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Early contribution of morphological awareness to literacy skills across languages varying in orthographic consistency

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Abstract In the present study, we examined the role of morphological awareness in reading and spelling performance across three languages varying in orthographic consistency (English, French, and Greek), after controlling for the effects of phonological awareness and rapid automatized naming (RAN). One hundred fifty-nine English-speaking Canadian, 238 French-speaking Canadian, and 224 Greek children were assessed at the beginning of Grade 2 on measures of morphological awareness, phonological awareness, and RAN. At the end of Grade 2, they were assessed on reading accuracy, reading fluency, reading comprehension, and spelling to dictation. The results indicated that morphological awareness was a unique predictor of reading comprehension and spelling in all three languages, of reading fluency in English and French, and of reading accuracy in English only. Furthermore, the results of multigroup analyses revealed no significant differences in the contribution of morphological awareness to the literacy outcomes across languages. Theoretical and practical implications of these finding are discussed.

Keywords Morphological awareness · Word reading accuracy · Word reading fluency · Spelling · Reading comprehension · Orthographic consistency · Phonological awareness · Rapid automatized naming

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Introduction

Morphological awareness, defined as the "ability to reflect upon and manipulate morphemes and employ word formation rules in one's language" (Kuo & Anderson, 2006, p. 161), has been found to be a significant predictor of literacy skills in different languages (e.g., Carlisle, 1995; Deacon & Kirby, 2004; Kirby et al., 2012; Rothou & Padeliadu, 2015; Ruan et al., 2017; Sanchez, Magnan, & Ecalle, 2012). However, it remains unclear if the influence of morphological awareness in literacy skills is moderated by the degree of orthographic consistency. Thus, the purpose of the present longitudinal study was to examine the role of morphological awareness in the development of different literacy skills in three alphabetic languages (English, French, and Greek) varying in orthographic consistency.[1]

A cross-linguistic perspective on morphemes

Morphemes are taken as "the minimal linguistic units with a lexical or a grammatical meaning" (Booij, 2012, pp. 8–9). Words created by derivation involve the concatenation of a lexical or free morpheme and affixes or bound morphemes (e.g., *buy* + *er* > buyer). Common affixes in English, French, and Greek take the form of prefixes and suffixes. Prefixes do not alter the grammatical properties of the lexical morpheme, but suffixes can do so. When -*er* is selectively attached to an English verb to form a noun, it is then said to apply a subcategorization. Other suffixes can be selectively attached to other parts of speech and specify other grammatical categories (e.g., adjectives, adverbs, verbs). The complexity of subcategorization properties varies across languages.

English suffixes can specify the grammatical category of words (e.g., nouns) and some semantic features of their referents (e.g., agent, process). French suffixes share the same subcategorization properties in addition to specifying the grammatical gender of nouns and adjectives if special cases are discarded. In this language, most suffixes are predominantly associated with one of two gender classes, called masculine (m) and feminine (f). This subcategorization property applies indiscriminately to animate and inanimate nouns (e.g., 'nurse' → *infirm* + *ier* (m), *infirm* + *ière* (f); 'apron' → *tabl* + *ier* (m); 'river' → *riv* + *ière* (f)) and it can control the form of other words in sentences (e.g., determiners, adjectives, participles) through an agreement process (Corbett, 2006). Both English and French typically specify number (one vs. more than one) by attaching the grammatical affix -*s* at the end of nouns, and, in the case of French, other word categories (e.g., determiners, adjectives, participles).

Greek suffixes possess all aforementioned subcategorization properties with some additional features, namely, three gender classes (masculine, feminine, and neuter) and case classes (nominative, genitive, accusative, vocative; Holton, Mackridge, & Philippaki-Warburton, 2004). The combination of subcategorization

[1] A common estimate of orthographic transparency is the entropy index based on letter-to-sound mappings. The lower the entropy index is the more transparent the orthography is. The estimate of this index is .83 for English, .46 for French (Ziegler et al., 2010), and .16 for Greek (Protopapas & Vlachou, 2009).

properties significantly increases the number of morphologically related word forms. In Greek, for instance, nouns can have up to seven different forms, each with its own suffix and associated spelling depending on declension (see Table 1 for an illustration). As they gain more experience with the use of language, children increase their mastery of these subcategorization properties (in English: Duncan, Casalis, & Colé, 2009; in French: Casalis & Louis-Alexandre, 2000; Seigneuric, Zagar, Meunier, & Spinelli, 2007; in Greek: Pittas & Nunes, 2014; Rothou & Padeliadu, 2015), even though word morphology in each of these three languages is not systematically and explicitly taught before Grade 2 or 3, if at all. The varying complexity of word morphology, however, raises an important issue in the present study: Does complexity moderate the effects of morphological awareness on different aspects of reading and spelling? We return to this issue below.

Measurement and evidence for morphological awareness in early grades

Deacon, Parrila, and Kirby (2008; see also Berthiaume, Besse, & Daigle, 2010) presented a detailed account of experimental tasks designed to measure morphological awareness. One dimension of morphological awareness tasks is based on the explicitness of the morphological information that children need to process. Some tasks tap implicit skills that do not necessarily involve explicit manipulation of morphemic units (e.g., Are these words related: *teach—teacher*, *fry—Friday*), while other tasks require children to demonstrate intentional manipulation of roots, prefixes or suffixes (e.g., word production: A man who drives is a … <*driver*>). There is now ample evidence that a shift between implicit to explicit knowledge of word morphology occurs during kindergarten and first grade (e.g., Carlisle, 1995; Casalis & Louis-Alexandre, 2000; Kirby et al., 2012). Another dimension of morphological awareness tasks is defined by the kind of morphemes involved. For instance, experimental tasks may be designed to measure the manipulation of either inflectional or derivational morphemes. In the present study, we used more complex tasks, given that the participants were recruited from Grade 2, and we examined the manipulation of inflectional and derivational morphemes.

