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On the role of morphology in early spelling in Hebrew and Arabic

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Abstract

It is well known that learning to spell is a complex and challenging process, especially for young learners, in part because it relies on multiple aspects of linguistic knowledge, such as phonology and morphology. The present longitudinal study investigated the role of morphology in early spelling in two Semitic languages, Hebrew and Arabic, that are structurally similar but differ in the phonological consistency of phoneme to letter mappings ("backward consistency"). Whereas Arabic mappings are mostly one-to-one – allowing children to rely mainly on phonology to spell words correctly, Hebrew has numerous one-to-many phoneme-to-letter mappings that are governed by morphological considerations, thereby precluding a purely phonological spelling strategy. We, therefore, predicted that morphology would make a more substantial contribution to early Hebrew spelling than to Arabic spelling. We tested this prediction in a longitudinal study of two large parallel samples (Arabic, N = 960; Hebrew, N = 680). We assessed general non-verbal ability, morphological awareness (MA), and phonological awareness (PA) in late Kindergarten and spelling in the middle of the first grade with a spelling-to-dictation task. Hierarchical regression analyses revealed that after controlling for age, general intelligence, and phonological awareness, morphological awareness contributed a significant additional 6% variance to Hebrew spelling but only 1% to Arabic word spelling. The results are discussed within the framework of the Functional Opacity Hypothesis (Share, 2008), which we extend to spelling.

Keywords Morphological awareness · Phonological awareness · Orthography · Early spelling · Hebrew · Arabic

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1 Introduction

Learning to spell is a complex and challenging process, especially for young learners, in part because it relies on multiple aspects of linguistic knowledge, primarily phonological and morphological knowledge (Ravid, 2012; Treiman 1993, 2018). Studies that have focused on the acquisition of spelling in alphabetic orthographies have consistently indicated that phonological awareness, the ability to analyze the sounds of spoken language (Liberman & Shankweiler, 1985; Mattingly, 1972), is a powerful determinant of spelling achievement, especially at the onset of literacy acquisition. Young spellers need to analyze the phonemes that makeup words before matching the graphemes corresponding to these phonemes (e.g., Blomert & Willems, 2010; Caravolas et al., 2001; Ehri, 1998; Treiman, 1993). Alongside phonological awareness, morphological awareness, the ability to reflect on and manipulate the constituent morphemes (the smallest units of meaning) in spoken words (Carlisle 1995, 2004; Kuo & Anderson, 2006) has also been considered essential for proficient spelling (e.g., Apel et al. 2012, 2004). Furthermore, morphological awareness predicts variance in spelling accuracy over and above the contribution of phonological awareness (e.g., Apel et al., 2012; Deacon et al., 2009). Several studies attest to the importance of morphological awareness from the very earliest stages of learning to spell across a range of languages and orthographies (e.g., Dutch: Rispens et al., 2008; French: Casalis et al., 2011; English: Treiman & Kessler, 2005; Deacon et al., 2009; Greek: Grigorakis & Manolitsis, 2016; Hebrew: Levin et al., 1999; Arabic: Taha & Saiegh-Haddad, 2016). However, not all theorists agree that morphology is integral to *early* literacy acquisition (see, e.g., Rastle, 2018), at least not in English. Moreover, several recent studies suggest that spelling acquisition may differ across writing systems (e.g., Casalis, 2018; Devonshire et al., 2013).

The present study examined the contribution of morphology to early spelling in the two major Semitic languages, Hebrew and Arabic. Both are root-and-pattern languages written in an abjadic (primarily consonantal) writing system.

2 The role of morphological awareness in spelling: a cross-linguistic view

Early models of spelling acquisition have proposed that the process of learning to spell can be characterized as a sequence of developmental stages (Ehri, 1989; Frith, 1985; Henderson, 1985; Marsh et al., 1980; Nunes et al., 1997a,b). According to these models, in the initial stages of spelling development, spellers rely mainly on their phonological knowledge to spell words. However, during the later stages of development, they refine their knowledge of phonological, orthographic, and morphological characteristics of words and use these processes when spelling (Ehri, 1989; Frith, 1985; Nunes et al., 1997a,b). However, other theoretical approaches to spelling development have argued that the notion of developmental stages does not fully capture the development of children's spelling ability because children use diverse linguistics strategies and multiple sources of knowledge in their spelling performance from a very early age (Apel et al., 2004; Rittle-Johnson & Siegler, 1999; Treiman, 2017;

Treiman & Bourassa, 2000; Treiman & Kessler, 2005; Treiman et al., 1994; Varnhagen et al., 1997). Among these linguistic strategies is the use of word morphemes which is considered a crucial strategy even in the early spelling attempts of children (e.g., Levin et al., 1999; Treiman et al., 1994).

Several recent studies have proposed that the acquisition of spelling may differ across writing systems (e.g., Casalis, 2018; Devonshire et al., 2013). For instance, some researchers argue that spelling acquisition is more complex in deeper orthographies such as English, French and Danish, compared with more consistent (or "transparent") orthographies such as Italian, Spanish, and German (e.g., Alegría & Carrillo, 2014; Marinelli et al., 2015). Furthermore, studies from various languages suggest that many well-established writing systems highlight morphological structure over and above encoding the phonology of a language (e.g., Aronoff et al., 2016; Berg 2013, 2016; Berg & Aronoff, 2017), whereas newly adopted or invented writing systems tend to emphasize phonology and are highly transparent (Probert, 2019; Sampson, 2018; Trudell & Schroeder, 2007). This difference in spelling acquisition across writing systems and the claim that many writing systems reflect morphological structure beyond phonology raise an essential question regarding the contribution of morphological awareness to spelling and the extent of its impact as a function of orthographic transparency.

