent with those of Deacon and Kirby (2004) who conducted a 4-year longitudinal study (Grades 2–5) on the effect of MA on single word reading, pseudo-word reading, and reading comprehension. These authors found that MA contributed significantly to pseudo-word reading alongside reading comprehension after controlling prior measures of reading ability, verbal and nonverbal intelligence, and PA. This contribution of MA was comparable to that of PA and remained three years after MA was assessed. These results provide evidence that MA has a wide-ranging role in reading development. MA made a significant contribution to reading development, concluding that it is not mere phonology (Deacon & Kirby, 2004).

Most surface words in most languages are morphologically complex like English, being made up of two or more

underlying morphemes, typically a stem and inflectional or derivational morphemes, as in darkness: dark + ness (Boudelaa & Marslen-Wilson, 2011). However, in Semitic languages such as Arabic and Hebrew, a word is made up of at least two abstract underlying morphemes, the word pattern and the root. Morphemes in Arabic may play composite roles regarding word recognition. First, word meaning processing, insured by the root; second, a grammatical function provided by pattern, as in the case of the differentiation between verbs and nouns as in [SLM]: SaLLaMa (to greet) / SeLM (peace). Thus, the general meaning of the word, inherent in the root [SLM] in this example, can be generated to new words. As such, the morpheme root conveys a semantic role and the pattern conveys a grammatical role (e.g. masculine, singular, etc.). Therefore, morpheme decomposition in Arabic is a capital function in the process of word recognition and the access to lexical representation.

Our result showing improvement of PA following MA training supports the idea that MA may be an important instructional focus when facilitating improvements in PA for school-age children with literacy deficits (Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2010). The finding of significant gains in both morphological and phonological tasks following morphological training is in line with the previous findings (Dallasheh-Khatib et al., 2014), indicating that the development of PA and MA may be reciprocal. As children who struggle to learn reading skills often experience difficulties with PA, instruction in MA may improve PA because morphologically based instruction incorporates the awareness of phonemes or sounds by linking this information to meaning (Wolter & Green, 2013). The ability to manipulate the sound structure of words might have facilitated the development of MA, and the manipulation of the morphological structure of words might have facilitated PA (Lyster, 2002). Casalis et al. (2004) suggested MA may potentially mediate or help in the processing of phonological skills for individuals with dyslexia. Thus, for elementary school children with literacy deficits, MA instruction may provide an ideal medium to target PA (Wolter & Green, 2013).

The MA root production test improved better than recognition of morphological patterns in the post-training period in this study. These differences may reflect both the greater informative weight conveyed by roots, which establish the basic semantic framework for word interpretation, and the greater processing complexity associated with the identification and extraction of word patterns (Boudelaa & Marslen-Wilson, 2011). As a consequence of the primarily consonantal nature of script in Arabic, the root is always fully specified in the orthographic form (consonants), while word patterns are at most only partially specified (patterns containing long vowels).

This experimental effect between the two metalinguistic skills, PA and MA, seems to be bidirectional. In a previous study, Layes et al. (2015) found significant gains in MA in the group of children with dyslexia receiving a PA training program, in line with correlational studies (Lyster, 2002) indicating that such participants developed morphological knowledge to a significantly higher level than typical readers. This finding demonstrates that the ability to manipulate the sound structure of words facilitated the development of MA and highlights a reciprocal relationship between MA and PA, though scores of each contribute to an independent part of variance in learning to read. The findings of the present study provide additional evidence for a relationship between PA and MA abilities in learning to read, although no causal connection has yet been established (Mahony et al., 2000). This may be ascribed to the development of morphology sensitivity underscored in Semitic languages that may hasten the decoding process and assist in the reading of complex words (Arnbak & Elbro, 2000).

The results from the present study, along with previous intervention-based studies, on the effects of morphological awareness on children's reading highlight the educational relevance of this type of intervention in enhancing MA skills of students with reading disorders in primary school settings. The current results also point out that morphological training should be integrated in a more comprehensive program addressing additional reading-related skills, as morphemes in Arabic facilitate lexical access for both typical readers and children with dyslexia (Layes, Khenfour, Lalonde, Rebai, 2019). Furthermore, based on the notion of potential metalinguistic knowledge transfer, demonstrated in previous phonological awareness-based studies on Arabic children populations (Layes et al., 2018), morphological training may not only help children to promote awareness of Arabic morphology, but also enhance their awareness of word structures in other languages being learned. Although there is ongoing debate regarding the age at which the morphological training effects become evident, morphological knowledge also has clear impacts on spelling in the primary school years (Castles et al., 2018). In an important longitudinal study, Nunes et al. (1997) showed that children demonstrate morphological knowledge in their spellings, but that the quality of this knowledge changes substantially between the ages of 6 and 10. Therefore, the age of the participants in our study might have attributed to the reported findings.

In conclusion, the MA training program contributed significantly in word and pseudo-word reading accuracy, through the development of the analysis of multi-morphemic words and MA and reading ability in children with dyslexia. Our findings suggest that MA has important roles in word reading and that it should be included more frequently in assessments and instruction (Kirby et al., 2012). The present data add further evidence to the view

that word recognition in Arabic Semitic language is mainly defined by root morphemes, and demonstrate that morphological effects in Arabic lexical access can be conclusively related to meaning (Layes, Khenfour, Lalonde, Rebai, 2019). This suggests the usefulness of pedagogical techniques based on morphological instruction in children with dyslexia.

Several limitations of this study should be considered when interpreting the results. The primary limitations are the relatively small number of children in the experimental group and the control group. Also, we attempted to assess the effects of the training program on reading and PA as metalinguistic awareness-based skill. However, because of strong ceiling effects for the morphological awareness measures at this time point, we did not include these measures in our model. Therefore, it could be more informative for the purpose of the research to examine such potential positive effects on reading comprehension, as morphological decomposing represents a key process in reading comprehension. Also, in the implementation of the training programme we did not include teachers who could have an influential factor on the students' performances in learning.

Due to the importance of morphological knowledge in reading Arabic as shown in the current study, our findings suggest that MA training could be effective for both children with dyslexia and those at risk with reading difficulties. Despite some limitations, this study clearly suggests that MA training could be a valuable component of preschool programmes and early stages of reading instruction in the school. The general procedure consists of providing preschoolers knowledge of the morphemic structure of words and helping them to integrate meaning with the spoken and written forms of words using images and concrete objects. This procedure may in turn provide learners with new comprehensive vocabulary. For older children in the first grades of schooling, this procedure should include direct instruction of morphology and processing rules, with special focus on the derivational morphology and word generation. More specifically, morphological instruction in Arabic language should focus on the enhancement of both the ability to identify and analyse root morphemes by the decomposition of complex words, and the generation of new words based on the identified morpheme roots. To be more effective, it is recommended to integrate such morphological instruction with the regular academic program in a sustained manner.

The present study has also social impact. First, this study may provide effective remediation method to promote children's reading skills in a relatively short period of time. Second, the present study provides method to facilitate teacher- child interaction which includes specific instruction in Arabic MA activities in school settings. Teacher involvement represents an additional benefit for children's reading skill acquisition. This also may make gains in terms of cost- and time-intervention methods and practices. Such training might also be used for children learning Arabic as a second language.

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