The distinction between these dimensions has led researchers to design a variety of oral morphological awareness tasks such as word or sentence analogy, and production of word forms. To illustrate, in the analogy tasks, children are asked to recognize a morphological relation in a word or in a sentence pair and to apply this relation to complete a second pair with the appropriate word or sentence (e.g., Deacon, Wade-Woolley, & Kirby, 2007; Nunes, Bryant, & Bindman, 1997). The morphological structure tasks (Carlisle, 2000) can target either inflectional or derivational morphemes. Children are asked to produce a derived word from a given base word (e.g., *Warm*: *He chose the jacket for its* … <*warmth*>) or decompose a given derived word (e.g., *Fourth*: *The girl counted from one to* … <*four*>) in order to complete a sentence. These explicit tasks are all assumed to tap a common construct, morphological awareness, and this assumption has received empirical support even though the exact factor structure is influenced by the outcome variables under consideration (Tighe & Schatscheider, 2015).

Table 1 Morphological subcategorization properties of the noun ‘singer’ in English, French, and Greek

English number	French gender	Greek case			
		Nominative	Genitive	Accusative	Vocative
Singular	Masculine	tragoudistis	tragoudisti	tragoudisti	tragoudisti
singer	*Chanteur*	‘τραγουδιστής’	‘τραγουδιστή’	‘τραγουδιστή’	‘τραγουδιστή’
	Feminine	tragoudistria	tragoudistrias	tragoudistria	tragoudistria
	Chanteuse	‘τραγουδίστρια’	‘τραγουδίστριας’	‘τραγουδίστρια’	‘τραγουδίστρια’
Plural	Masculine	tragoudistes	tragoudiston	tragoudistes	tragoudistes
singers	*Chanteurs*	‘τραγουδιστές’	‘τραγουδιστών’	‘τραγουδιστές’	‘τραγουδιστές’
	Feminine	tragoudistries	tragoudistrion	tragoudistries	tragoudistries
	Chanteuses	‘τραγουδίστριες’	‘τραγουδιστριών’	‘τραγουδίστριες’	‘τραγουδίστριες’

From a developmental perspective, children's ability to detect and manipulate morphemes increases over the elementary school grades as shown in a variety of morphological processing tasks (Bryant, Nunes, & Bindman, 2000; Carlisle & Fleming, 2003; Kirby et al., 2012; Pittas & Nunes, 2014). For instance, tasks that require a transformation from the derived form to the corresponding base word form (e.g., *fourth* to *four*) have been found to be easier for children in the early elementary grades than tasks requiring a transformation from the base word form to a derived form (e.g., *produce* to *production*; Carlisle, 2000; Carlisle & Nomanbhoy, 1993). On the basis of these studies, we used word and sentence analogy tasks in order to assess intentional manipulation of both derived and inflected words, as well as a morphological structure task to assess composition and decomposition of derived words. These tasks, despite their cognitive complexity, are considered as appropriate for the assessment of morphological awareness for young elementary school children (e.g., Kirby et al., 2012; Nunes et al., 1997) and as good predictors of future reading (Deacon, 2012; Deacon & Kirby, 2004) and spelling (Casalis, Deacon, & Pacton, 2011) performance.

Relationship between morphological awareness and literacy skills

A number of studies have reported a significant contribution of morphological awareness to reading development beyond the initial phases of learning to read (e.g., Deacon & Kirby, 2004; Kirby et al., 2012; Pittas & Nunes, 2014). Even though the main bulk of research on morphological awareness has been conducted in English, there is now ample evidence for its contribution to literacy development across a broad range of European languages (e.g., Dutch: Rispens, McBride-Chang, & Reitsma, 2008; French: Casalis & Louis-Alexandre, 2000; Greek: Rothou & Padeliadu, 2015). There are several reasons why morphological awareness can be expected to relate to learning to read and spell: (a) morphemes carry semantic, phonological, and syntactic information, (b) morphemes can disambiguate inconsistent print-to-sound and sound-to-print relations, (c) morphemes are more stable in their written than their spoken form (e.g., *sign—signature*), and (d) word morphology seems to play a role in the memory storage and retrieval of lexical information (Kuo & Anderson, 2006; Peereman, Sprenger-Charolles, & Messaoud-Galusi, 2013).

The early contribution of morphological awareness to reading, however, is not entirely consistent across languages. Studies with English- and French-speaking children have shown that the ability to manipulate inflectional and derivational morphemes is significantly related to word and nonword reading in Grades 1 and 2 (Carlisle, 1995; Carlisle & Nomanbhoy, 1993; Casalis & Louis-Alexandre, 2000; Deacon, 2012; Kirby et al., 2012; Sanchez, Magnan, & Ecalle, 2012; Wolter, Wood, & D'zatko, 2009). In Greek, Rothou and Padeliadu (2015) conducted a cross-sectional study and found inflectional morphological awareness to be related to word reading in Grade 1, but not in Grade 2, while Grigorakis (2014) reported a predictive relationship between derivational morpheme manipulation and compound word reading in Grade 2, but not in Grade 1. Similar inconsistencies have been reported for reading fluency. For instance, for English-speaking children, Kirby et al. (2012) found that performance on the word analogy task in Grade 2 predicted text reading fluency, but not word reading fluency in Grade 3. In more transparent orthographies, several studies have reported non-significant effects on reading fluency when phonological skills were controlled for (e.g., Grigorakis, 2014; Manolitsis, 2006; Müller & Brady, 2001). In Dutch, however, inflectional morpheme manipulation was found to contribute to word reading fluency in Grade 1 (Rispens et al., 2008). These inconsistent findings may be attributable to differences in the requirements of each orthography for efficient word reading, differences in the research designs employed (e.g., longitudinal vs. cross-sectional) or differences in the tasks used to assess morphological awareness (e.g., manipulation of inflections or/and derivations) or word reading (e.g., different types of words). Each morphological awareness measure may contribute differently to reading different types of words (e.g., compounds, derived words, base words) depending on the level of word reading development achieved by children and the orthographic characteristics of each language.