Only a handful of cross-linguistic studies have investigated the association of morphological awareness with spelling in languages varying in orthographic consistency (Boulware-Gooden et al., 2015; Desrochers et al., 2018). Desrochers et al. (2018) examined the role of morphological awareness (at the beginning of Grade 2) in spelling (at the end of Grade 2) among English, French, and Greek-speaking children. Findings showed that morphological awareness predicted spelling equally well in the three languages. However, these results were based only on a short period during Grade 2. Manolitsis et al. (2019) examined the direction of the relation between morphological awareness and spelling in English-speaking Canadian and Greek children assessed four times between Grade 1 and 3. The findings revealed that in English morphological awareness predicted spelling between the end of Grade 2 and the beginning of Grade 3, whereas, in Greek, it had a significant effect on spelling already between Grade 1 and Grade 2. The authors concluded that Greek children use morphological awareness to overcome spelling inconsistencies earlier than in English. In an investigation of morphological awareness in spelling among English- and Russian-speaking children in grades 4 and 6, Boulware-Gooden et al. (2015) reported that morphological awareness was associated with spelling in both languages.

Alongside cross-linguistic studies, evidence from single languages with inconsistent orthographies, such as English and French, have confirmed the predictive value of morphological awareness in spelling in primary school children (see, e.g., Casalis et al., 2011; Fejzo, 2016 in French; Deacon & Bryant, 2006; Deacon et al., 2009 in English). For instance, in a study of English-speaking Canadian children, Deacon et al. (2009) investigated the contribution of morphological awareness in Grade 2 to general spelling skills in Grade 4. Their findings revealed that Grade 2 morphological awareness accounted for approximately 8% of the variance in Grade 4 spelling. Casalis et al. (2011) also found that morphological awareness contributed a significant and independent portion of spelling variance beyond phonological awareness

across Grades 3 and 4 French-speaking children. Additional studies focused on the contribution of specific morpheme segments' awareness to spelling (French: Fejzo, 2016; Mussar et al., 2020; English: Nunes et al., 1997a,b).

In contrast, several studies in orthographies with high phoneme to grapheme consistency showed limited effects of morphological awareness on spelling after controlling for phonological awareness (e.g., in Finnish: Lehtonen & Bryant, 2005; in Dutch: Rispens et al., 2008; in Korean: Kim, 2010). These studies demonstrated that when the words are easily spelled, young spellers can rely mainly on phonological strategies.

One concern about conclusions from many of these cross-sectional studies (e.g., Boulware-Gooden et al., 2015; Casalis et al., 2011; Deacon et al., 2009; Desrochers et al., 2018; Manolitsis et al., 2019) is that morphological awareness has been assessed *after* children commenced formal reading and spelling instruction putting the observed effects of morphological awareness on spelling in doubt (Diamanti et al., 2017; Grigorakis & Manolitsis, 2016; Grigorakis & Manolitsis, 2021; Levin et al. 1999, 2001). Since it precludes "purely and clean" evidence of morphological awareness effects due to the reciprocal influences between morphology and literacy. In the present study, we examined morphological awareness *before* the onset of formal reading and spelling instruction to provide clearer evidence for the direction of influence in the morphological awareness-spelling association. The present study also stepped outside the family of European alphabetically written languages and focused on two structurally similar Semitic languages with different degrees of orthographic consistency: Hebrew and Arabic. In two parallel longitudinal cohorts, we examined the prediction of early spelling (mid-Grade 1) from morphological awareness measured before children received formal reading and spelling instruction.

3 A brief sketch of the Hebrew and Arabic morphology-orthography interface

Hebrew and Arabic are genetically similar (Semitic) languages, yet each language has its own unique features (Berman & Ravid, 2000). Israeli Hebrew and Modern Standard Arabic are written from right to left in an abjad or consonantal writing system (Daniels 1992, 2018). Each language consists of two sets of graphic signs: horizontally arrayed (consonantal) letters and vertically arrayed extra-linear diacritic-like signs. Hebrew orthography has twenty-two letters. Eighteen letters denote consonants alone, five of these consonantal letters have two different allographic forms, a word-final and a non-final form. Another four letters are matres lectionis 'mothers of reading' AHWY, which perform double duty denoting consonants, and, in certain positions, also vowels (Ravid, 2006). A child must learn a set of regularities defining when to write the vowel letter and when not. This learning relies on graphotactic and morphological learning (Bar-On & Kuperman, 2019; Ravid & Haimowitz, 2006). For example, the Y letter systematically occurs in the word when it functions as a vocalic root letter or as a function letter, but when *i* is part of the vocalic pattern, the rule is accompanied by many exceptions and may be accessible for professional linguists but is not a viable option for others (Bar-On & Kuperman, 2019). The Hebrew

diacritic-like signs, termed *nikud* 'pointing', are 13 extra-linear points and dashes that mainly represent the five vowels *a*, *e*, *i*, *o*, *u* each vowel phoneme has 2-4 vowel signs. However, this potential opacity may not be problematic since vowel signs are often similar. In addition, the nikud can be used to denote also stop/spirant alternations and the distinction between *š* and *s* in the letter ש. Unlike the letters of most alphabets that are arrayed along a single horizontal axis, these marks are placed primarily below but also above, between, or within the letters (Share & Bar-On, 2018). Arabic orthography consists of twenty-nine letters. Twenty-eight of the 29 letters denote consonants. Three of the Arabic letters A *ʔalif*, Y *ya:ʔ*, and W *wa:w*, function as matres lectionis. The Y and W represent both consonants and vowels, while the A represents only a vowel. As vowels, they represent the three long vowels: *i:, u:, a:* (Saiegh-Haddad, 2013).

Two conspicuous features of Arabic script are ligaturing and allography. The ligaturing, where the majority of the letters in a word connect to the adjacent letters creating a word that, in most cases, forms a single unbroken graphic unit (Saiegh-Haddad & Henkin-Roitfarb, 2014). All letters connect backward, but only six (called 'kicking letters') do not connect forward (see Saiegh-Haddad and Henkin-Roitfarb (2014)). Whereas the allographic variability depends on the position of the letter in the word-initial, medial, final, and whether or not it connects to the letter that precedes it (Yassin et al., 2020). Together, letter position and ligaturing create the allographic variants: 23 letters are considered to have four letter-forms, and six letters have two forms.

Like Hebrew, extra-lineal diacritic-like signs, named *tashkeel*, appear primarily above but at times below the letters and are used extensively in Arabic. This abundance of *tashkeel* stems from the fact that in Arabic, there are two classes of *tashkeel*: phonemic and morpho-syntactic *tashkeel*. The phonemic *tashkeel* consists of five major signs, three of which consistently map the three short vowels *a*, *i*, *u*. In contrast, the morpho-syntactic *tashkeel* consists of the three short vowels that can also appear word-finally along with other three extra-lineal signs, called nunation *tanwi:n* (see, for details, Saiegh-Haddad & Henkin-Roitfarb, 2014). Although the Hebrew script (with one rare exception) does not mark case on nouns and mood on verbs, its *nikud* does reveal a morpho-syntactic layer beyond its superficial phonology. The existence of specific *nikud* in the Hebrew word is governed by the Classical Tiberian system, which reflects Hebrew morpho-phonological behavior (see, for details, Ravid, 2005). Notably, the *tashkeel* is not expected to be encoded in spelling and is not considered a spelling error among beginning readers/spellers.

Modern Israeli Hebrew and Modern Standard Arabic share another important feature. Both employ two versions of the same orthography differing in the amount of phonological information they supply: The phonologically transparent version called *pointed script* in Hebrew and *mashkoul script* in Arabic are mainly used in printed materials in the initial years of learning to read and spell, as well as in poetic texts and the Holy Scriptures (Bar-On & Kuperman, 2019; Ravid, 2006; Saiegh-Haddad, 2017). The second version of the orthography, the default for Hebrew and Arabic speakers, is the *unpointed version* in Hebrew and *non-mashkoul* script in Arabic, which relies on letters alone with no diacritic-like signs. As the present study focuses on early spelling acquisition, we confine our review of the morphological structure

and its representation to the transparent version of the Hebrew and Arabic writing systems.

Since Hebrew and Arabic are both Semitic languages, there is a remarkable similarity between them in the word's morphological structure. Most written Hebrew and Arabic content words reflect the interwoven *bi-morphemic* nature of the spoken word (Ravid, 2012), which combines two independent and unpronounceable bound morphemes: a root and a word pattern. The root is a typically tri-consonantal skeleton that encapsulates the word's core meaning or semantic neighborhood. The other morpheme is the word pattern, a fixed prosodic template that specifies the word's categorical meaning and some of the phonological characteristics of the surface form (vocalic, syllabic, and prosodic form) (Bar-On & Ravid, 2011; Saiegh-Haddad & Henkin-Roitfarb, 2014). The root-and-pattern structure of Arabic is a salient feature of the orthographic structure of written Arabic (Saiegh-Haddad & Taha, 2017). However, Semitic orthography deals with them on an unequal footing. It highlights the root consonants by transforming the phonologically discontinuous spoken root into an orthographically continuous core unit (separated only by a subset of vowel letters), which is easily unitized as an integral orthographic representation (Share, 2017). In contrast, word patterns have less prominent orthographic representation and are orthographically discontinuous. Nevertheless, it preserves morphemic constancy, with consistent spelling at consistent slots (Bar-On & Kuperman, 2019). The vowel letters appear at well-defined slots within the word pattern and between the root letters. The consonantal segments of the word pattern are represented by a consistent subset of letters which are used as affixes at the edges of the word (Ryding, 2005). Unlike the word pattern's long vowels and consonants which are represented as letters, the short vowels of the word pattern are marked by extra-lineal diacritic-like signs, appearing above or below the letters in the transparent script. However, these diacritic-like signs (*nikud* and *tashkeel*) are omitted in the standard default version of the Semitic script (Bar-On & Kuperman, 2019; Saiegh-Haddad & Henkin-Roitfarb, 2014).

With regard to learning to spell in the first years of schooling, even though both languages have a phonologically transparent version (*pointed script* in Hebrew and *mashkoul script* in Arabic), they differ considerably in the degree of their "feedback" consistency from phoneme to the letter. Arabic is characterized by a high degree of consistency in which phoneme-to-letter correspondences are mostly one-to-one. Nevertheless, it features a few occurrences of feedback inconsistency (Saiegh-Haddad & Henkin-Roitfarb, 2014). The main source of this inconsistency is the phonological assimilation process called emphasis spread or velarization spread (Holes, 2004). In this process, non-velarized consonants become velarized through proximity to a velarized phoneme (Saiegh-Haddad & Henkin-Roitfarb, 2014). As such, the phonetic realization of these secondarily velarized consonants might coincide with the phonemic representation of other letters in Arabic orthography. This process causes some letters to become homographic, a matter that leads to difficulty in the spelling process (for additional instances of inconsistency, see Saiegh-Haddad & Henkin-Roitfarb, 2014).