In contrast, the findings on the relation between morphological awareness and reading comprehension are fairly consistent. Morphological awareness has been found to contribute more to reading comprehension than to word reading accuracy or fluency in English (e.g., Deacon & Kirby, 2004; Kirby et al., 2012), in French (e.g., Casalis & Louis-Alexandre, 2000), and in Greek (e.g., Grigorakis, 2014; Rothou & Padeliadu, 2015). Moreover, morphological awareness has been found to predict reading comprehension as early as in Grade 1, even after controlling for various cognitive skills such as general cognitive abilities, phonological awareness, phonological short-term memory, and rapid automatized naming (e.g., Carlisle, 1995; Casalis & Louis-Alexandre, 2000; Grigorakis, 2014; Kirby et al., 2012; Kuo & Anderson, 2006; Pittas & Nunes, 2014).

Spelling is another prominent aspect of literacy to which morphological awareness can contribute since the morphemic structure of words in many alphabetic languages constrains their spelling. Children with an awareness of morphemes and grammar at younger ages learn to use morphemes in spelling more systematically at a later age (Nunes & Bryant, 2006). Even though the mapping between oral and written morphemes is difficult to learn, there is solid evidence that children can use morphological knowledge in their spelling as early as in Grade 1 (Chliounaki & Bryant, 2007; Treiman & Cassar, 1996) as well as beyond the first phases of learning to spell (Nunes, Aidinis, & Bryant, 2006; Nunes et al., 1997). In English, morphological awareness in Grade 1 has been found to be associated concurrently (Wolter et al., 2009) and longitudinally (Deacon, Kirby, & Casselman-Bell, 2009) with spelling performance. Similar findings have been reported in cross-sectional studies with French-speaking children in Grades 2, 3, and 4 (Casalis et al., 2011; Sénéchal, 2000). However, in orthographies that are more transparent than English and French, such as Finnish and Dutch, morphological awareness was not uniquely associated with spelling in the early grades (e.g., Lethonen & Bryant, 2005; Rispens et al., 2008). In these languages, morphological awareness may not provide any special advantage when phoneme-to-grapheme relations are regular and sufficient for spelling. Greek, however, provides a special case because phoneme-to-grapheme correspondences are less transparent than grapheme-to-phoneme correspondences (Protopapas & Vlahou, 2009) and the contribution of morphological awareness to children's spelling has been detected in the early grades (Bryant, Nunes, & Aidinis, 1999; Manolitsis & Grigorakis, 2012; Nunes et al., 2006) and later (e.g., in Grade 3; Pittas & Nunes, 2014).

The present study

Our review of the literature indicates that there is an association between morphological awareness and literacy skills in several alphabetic languages, albeit with some inconsistencies. Inconsistent results are particularly difficult to interpret when the set of longitudinal predictors and outcome variables varies across studies or languages. In addition, a number of linguistic differences on morphological structure across languages set an intricate context for comparing the morphological awareness effects on literacy acquisition in different orthographies. For example, Duncan et al. (2009) showed that awareness of derivational morphemes developed earlier in French-speaking children than in English-speaking children. This difference is attributed to the greater variety and productivity of French suffixes, relative to English. Also, other cross-linguistic studies have shown differences across languages on cognitive and linguistic predictors of learning to read and spell (e.g., Caravolas, Lervåg, Defior, Seidlová Málková and Hulme, 2013; Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012b).

Therefore, the aim of the present study was to examine the relative contribution of morphological awareness at the beginning of Grade 2 to various literacy outcomes at the end of Grade 2 among speakers of English, French, and Greek. We expected morphological awareness, as another crucial cognitive-linguistic factor of leaning to read and spell, to predict future literacy development differently across languages depending on the morphological structure of each language and its orthographic consistency. Special care was taken to make all measures of the predictor and outcome variables as comparable as possible across languages. Previous studies provide evidence that sufficient variance in morphological awareness can be observed in the early elementary grades of schooling and that significant relations can be observed between morphological awareness and various literacy outcome variables such as accuracy and fluency of word and pseudoword reading, reading comprehension and spelling when the effects of other relevant variables are statistically controlled for.

Method

Participants

The data used in the present study are part of a larger longitudinal project carried out in five different languages. The present sample consisted of 621 children assessed at the beginning and end of Grade 2: 179 English-speaking children from six public elementary schools in Edmonton, Canada (77 girls; mean age = 87.53 months), 238 French-speaking children from eight public elementary schools in Gatineau, Canada (136 girls; mean age = 90.15 months), and 224 Greek-speaking children from six public elementary schools in Heraklion and Rethymnon, Greece (118 girls; mean age = 87.52 months). The participants from all sites came mostly from families of middle socioeconomic background (based on the location of the schools and on mother's education). None of these children were identified as having learning, emotional, or sensory disabilities. Parental and school consent was obtained prior to testing.