Hebrew, by contrast, has thirteen homophonic letters (i.e., a single phoneme can be spelled by more than one letter); six of the 18 consonantal phonemes in modern Israeli Hebrew have two (and in one case three) alternate (letter) spellings. For instance: the letters ת and ט represent the phoneme *t*, and the letters ח and כ represent

the phoneme *x*.[1] Hence, the correct letter choice, unlike Arabic, cannot be determined based on phonology alone and is governed by a variety of morphological factors (such as roots, verbal and nominal patterns, inflectional morphemes, clitics, and more, see Ravid, 2012). For example, the morphological family based on the root k-t-b yields words like MKTB *mixtav* 'letter', KWTB *kotev* 'he writes', HKTBH *haxtava* 'dictation', and KTYBH *ktiva* 'writing'. The spelling of this root in different inflections and derivations is consistent, yet its sound can vary in different words owing to stop/spirant alternations (*k*/*x*). Thus, a child who knows how to spell the word K*W*TB *kotev* 'he writes' correctly, which contains two homophonic letters, and understands the morphological relations between (he) writes and dictation, should be able to spell the word HKTBH *haxtava* 'dictation' even if he has never seen that word before. Hence, using root awareness can help spell different words related to a shared root. Some homophonic letters are also morphemic "function" letters that serve as non-root derivational and inflectional morphemes in patterns and linear affixation (Ravid, 2001). Hence, it is critical to know the morphological role of a homophonic function letter to spell the word correctly. For example, of the two letters ת and ט that represent the phoneme *t*, only the letter ת can denote an affix. Similarly, the inflectional suffix, which marks the second-person singular masculine form, is always written with ת *t* instead of ט *t*. (Ravid, 2001).

4 Learning to spell in Hebrew and Arabic

Studies of spelling acquisition in Hebrew and Arabic have understandably focused on the role of phonology. Several investigations have shown that phonological awareness plays a crucial role in the early stages of Hebrew and Arabic spelling (Abu-Rabia & Taha, 2006; Batnini & Uno, 2015; Saiegh-Haddad & Taha, 2017). However, as already noted above, spelling in these languages primarily reflects their morphology rather than their phonology (Frost, 2012; Ravid, 2012; Saiegh-Haddad, 2013; Saiegh-Haddad & Taha, 2017). Hence, alongside phonology, several studies in Hebrew and Arabic have emphasized the importance of morphology in the early stages of spelling (e.g., Ravid, 2001; Saiegh-Haddad & Taha, 2017; Taha & Saiegh-Haddad, 2016).

Research in Hebrew has examined the role of morphological knowledge mainly through comparisons between words with different morphological structures or with specific morpheme units. Ravid (2001) showed that grammatical words are spelled correctly earlier than content words, and the spelling of function letters is mastered before the spelling of root letters. Another study found that root priming improved root spelling among children in Grades 3-6 and 10, indicating that Hebrew-speaking children can extract, store and use morphological information in written words and use it for spelling (Bar-On & Ravid, 2005). Moreover, Schiff et al. (2020) investigated the knowledge of how morphological roles are realized in orthography. They examined the factors underlying native Hebrew speakers' ability to learn homophonous affix spellings in grades 2, 4, 7, and 10. Younger spellers were assisted mainly by morpho-orthographic sites, morphological category frequency, and phonological

[1] Refer to mainstream (Ashkenazi) Hebrew variety.

transparency, whereas spelling in the higher grades was more affected by morpho-orthographic prevalence. Additionally, two longitudinal studies examined the role of morphological awareness prior to the onset of reading and spelling instruction. One found a reciprocal relation between morphological awareness and spelling from kindergarten to Grade 1 (Levin et al., 1999). The other showed that kindergartners who outperformed their peers in morphology progressed more in writing vowels (Levin et al., 2001).

Turning to Arabic, research has shown that young Arabic spellers (2nd, 4th, and 6th grades) spell real words and pseudowords more accurately when they are constructed in accordance with a transparent morphological structure than when they are opaque (Taha & Saiegh-Haddad, 2017). This study also showed that morphological processing is functional very early on in Arabic spelling and that the degree to which children utilized morphological structure in spelling can vary with a morphological affiliation such as root, word pattern, and affix (Saiegh-Haddad, 2013). This finding has been examined at different grades (1st–5th grade) through the letter T, the most frequent letter in Arabic, which participates in the encoding of three morphological structures: root, word pattern, and affix.

This study revealed that the degree to which children utilized morphological structure in spelling was found to vary with morphological affiliation, with spelling the T letter more accurately when it was affiliated with the root of the word implying more salience of the root and an affix (more so a suffix) reflecting the role of frequency of affixes and probably also the salience of word-ends. As for the link between morphological awareness and spelling, it has been found that morphological awareness predicts concurrent unique variance in spelling of words and pseudowords, beyond phonological awareness and general cognitive skills among normal and reading-disabled children (Saiegh-Haddad & Taha, 2017). Finally, it has also been shown that intervention in morphological awareness significantly impacts spelling in Arabic, among normal and reading-disabled children, especially in the initial grades (Taha & Saiegh-Haddad, 2016).

The present study aimed to examine the longitudinal prediction of early spelling (mid-first grade) from preschool morphological awareness across two languages: Hebrew and Arabic. Although both are morphologically rich and structurally similar languages, they differ substantially in their feedback (phoneme to grapheme) consistency. Arabic is characterized by a high degree of consistency in which phoneme-to-letter correspondences are mostly one-to-one. Nevertheless, it features a few instances of feedback inconsistency (Saiegh-Haddad & Henkin-Roitfarb, 2014). However, in light of the fact that the present study focuses on mid-first grade, the issues of inconsistency are less salient. Thus, phonology alone (i.e., knowledge of phoneme-to-letter correspondences) is the overriding factor enabling children to spell any word correctly. Hebrew, by contrast, poses a serious major challenge in spelling owing to the abundance of homophonic letters whose spelling is governed primarily by morphological considerations. Hence, we predicted that morphology would make a stronger contribution to early Hebrew spelling than to Arabic spelling, therefore, we hypothesized that morphological awareness would contribute significant unique variance to early Hebrew spelling (over and above the contribution of PA) but little or no variance to early Arabic spelling. This prediction is based on the Functional Opacity

Hypothesis (Share, 2008), which argues that the role of phonology (PA) in decoding is greatest when letter-sound relationships are inconsistent or when children have yet to master these relationships in a regular transparent orthography, at which point the orthography is *functionally opaque* for beginning readers. The Functional Opacity Hypothesis was originally developed to account for differences between orthographies in the PA-*reading* relationship, specifically the fact that PA-reading correlation in English- a highly opaque orthography typically stronger than in transparent orthographies. The present study aimed to extend this hypothesis to spelling and other non-phonological influences on early reading and writing, such as morphology.

5 Method

5.1 Design

Our study adopted a quasi-pre/post longitudinal design in which we examined the influence of morphology *before* children learn to read and spell (Kindergarten) on later (first grade) spelling in school. Unlike the standard North American context, formal reading instruction in Israel begins only in Grade 1. Kindergarten is the final year of the three-year pre-school system, which is entirely separate, physically and institutionally, from the six-year (Grades 1 to 6) elementary school system.

5.2 Participants

A sample of 1,146 Hebrew-speaking children and 1,197 Arabic-speaking children were recruited from 210 kindergartens in the north of Israel. These two cohorts were followed up longitudinally from kindergarten to 1st Grade. Six hundred and ten Hebrew-speaking children (269 boys and 341 girls, mean age 5.9 years, SD = 0.5). And 667 Arabic-speaking children (329 boys and 338 girls, mean age 5.8 years, SD = 0.4) were individually tested on a comprehensive test battery in the middle of the first grade – before the outbreak of the COVID-19 pandemic. At that time (March 13, 2020), schools were closed, and testing stopped. No child was excluded due to developmental or learning/attentional disorders or a non-Hebrew-speaking (or non-Arabic) home background.

The Ministry of Education has granted ethical approval for this study – the Office of the Chief Scientist (permit #9667) and the Institutional Review Board of the Faculty of Education at the University of Haifa. Parents signed an informed consent form allowing their children to participate in the data collection.

5.3 Materials

The measures described below were administered in two phases: the first at the end of the kindergarten year (May-June) and the second in mid-Grade 1 (January-March).

5.3.1 Kindergarten measures

Since there are few standardized developmental tests in Arabic and Hebrew, almost all kindergarten measures were either developed from scratch by the authors or adapted from existing clinical or research instruments. We aimed to develop tests that were as "parallel" as possible in both languages. These tasks were piloted before each phase of the study. All measures were administered individually to the children in their kindergartens/schools and presented orally (without any accompanying written or printed material) by a team of trained testers with a background in education, psychology, or speech pathology. In Arabic, all tasks were presented in the spoken Palestinian dialect.[2]

5.3.2 Morphological awareness (MA)

Resultative Adjective Derivation Test - (The Hebrew version: Cohen-Mimran et al. (2019a,b,c), adapted from Yegev, 2001; The Arabic version: Shalhoub-Awwad et al. (2019a,b,c)). The children were asked to complete sentences by deriving an adjective from a given verb. For example: They *sidru – rattabu* 'organized' the books. Now the books are _____ *mesudarim - mrattabi:n* 'organized' (in Hebrew and Arabic, respectively). A demonstration sentence and a practice sentence (with corrective feedback) were presented before the test began. The Hebrew version included ten items, and the Arabic version 12 items. One point was awarded for producing the correct derivation. (Cronbach's alpha: Hebrew = 0.71; Arabic = 0.77)

Verb Derivation Test - (The Hebrew version: Cohen-Mimran et al. (2019a,b,c), adapted from Novogrodsky & Kreiser, 2015; The Arabic version Shalhoub-Awwad et al. (2019a,b,c)). Children were asked to complete sentences by deriving a verbal pattern in this task. For example, Hebrew: "What do we do with the *mishata - ʕasˤsˤara_* 'wringer'? With the *mishata - ʕasˤsˤara, we* _____(*soħatim - mnoʕsˤor 'squeeze'*) (in Hebrew and Arabic, respectively). A demonstration sentence and a training sentence (with corrective feedback) were presented before the test began. The Hebrew version included eight items, and the Arabic version 12 items. One point was awarded if the child produced the correct derivation. (Cronbach alpha: Hebrew = 0.75; Arabic = .71).

Noun Pluralization Test (The Hebrew version: Cohen-Mimran, Gott, Reznik-Nevet, & Share, 2019; adapted from Lavie, 2006 & Yegev, 2001; The Arabic version: Shalhoub-Awwad, Joubran-Awwadie & Mansour-Adwan, 2019). This task requires the child to complete a set of 15 sentences accompanied by pictures of objects (nouns). The tester named an object (a singular noun) and then asked the child to produce the plural form (or the dual in Arabic) (e.g., *here is one baby. Here there are many*_____ (*babies*). In Hebrew, the test items included both regular and irregular forms of the plural inflectional suffix. The target nouns included masculine and feminine nouns, with equal numbers of regular and irregular suffixes. An irregular suffix

[2]The sample covered four main Palestinian dialects: rural-northern, urban-northern, Druze, and Bedouin. The different kindergartens were selected by taking into consideration their proportional distribution in the population (according to CBS, the Israel Central Bureau of Statistics, 2017): 73% rural-urban, 17% Druze, and 10% Bedouin.

in Hebrew takes a plural marker of the opposite gender, e.g., the masculine noun *fulxan* 'table' takes the feminine plural marker *ot* to create *fulxanot* 'tables'. Target nouns also included unaltered stems as well as stem-internal changes. For example, the stem of the singular noun *ɛz* 'goat' changes to *ɪz-im* 'goats' when pluralized. In Arabic: the test items included one of the three plural forms: feminine plural, masculine plural, and broken plural or the dual form, e.g., for the dual form *tuffa:ħtein* 'two apples' or four items for the plural form *ʔarbaʕ tuffa:ħa:t* 'four apples'. The broken plural items were chosen according to the frequency of their patterns based on earlier research with native Arabic-speaking children (Boudelaa & Gaskell, 2002; Ravid and Farah 1999, 2009; Saiegh-Haddad et al., 2012). On the basis of these studies, the following high-frequency plural patterns were targeted: *CCa:C* (e.g., *kla:b* 'dogs'), *CCu:C* (e.g., *χtʔu:tʔ* 'lines'), and CaCa:CeC (e.g., *dʔafa:deʕ* 'frogs'). A correct answer was awarded 1 point. (Cronbach alpha: Hebrew = 0.77; Arabic = .82). For each language, we combined the three morphological measures using Principal Components Analysis. The first principal component accounted for 73.36% of the variance in Hebrew and 57.31% in Arabic, with high and very similar factor loadings that ranged from 0.85-0.86 in Hebrew and 0.73-0.76 in Arabic.