Measures

To make measures comparable across the three languages, special attention was paid to the task selection and the cross-linguistic standardization of these tasks (e.g., number of items, word type, word structure, word length) as well as test administration procedures (e.g., instructions, application of discontinuation rules). For several of these tasks a similar laptop computer and shared program applications (run by Empirisoft DirectRT, version 2012) were used to present the stimuli and record children's responses.

Beginning of Grade 2

Rapid automatized naming (RAN) RAN was assessed with two tasks: Color Naming and Digit Naming. In both tasks, children were asked to name as fast as possible four color tiles (blue, red, green, and yellow) or digits (2, 4, 5, and 7) dispersed in semi-random order in four rows of six items. Each task was preceded by a practice trial to ensure children knew the name of the items and then administered twice with the items arranged in a different order. A participant's score was the average time to name both cards in each task.

Phonological awareness Two tasks were used to measure phonemic awareness: Phoneme Elision with real words and Phoneme Elision with nonwords. Each task was designed so as to match items phonologically across the three languages. Both tasks included four practice items and 24 experimental items, all pre-recorded by a native speaker of each language and presented through speakers plugged into a laptop computer. Children were presented with one item at a time, asked to repeat it, and then asked to remove a phoneme from it and say what was left. The items were presented in four blocks of six items. The blocks were ordered in increasing levels of difficulty and a discontinuation rule of four errors in a given block was applied. A participant's score was the total number of correct responses.

Morphological awareness Three tasks were used to measure morphological awareness: Word Analogy, Sentence Analogy, and Word Production. The word analogy task was modeled after similar tasks in English, French, and Greek (Casalis et al., 2011; Grigorakis, 2014; Kirby et al., 2012). Each task was designed so as to match the morphological processing demands of each item across the three languages.

The Word Analogy task included three practice items and 14 experimental items. Children were given a pair of morphologically related words (e.g., *to run—runner*), then given a new word (e.g., *to climb*) and asked to transform it to match the model of the first word pair (e.g., *climber*). Half of the items required children to find inflected word types and the other half required children to find derived word types based on the target word analogy. For the inflected condition, in four items the change of the second part of the analogy was based exclusively on morphological rules and not on phonological similarities [e.g., *jumped*: *jump* :: *stood*: (*stand*)], while in two items the morpheme changes could be based on similar phonological changes [e.g., *doll*: *dolls* :: *sneaker*: (*sneakers*)]. For the derived condition, four items required children to transform a base word into a derived word similar as in the target analogy pair of words [e.g., *high*: *height* :: *deep*: (*depth*)] and two items required children to transform a derived word into a base word [e.g., *decision*: *decide* :: *action*: (*act*)]. The inflected condition preceded the derived condition because children acquire knowledge of inflected word types earlier than knowledge of derived ones (Carlisle, 1995; Casalis & Louis-Alexandre, 2000; Grigorakis, 2014).

The Sentence Analogy task was modeled after the task developed by Deacon et al. (2007); it was comprised of three practice items and 10 experimental items. Children received a sentence pair (e.g., *Tom helps Mary*: *Tom helped Mary*), then were given a third sentence (e.g., *Tom sees Mary*), and were asked to produce a fourth sentence that matched the model of the first two (e.g., *Tom saw Mary*). In all items, children had to make inflected transformations to the target verbs of each sentence from one tense to another (e.g., from present to past tense). In two items, the transformations could be based on phonological or morphological similarities with the target analogy sentence pair, while in the other eight items the changes could be based solely on morphological rules. The items that required a simple verb change from the present tense to past or in the reverse direction were presented before more complex sentence transformations.

The Word Production task was adapted in all three languages from the "Test of Morphological Structure" (Carlisle, 2000); it included three practice items and 10 experimental items. Children were given a noun (e.g., *farm*) and a short sentence (e.g., *My uncle is a* ___); they were then asked to complete the sentence by transforming the noun presented first (e.g., *farmer*). The first five items required children to make changes from target base words to derived word types while the next five items required children to make changes from a target derived word to a base word [*dangerous—Are the children in any* (*danger*)?].

Items in these tasks were presented in increasing order of difficulty based on the morphological manipulation (e.g., inflections vs. derivations, phonologically-based changes vs. morphologically-based changes) and each task was discontinued after four consecutive incorrect responses. A participant's score in each task was the total number of correct responses.

End of Grade 2

Reading accuracy The Word Identification and Word Attack tasks from the Woodcock Reading Mastery Tests—Revised (Woodcock, 1998) and their adaptation into French (Desrochers, 2012a) and Greek (Papadopoulos, 2001), were used to assess reading accuracy. In Word Identification, children were shown a series of isolated words of increasing difficulty and asked to read them aloud. In Word Attack, children were shown a series of pronounceable pseudowords of increasing difficulty and were asked to sound them out. A participant's score was the total number of correctly read words or pseudowords.

Reading fluency The word reading efficiency (WRE) and phonemic decoding efficiency (PDE) from the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) and their adaptations into French (Desrochers, 2012a) and Greek (Georgiou, Papadopoulos, Fella, & Parrila, 2012a) were used to assess reading fluency. Children were asked to read a list of 104 real words or 63 pseudowords as fast and accurately as possible within a 60-s time limit. In both tasks, the child's score was the total number of syllables in the correctly read items within the specified time limit. This scoring procedure was necessary because of differences in the length of the words or pseudowords included in each task across languages.