5.3.3 Phonological awareness (PA)

All test items were real familiar words. In Hebrew, the words were chosen from a corpus of 50 words common among toddlers aged 1;4, to 3;3 collected from the Berman longitudinal corpus (Berman, 1990). In Arabic, high frequency words were selected based on a pilot study undertaken with an independent sample of 50 Kindergarten children. In this test, four pictures were presented, and the child was asked to choose the matched picture for each spoken Palestinian word. Only items that received 90-100% correct answers were picked.

Initial consonant isolation in CCVC words (The Hebrew version: Share et al., 2019a, 2019b; The Arabic version: Jabbour-Danial et al., 2019.) The children were asked to repeat a spoken target word and isolate the initial consonant. One demonstration example and four training items were presented before the task started. All target items were CCVC words. The Hebrew test included ten items, and the Arabic version had 12 items. A correct answer was awarded 1 point. (Cronbach alpha: Hebrew = 0.80; Arabic = .76).

Final consonant isolation in CVC words (The Hebrew version: Share, et al., 2019a, 2019b; The Arabic version: Abu-Ahmad et al., 2019.) The children were asked to repeat the target word and isolate the final consonant. One demonstration example and four training items (with corrective feedback) were presented before the task started. The Hebrew version of this test contained ten items and the Arabic version had 12 items. A correct answer was awarded 1 point. (Cronbach alpha: Hebrew = 0.80; Arabic = .83)

A single composite PA measure was developed based on a Principal Components Analysis. The first principal component accounted for 80.5% of the variance in Hebrew and 72.9% in Arabic, again with high and very similar factor loadings around 0.90 in Hebrew and 0.85 in Arabic.

Table 1 Descriptive statistics for kindergarten morphological and phonological measures and mid-Grade 1 spelling

Measures	Hebrew M (SD)	Arabic M (SD)
Age	5.9 (0.5)	5.8 (0.4)
Raven (%)	63.1 (15.1)	59.3 (11.7)
Morphological awareness (%)		
Verb derivation	56.5 (24.52)	84.4 (17.28)
Adjective derivation	52.3 (26.19)	73.4 (22.05)
Noun pluralization	70 (18.96)	72.7 (22.67)
Phonological awareness (%)		
Initial consonant isolation	51 (37.30)	58.9 (38.97)
Final consonant isolation	43.6 (40.47)	35.2 (34.49)
Spelling	72.7 (14.88)	78.7 (17.13)

5.3.4 Grade 1

Spelling measure Children have presented a word orally and were asked to write the word down. A total of 8 words (see Appendix A) were included containing a total of 28 letters. In Hebrew, the words were selected to contain all 22 letters and five final letters in the Hebrew abjad. All words held only the default *a* vowel signs composed of dashes (*kamac* and *patah*) that had been learned up to the time of the assessment. In Arabic, the eight words were selected to include only those consonants and vowels that had been learned up to the time of the assessment (mid-first grade). All items were based on morphological patterns that have a high frequency in the children's schoolbooks (see Appendix B). Each letter produced correctly was awarded 1 point. (Cronbach alpha: Hebrew = 0.82; Arabic = .87).

Non-verbal general ability The colored version of Raven's Standard Progressive Matrices was used to measure non-verbal ability (Raven, 1998). Following an explicit demonstration example, participants were asked to select the missing part of a geometric pattern from several alternatives. We administered all three sets in this test (18 items).

6 Results

Table 1 presents the means and standard deviations of all the measures. The morphological and phonological measures were neither too easy nor too difficult, with no evidence of serious floor or ceiling effects.

To investigate the relationships between spelling, morphology, and phonology skills, we first report Pearson correlation coefficients between the composite variables (see Table 2).

In both languages, age was uncorrelated with the other measures, Raven was weakly correlated with language and spelling. MA and PA were both modestly correlated with each other, a little more strongly in Arabic (0.44 vs. 0.34). As predicted,

Table 2 Pearson correlation coefficients between measures in Hebrew and Arabic

	Hebrew				Arabic			
Measures	2	3	4	5	2	3	4	5
1.Age	.16*	.02	.05	-.03	.01	.06	.06	.06
2. Raven	__	.19*	.25*	.29*	__	.20*	.17*	.19*
3. Morphological awareness		__	.34*	.38*		__	.44*	.28*
4. Phonological awareness			__	.39*			__	.34*
5. Spelling								

both MA and PA were correlated significantly with spelling, but, consistent with the Functional Opacity Hypothesis, somewhat more strongly in Hebrew (especially MA) than in Arabic.

6.1 The unique contribution of morphology to spelling

Hierarchical regressions were then employed to explore the contribution of MA to spelling. We first assessed the unpartialled contribution of morphology, then partialling out age and Raven (Step 1) followed by PA (Step 2) (see Table 3).

6.2 Hebrew

The results of the hierarchical regression predicting spelling from age, general non-verbal ability, PA and MA are displayed in Table 3. At step 1, age and general ability accounted for a statistically significant 9% of the variance in Hebrew spelling. At the next step, the MA composite score accounted for an additional and statistically significant 11% of the variance. After PA was entered at Step 2, MA also added another statistically significant 6% of the variance over and above the contributions of age, general ability, and PA.