Spelling The Spelling Dictation task from WIAT-II (Wechsler, 2001) and its adaptation into French (Wechsler, 2005) and Greek (Mouzaki, Protopapas, Sideridis, & Simos, 2010) was used to assess spelling performance. Children were initially given 12 letters or letter strings one at a time and were then asked to write them down. In addition, they were given up to 42 short sentences and for each they were asked to write down a specific word. The test was discontinued after six consecutive incorrect responses. A participant's score was the total number of correct responses.

Reading comprehension The Passage Comprehension task from Woodcock Reading Mastery Test (Woodcock, 1998) and its adaptation into French (Desrochers, 2012b) and Greek (Georgiou, Manolitsis, Nurmi, & Parrila, 2010) was used to assess reading comprehension while keeping constant the pictures and the wording of the original test. Children were asked to read short passages of one or two sentences and then fill in the empty space by a semantically appropriate word. The test was discontinued after four consecutive incorrect responses. A participant's score was the total number of correct responses.

Procedure

Data collection

All tasks were administered in a quiet room in the child's school by trained research assistants. Children were tested at the beginning of Grade 2 (early October 2012) and again at the end of the school year (May 2013). The tests were administered in two sessions of about 30 min each. All tests were given in the same order and all administration and scoring procedures were standardized across all children and all three languages.

Data analytic method

Structural equation modeling with latent variables was used to test the hypothesized relations between morphological awareness and literacy outcome variables (while controlling for phonological awareness and RAN) as well as the invariance of these relations across languages. All analyses were conducted in MPLUS 7.4 with the MLR estimator that corrects the standard errors of the estimators and the fit indices for non-normality of the data (Lei & Wu, 2012; Muthén & Muthén, 1998–2012). Missing data was treated using the Full Information Maximum Likelihood implemented as the default in MPLUS. We started with a *measurement model* and verified its fit for each language group. The measurement model included seven latent variables. The latent variables were created using the indicators as defined and explained in the measures section. Two latent variables (i.e., spelling, reading comprehension) had only one indicator and were created by fixing the loading to unity and the variance of the latent variable to zero. Four latent variables (i.e., phonological awareness, RAN, reading accuracy, reading fluency) had two indicators and one latent variable (i.e., morphological awareness) had three indicators. The first loading was fixed to unity to set the metric of the latent variable and its variance was freely estimated. Fit of the measurement models was assessed using absolute fit (scaled χ^2; Satorra & Bentler, 2001) and several relative fit indices (West, Taylor, & Wu, 2012): Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). CFI and TLI higher than .95 and RMSEA and SRMR lower than .08 were taken as indicators of acceptable fit. We estimated the composite reliability of the latent scores using the H coefficient to obtain the upper-bound estimate of scores' reliability (Hancock, 2001).

We then followed up with a *fully saturated structural model* (see Fig. 1) in which phonological awareness, RAN, and morphological awareness (i.e., predictors) each predicted reading accuracy, reading fluency, spelling, and reading comprehension. The exogenous and endogenous latent variables were left free to correlate. Our analysis was adequate to estimate the unique/main effect of morphological awareness on each of the four outcomes while controlling for the effects of phonological awareness and RAN. The structural model was examined separately in each group to properly estimate the relations between the predictors and the outcome variables as well as the effect size (R^2).

Finally, we performed multi-group analyses in order to determine whether each of the relations between the predictors and the outcomes was significantly moderated by the language group. We tested a model in which equality constraints (i.e., French = English = Greek) were added on each of the relations between predictors and outcomes. These equality constraints were needed to test a model in which all moderating effects were assumed to be null. In this model, all relations

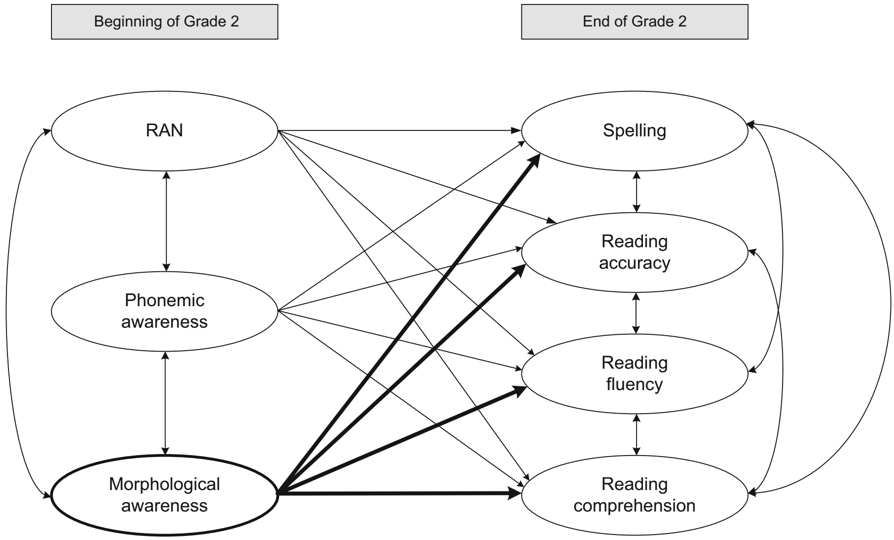

Fig. 1 Structural model of the relations between morphological awareness and control variables at the start of grade 2 and the literacy outcomes at the end of grade 2 in each of the three language groups

between the predictors and outcomes were assumed to be invariant or identical across language groups. If this null hypothesis of invariance was rejected, pairwise comparisons [(a) English vs. French, (b) English vs. Greek, and (c) French vs. Greek)] of each parameter was subsequently carried out in order to identify which relation was significantly different across language groups.