6.3 Arabic

As predicted, the parallel results of the hierarchical regression painted a different picture for Arabic (see Table 3). After accounting for age and general non-verbal ability, which together explained 4% of the variance at Step 1, MA accounted for an additional 6% of the spelling variance. This compares to 11% for Hebrew. After PA was entered at Step 2, MA added only an additional 1% of the variance in spelling. These outcomes contrast sharply with the Hebrew data and suggest, as predicted, that the role morphology is much smaller in Arabic than in Hebrew.

7 Discussion

The main goal of the present study was to examine the longitudinal contribution of pre-school morphological awareness to early Grade 1 spelling performance in two Semitic languages: Hebrew and Arabic. These languages have similar morphological (root-and-pattern) structures yet differ in their orthographic consistency. Whereas

Table 3 Hierarchical regression analyses evaluating predictors of Hebrew and Arabic spelling

Measures	R	R^2	ΔR^2	ΔF		df	β	
Hebrew								
1. Age	.30	.09	.09	36.67	***	2, 607	−.08	–
General ability							.30	***
2. MA	.44	.20	.11	80.63	***	1, 606	.33	***
3. PA	.50	.26	.06	45.34	***	1, 605	.26	***
2. PA	.44	.20	.11	79.25	***	1, 606	.34	***
3. MA	.50	.26	.06	46.65	***	1, 605	.26	***
Arabic								
1. Age	.20	.04	.04	13.34	***	2, 664	.06	–
General ability							.19	***
2. MA	.31	.10	.06	41.87	***	1, 663	.24	***
3. PA	.39	.15	.05	43.26	***	1, 662	.26	***
2. PA	.37	.14	.10	75.86	***	1, 663	.32	***
3. MA	.39	.15	.01	10.81	**	1, 662	.13	**

Note. *p < .001. MA=Morphological Awareness; PA=Phonological Awareness

Arabic mappings are mostly one-to-one – allowing children to rely mainly on phonology to spell words correctly, Hebrew has numerous one-to-many phoneme-to-letter correspondences that are governed by morphological considerations, thereby precluding a purely phonological spelling strategy. Consequently, we predicted that morphological awareness would contribute significant unique variance to early Hebrew spelling (over and above the contribution of PA) but little or no variance in early Arabic spelling**.** Confirming our expectations, we found that after controlling for age, general intelligence, and phonological awareness, morphological awareness contributed a significant 6% additional variance to Hebrew spelling but only 1% to Arabic word spelling. Furthermore, because our study examined morphological awareness prior to the onset of formal literacy instruction, our data provide evidence of the unique contribution of morphological awareness to Hebrew and Arabic spelling while ruling out the influence of literacy instruction.

This cross-linguistic evidence for the longitudinal effects of morphological awareness on beginning spelling in Hebrew and Arabic is inconsistent with models of early spelling acquisition, which assume that phonological skills influence spelling development earlier than morphological ones (e.g., Ehri, 1989; Frith, 1985; Nunes et al., 1997a,b). Here we show a morphological awareness effect on spelling much earlier than these theories suggest.

On the other hand, our findings are congruent with theoretical frameworks that emphasize the importance of multiple linguistic strategies and multiple sources of knowledge in spelling performance from a very early age as alternative sources of information that enable the speller to overcome spelling inconsistencies (Apel et al., 2004; Rittle-Johnson & Siegler, 1999; Treiman, 2017; Treiman & Bourassa, 2000; Treiman et al., 1994; Treiman & Kessler, 2005; Varnhagen et al., 1997). Among

these linguistic strategies is the use of morphological information. We show that early spelling depends on the interplay of the specific characteristics of each orthography as well as the specific morphological structures in each language.

The more substantial contribution of morphological awareness to Hebrew word spelling relative to Arabic appears to stem from the differences in the phoneme-to-letter consistency between these two languages. Hebrew orthography has thirteen homophonic letters; six of the 19 consonantal phonemes in modern Israeli Hebrew have two (and, in one case, three) alternate (letter) spellings (Ravid, 2006). This phoneme-letter multivalence of the Hebrew spelling system precludes reliance on phonological information alone. Instead, it obliges attention to the morphological structure of the words, which is a salient and consistent feature of Hebrew orthography (Ravid, 2012). This contribution of morphological awareness in Hebrew attests to the centrality of morphology in Hebrew as a key psycholinguistic factor in learning to spell. It demonstrates that in the absence of phoneme-to-letter consistency, children exploit morphology as a compensatory mechanism for achieving correct spelling as they do in reading (see Elbro & Arnbak, 1996; Leikin & Even-Zur, 2006). For example: when the child needs to spell the words: *kotev* 'he writes' and *haxtava* 'dictation' in Hebrew it is more profitable for him/her to identify and reproduce the shared root morpheme k-t-b than their phonological forms alone. Once the root is identified, it allows the child to choose the correct letter for the consonants *k and x*, which each have two possible spellings.

Our findings add to a growing body of research in different languages showing a significant contribution of morphological awareness at the earliest stages of learning to spell across orthographies (e.g., Dutch: Rispens et al., 2008; French: Casalis et al., 2011; English: Treiman & Kessler, 2005; Deacon et al., 2009; Arabic: Taha & Saiegh-Haddad, 2016). However, most of these studies have been undertaken after formal schooling commences introducing concerns regarding reciprocal influences between morphology and literacy. Hence, it joins a very small set of longitudinal studies (Greek: Grigorakis & Manolitsis, 2016; Hebrew: Levin et al., 1999; Ravid, 2001) that provide relatively "clean" evidence of the unique contribution of morphological awareness as a significant longitudinal predictor to early spelling.