Results

Preliminary analyses

Sixteen participants (English, $n = 4$; French, $n = 8$; Greek, $n = 4$) were excluded from the analyses because they were identified as multivariate outliers in their respective group using the critical value of the Mahalanobis distance ($\chi^2 > 35.53$, $df = 13$, $p < .001$). Thus, all subsequent analyses were performed with a sample of 155 English, 233 French, and 220 Greek children. Table 2 reports the means, standard deviations, skewness and kurtosis estimates of each measure, separately for each language.

Results of structural equation modeling

Measurement model

The fit of the measurement model was acceptable in each of the three language groups: English (MLR $\chi^2 = 95.15$, $df = 46$, $p < .001$, CFI = .967, TLI = .944,

Table 2 Descriptive statistics for all variables organized by language

Variables	English				French				Greek			
	M	SD	Skewness	Kurtosis	M	SD	Skewness	Kurtosis	M	SD	Skewness	Kurtosis
Phonemic Elision—words	14.56	4.66	.10	−.74	18.09	4.66	−.82	.54	14.20	6.11	−.26	−.74
Phonemic Elision—nonwords	12.54	4.57	.23	−.76	16.00	5.44	−.65	−.08	13.71	6.43	−.21	−.90
RAN-colors	22.34	4.31	1.19	2.48	21.95	4.85	.78	−.10	24.45	5.70	1.63	6.14
RAN-digits	16.63	4.31	1.79	5.27	15.57	3.69	1.17	−.14	16.67	3.77	1.37	3.93
Word analogy	4.52	3.74	.33	−1.27	4.40	3.20	.62	−.88	7.57	3.58	−.49	−.45
Sentence analogy	3.50	3.36	.31	−1.42	6.44	3.25	−.84	−.60	3.14	2.68	.86	−.01
Word formation	5.83	1.60	.17	−.15	7.60	2.19	−1.37	1.51	8.29	1.66	−1.99	5.33
Word identification	58.75	12.18	−.27	−.31	80.12	8.54	−.40	−.39	96.46	6.47	−1.19	1.15
Word attack[a]	24.55	10.60	−.36	−.98	60.65	3.08	−1.42	1.98	39.21	4.83	−1.78	3.96
Word reading fluency	90.98	29.87	.04	−.35	102.13	28.05	.27	.26	103.53	39.22	.70	.11
Decoding fluency	36.41	19.06	.19	−.85	65.23	17.35	.50	1.62	64.99	22.18	.48	−.09
Spelling	23.62	4.73	.99	2.37	21.88	4.16	−.19	.94	22.89	7.02	.28	−.34
Comprehension	28.31	6.70	−.57	.21	25.57	6.45	−.21	.74	26.66	7.42	.79	1.16

[a] The maximum score in the French adaptation of the Word Attack task was 72

SRMR = .044, RMSEA = .083, RMSEA 90% CI [.059, .107]), French[2] (MLR $\chi^2 = 96.65$, $df = 47$, $p < .001$, CFI = .971, TLI = .942, SRMR = .038, RMSEA = .067, RMSEA 90% CI [.048, .086]), and Greek (MLR $\chi^2 = 54.68$, $df = 46$, $p = .178$, CFI = .993, TLI = .988, SRMR = .033, RMSEA = .029, RMSEA 90% CI [.000, .056]). The standardized factor loadings ranged from .639 to .951 in the English group (average $\lambda = .843$), .646–.965 in the French group (average $\lambda = .781$), and .431–.984 in the Greek group (average $\lambda = .782$). The composite reliability and the error-free correlations between the latent variables in each of the three language groups are presented in Table 3.

Structural model

We tested a fully saturated structural model in which the three exogenous latent variables predicted the four endogenous latent variables.[3] The unique/main effects of each of the three predictors on each of the four dependent variables are presented in Table 4 for each of the three language groups.[4]

Reading accuracy was significantly predicted by morphological awareness only in English. The three predictors accounted for 70, 65, and 40% of the variance in reading accuracy in English, French, and Greek, respectively. Morphological awareness explained 2% of unique variance in English and less than 0.5% of unique variance in French and Greek, after controlling for RAN and phonological awareness.

Reading fluency was significantly predicted by morphological awareness in English and French. The three predictors explained a total of 69, 44, and 45% of the variance in reading fluency in English, French, and Greek, respectively. Morphological awareness explained 2.0, 2.6, and 0.7% of unique variance in English, French, and Greek, respectively, after controlling for RAN and phonological awareness.

Spelling was significantly predicted by morphological awareness in each of the three language groups. The three predictors explained a total of 45, 32, and 35% of the variance in spelling in English, French, and Greek, respectively. Morphological awareness explained 1.4, .6, and 1.7% of unique variance in English, French, and Greek, respectively, after controlling for RAN and phonological awareness.

[2] The negative variance of the first indicator of the reading accuracy latent variable had to be fixed at 0 in the French group, thus resulting in a model with 47 degrees of freedom. This constraint did not result in a significant decrement in the model fit and it was deemed necessary to ensure the identification of the measurement model.

[3] The fit of this model was identical to the measurement model because it estimated all relationships between the predictors and the outcomes. However, as in a multiple regression, this model estimated the effect of a predictor when holding constant the effect of the other predictors.

[4] We calculated the change in R^2 to estimate the unique/incremental variance explained by morphological awareness. We tested a first model in which the effects of the covariates were freely estimated but the effect of morphological awareness was fixed to zero (i.e., equivalent to the first step in a hierarchical regression). We tested a second model (equivalent to the second step of a hierarchical regression) in which both the effects of the covariates and morphological awareness were freely estimated. Therefore, the unique/incremental variance explained by morphological awareness (R^2 *change*) is obtained with this formula: R^2 of model 2 minus R^2 of model 1. Results of the second model are presented in Tables 4 and 5. All results from the first model are available upon request.

Table 3 Error-free correlations and composite reliability of the latent variables in each language group

Latent variables	1	2	3	4	5	6	7
English sample							
1. PA	.895						
2. RAN	−.485**	.899					
3. MA	.600**	−.277**	.753				
4. SPELL	.608**	−.476**	.510**	n/a			
5. READCOMP	.509**	−.426**	.645**	.559**	n/a		
6. READACC	.776**	−.558**	.647**	.797**	.726**	.936	
7. READFLU	.745**	−.621**	.614**	.776**	.710**	.967**	.937
French sample							
1. PA	.838						
2. RAN	−.311**	.818					
3. MA	.700**	−.196*	.716				
4. SPELL	.530**	−.192*	.504**	n/a			
5. READCOMP	.539**	−.242**	.661**	.558**	n/a		
6. READACC	.800**	−.276**	.621**	.541**	.479**	.836	
7. READFLU	.454**	−.549**	.468**	.562**	.522**	.418**	.931
Greek sample							
1. PA	.896						
2. RAN	−.558**	.867					
3. MA	.636**	−.422**	.623				
4. SPELL	.545**	−.457**	.479**	n/a			
5. READCOMP	.459**	−.300**	.473**	.419**	n/a		
6. READACC	.533**	−.572**	.427**	.394**	.502**	.844	
7. READFLU	.452**	−.662**	.296**	.667**	.450**	.580**	.971

H coefficient of reliability on the diagonal. *PA* phonemic awareness, *RAN* rapid automatized naming, *MA* morphological awareness, *SPELL* spelling, *READCOMP* reading comprehension, *READACC* reading accuracy, *READFLU* reading fluency

* $p < .05$; ** $p < .01$

Finally, *reading comprehension* was significantly predicted by morphological awareness in each of the three language groups. The three predictors explained a total of 49, 46, and 27% of the variance in reading comprehension in English, French, and Greek, respectively. Morphological awareness explained 14.2, 10.2, and 4.4% of unique variance in English, French, and Greek, respectively, after controlling for RAN and phonological awareness.

Multi-group structural model

We tested a multi-group model in which the relations between the exogenous (i.e., predictors) and endogenous (i.e., outcomes) latent variables were freely estimated in

Table 4 Effects of between morphological awareness on the outcomes in each language group while controlling for phonological awareness and RAN

	English				French				Greek			
	R^2	B	β	*p*	R^2	B	β	*p*	R^2	B	β	*p*
READACC	.699				.648				.400			
MA		1.221	.289	.008		.427	.122	.214		.252	.104	.401
PA		1.289	.484	.000		1.602	.704	.000		.275	.251	.055
RAN		−.761	−.243	.001		−.080	−.032	.627		−.611	−.388	.000
READFLU	.690				.440				.450			
MA		2.770	.268	.015		3.479	.314	.013		−.839	−.052	.643
PA		2.711	.417	.000		.664	.092	.458		1.089	.150	.181
RAN		−2.636	−.345	.000		−3.574	−.458	.000		−6.256	−.600	.000
SPELL	.447				.317				.354			
MA		.402	.232	.027		.446	.262	.023		.580	.199	.044
PA		.382	.351	.003		.373	.336	.006		.403	.306	.002
RAN		−.309	−.241	.001		−.043	−.036	.673		−.383	−.202	.017
READCOMP	.485				.457				.267			
MA		1.312	.537	.000		1.483	.562	.000		.925	.300	.023
PA		.105	.068	.535		.199	.116	.257		.347	.248	.044
RAN		−.442	−.244	.018		−.178	−.096	.118		−.071	−.035	.673

MA morphological awareness, *PA* phonemic awareness, *RAN* rapid automatized naming, *READACC* reading accuracy, *READFLU* reading fluency, *SPELL* spelling, *READCOMP* reading comprehension

Table 5 Significance testing of the difference in parameter estimates across the three language groups

	English versus French		English versus Greek		French versus Greek	
	t test	*p*	*t* test	*p*	*t* test	*p*
READACC						
MA	−1.376	.169	1.757	.079	.385	.700
PA	.907	.364	3.422	.001	4.916	.000
RAN	2.465	.014	−.554	.580	2.356	.018
READEFF						
MA	.393	.695	1.687	.092	1.884	.060
PA	−1.897	.058	1.598	.110	−.352	.725
RAN	−1.054	.292	3.272	.001	2.251	.024
SPELL						
MA	.168	.866	−.525	.600	−.384	.701
PA	−.049	.961	−.117	.907	−.161	.872
RAN	1.904	.057	.397	.692	1.798	.072
READCOMP						
MA	.401	.689	.731	.465	1.158	.247
PA	.383	.702	−1.000	.317	−.603	.547
RAN	1.210	.226	1.484	.138	−.503	.595

MA morphological awareness, *PA* phonemic awareness, *RAN* rapid automatized naming, *READACC* reading accuracy, *READFLU* reading fluency, *SPELL* spelling, *READCOMP* reading comprehension

each of the three language groups. The fit of this model was acceptable[5]: MLR $\chi^2 = 245.09$, $df = 139$, $p < .001$, CFI = .975, TLI = .957, SRMR = .038, RMSEA = .061, RMSEA 90% CI [.049, .074]. We then tested a model in which the 12 relations were fixed to be equal across the three language groups. The fit of this model was not acceptable: MLR $\chi^2 = 423.34$, $df = 163$, $p < .001$, CFI = .938, TLI = .911, SRMR = .176, RMSEA = .089, RMSEA 90% CI [.078, .099]. This model was found to be significantly worse than the one in which the 12 relations were free to vary across groups (ΔMLR $\chi^2 = 199.36$, $\Delta df = 24$, $p < .001$, ΔCFI = .037). Therefore, the null hypothesis of invariance was rejected (Satorra & Bentler, 2001) and language groups significantly moderated some of the 12 relations.