Our cross-linguistic findings clearly show that the role of morphological knowledge varies in response to the unique characteristics of each orthography (Levesque et al., 2021). They are also congruent with evidence from recent studies showing that spelling acquisition may differ across writing systems (e.g., Casalis, 2018; Devonshire et al., 2013). Hence, our findings reveal differences in the relevance of phonological and morphological awareness for spelling prediction between two structurally similar languages: Hebrew and Arabic, at least for the age examined here, that is, early Grade 1. With regard to the contribution of phonological awareness to spelling in the two Semitic languages, we found that after controlling for age and general intelligence, phonological awareness contributed significant additional variance (11% and 10%) to word spelling in Hebrew and Arabic, respectively. Even when it was entered into the regression equation after controlling for age, general intelligence, and morphological awareness, it still added significant additional variance (6% and 5%) in Hebrew and Arabic, respectively. The similar contribution of phonological awareness across the two languages aligns well with ample evidence regarding the importance

of phonological awareness to spelling achievement, especially at the start of literacy acquisition. It affirms the need to analyze the phonemes that makeup words before matching the letters to these phonemes (e.g., Blomert & Willems, 2010; Caravolas et al., 2001; Ehri, 1998; Treiman, 1993). Furthermore, these data offer an interesting case study of the role of writing system variation on reading and spelling development.

The similar contribution of phonological awareness to consistent Arabic (i.e., phoneme to letter consistency) and inconsistent Hebrew would appear to contradict the Functional Opacity Hypothesis (Share, 2008). This hypothesis was initially developed to explain differences between orthographies in the phonological awareness-reading relationship. Specifically, Share argued that the phonological awareness-reading association is more robust when a script creates decoding ambiguity either owing to inconsistent letter-to-sound relationships (as in English) or a child's incomplete mastery of a regular transparent script. The present study extended this idea to spelling and morphology as an additional non-phonological source of information likely to help reduce decoding ambiguity. However, inconsistent letter-to-sound and/or sound-to-letter correspondence may not be the only source of decoding complexity. Daniels and Share (2018) have argued that multiple dimensions of orthographic complexity may complicate the task of decoding and spelling. One of these dimensions is visual-orthographic complexity. In the case of Arabic, there are several dimensions of visual-orthographic complexity, including letter shape similarity, allography, ligaturing, and multi-linearity (see Yassin et al., 2020 for a brief exposition). Thus, Arabic represents an interesting case of a supposedly "shallow" or "transparent" orthography (in terms of phonology-orthography mappings) which is functionally opaque owing to non-phonological factors that create challenges for the young reader and speller. In this context, it is noteworthy that the overall performance levels on the spelling test in both languages were not as dramatically different as the Orthographic Depth Hypothesis would predict. Moreover, the correlations between reading and phonological awareness in the two languages were also quite similar, with similar amounts of unique variance explained in both languages.

8 Conclusion and implications

The present study shows that the contribution of morphology (MA) to spelling is more robust when a script creates encoding ambiguity owing to inconsistent sound-to-letter relationships. This finding extends the Functional Opacity Hypothesis (Share, 2008) to spelling and other non-phonological influences on early reading and writing, such as morphology. Our findings are also consistent with Daniels and Share's (2018) claim that there exist multiple dimensions of writing system variation each liable to create difficulties in learning to read and spell. In the case of Arabic, a superficially "transparent" orthography in terms of orthography-to-phonology and phonology-to-orthography mappings is functionally opaque in other ways, such as visual-orthographic complexity and diglossia, which can challenge the young speller. Hebrew, on the other hand, is transparent from print to sound but complex and multi-valent from sound to print; hence the need for non-phonological or extra-phonological support of morphological knowledge helps constrain the ambiguity.

This means that promoting morphological knowledge in the classroom and in the clinic among young Semitic readers and spellers (in addition to phonological awareness) will be an important priority among beginning readers and, contrary to popular opinion among many Anglophone researchers, should not be delayed until later stages of reading development when longer multi-morphemic words appear in children's texts.

Appendix A

Written word in Hebrew	Word pronunciation	Spelling	Morpho-syntactic characteristics	Spelling[a] alternatives	English translation
שָׁכַב	*shaxav*	ŠKB	Verb, Masc, Sg	K/*H* *B/W*	lie down
בַּרְוָז	*barvaz*	BRWZ	Noun, Masc, Sg	*B/W*	duck
אֲגַם	*agam*	AGM	Noun, Masc, Sg	A/H/9	lake
עָפָה	*afa*	9PH	Verb, Fm, Sg	9/A/H/	fly
קְטַנָּה	*ktana*	Q*T*NH	Adj, Fm, Sg	K/Q T/*T* 9/A/H/	small
מָסָךְ	*masach*	MSK	Noun, Masc, Sg	K/*H*	screen
צַיָּד	*tsayad*	CYD	Noun, Masc, Sg		hunter
הַתְחָלָה	*hatchala*	HT*H*LH	Noun, Fm, Sg	H/A/9 T/*T* K/*H*	beginning

[a]The following symbols were chosen to designate the following Hebrew letters: Tet is represented as italicized *T*, as distinct from Taf, represented by T; Het is represented by italicized *H*, as distinct from K; Tsadi is represented by C; and the digit 9 represents the letter Ayin (voiced pharyngeal fricative) (Ravid, 2001)

Appendix B

Written word in Arabic	Word pronunciation	Spelling	Morpho-syntactic characteristics	English translation
سام	*sa:m*	SAM	Proper Noun	'Sam'
رازي	*ra:zi:*	RAZY	Proper Noun	'Razy'
دَرَج	*daraʒ*	DRʒ	Noun, Masc, Sg	'stairs'
هَرَ ب	*haraba*	HRB	Verb, Masc, Sg	'run away'
راس	*ra:s*	RAS	Noun, Masc, Sg	'head'
سَمَك	*samak*	SMK	Noun, Masc, Pl	'fish'
رَزان	*raza:n*	RZAN	Proper noun	'Razan'
زَرَ ع	*zaraʕa*	ZRʕ	Verb, Masc, Sg	'planted'

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