The model without equality constraint was retained as the best fitting structural model (see Table 4). This result provided evidence that at least one of the 12 structural paths (predictors → outcomes) differed significantly across the three language groups. Therefore, to identify the source(s) of non-invariance we performed pairwise comparisons of each parameter in the model. Table 5 indicates that the relations between morphological awareness and literacy outcomes were not significantly different across language groups. However, some of the relations between the covariates and literacy outcomes significantly differed across groups.

[5] The fit of this model corresponds to the sum of MLRχ^2 for the model previously estimated in each of the three language groups.

For instance, the relation between phonological awareness and reading accuracy was weaker in Greek ($\beta = .251$) than in French ($\beta = .704$) or English ($\beta = .484$). The relation between RAN and reading accuracy was weaker in French ($\beta = -.032$) than in English ($\beta = .243$) or Greek ($\beta = -.388$). Finally, the relation between RAN and reading fluency was stronger in Greek ($\beta = -.600$) than in French ($\beta = -.458$) or English ($\beta = -.345$). The relation between morphological awareness and the outcome measures was not significantly moderated by the language groups.

Discussion

The purpose of this study was to examine the relationship between morphological awareness and literacy skills in Grade 2 in three languages with diverse forward consistency (from graphemes to phonemes) and relatively similar backward (from phonemes to graphemes) consistency. We examined the effects of morphological awareness on literacy skills, after controlling for two key predictors of reading and spelling, namely phonological awareness and RAN. Below we discuss the findings that pertain to each literacy outcome.

Morphological awareness and reading accuracy/fluency

The results indicate that morphological awareness uniquely predicted reading accuracy at the end of Grade 2 in English, but not in French or Greek. It was also a unique predictor of reading fluency in English and French, but not in Greek. This pattern of results is consistent with the hypothesis that morphological awareness provides extra support to visual word recognition, particularly in opaque orthographies like English or French. In this respect, English is noticeably more opaque than French, which, in turn, is more opaque than Greek.

The present findings are consistent with those of previous studies with English-speaking (Carlisle, 1995) and French-speaking children (Casalis & Louis-Alexandre, 2000), but they differ from those that did not detect a significant contribution of morphological awareness before Grade 3 (Deacon & Kirby, 2004; Kirby et al., 2012). A possible explanation is that a broader range of indicators was used to assess morphological awareness in the present study than in previous studies, which may have resulted in a more precise or stable estimation of this ability. Another feature of the present study is that reading accuracy and reading fluency were measured by separate tasks rather than by a single task, as in Casalis and Louis-Alexandre's (2000) study. This decision may have made it easier to pinpoint which aspects of early reading performance are facilitated by morphological awareness within each language.

The absence of morphological facilitation in Greek is consistent with the results reported in previous studies (Grigorakis, 2014; Manolitsis, 2006). These showed that composite measures of morphological awareness did not predict word reading accuracy or fluency up to Grade 2, after controlling for the effects of phonological awareness and RAN. This finding was expected because Greek-speaking children can rely on grapheme-to-phoneme correspondences to read any word (Georgiou et al., 2012a, b; Papadopoulos, 2001). RAN explained most of the variance in reading accuracy and fluency in Greek, which is also consistent with previous findings (e.g., Georgiou, Parrila, & Papadopoulos, 2008; Georgiou et al., 2012a, b; Protopapas, Altani, & Georgiou, 2013).

Morphological awareness and reading comprehension

The results showed clearly that morphological awareness was a unique predictor of reading comprehension beyond the effects of phonemic awareness and RAN across the three languages. The unique and equal contribution of morphological awareness to reading comprehension across languages is consistent with the assumption that both involve semantic processing: as the ability to manipulate units of meaning develops so does reading comprehension. Previous studies have indeed shown that morphological awareness is associated with vocabulary knowledge (Carlisle & Fleming, 2003; Singson, Mahony, & Mann, 2000) and with reading comprehension in English (Carlisle, 2000; Cunningham & Carroll, 2015; Kirby et al., 2012), in French (Casalis & Louis-Alexandre, 2000), and in Greek (Grigorakis, 2014; Pittas & Nunes, 2014; Rothou & Padeliadu, 2015). The present study provides additional empirical evidence in support of a longitudinal contribution of morphological awareness to reading comprehension as early as in Grade 2 (Casalis & Louis-Alexandre, 2000; Grigorakis, 2014) and thus prior to Grade 3 as reported in other studies (Carlisle, 2000; Deacon & Kirby, 2004; Kirby et al., 2012; Rothou & Padeliadu, 2015).

Word morphology is expected to play a role at several levels of language processing (Nagy, Carlisle, & Goodwin, 2014). At the word level, for instance, morphological knowledge may support a form of chunking that highlights semantic relations among words (e.g., *act*, *acting*, *enacting*, and *actor*) and facilitates their interpretation. At the syntax level, bound morphemes may signal particular subcategorization functions (e.g., grammatical categorization, number, gender, case, verb attributes such as tense, mode, and aspects) that facilitate sentence interpretation. The developmental trajectory of these subcategorization functions, however, may vary according to the complexity of the linguistic signals that carry them and the complexity of the concepts these signals convey.

Morphological awareness and spelling

A basic procedure for spelling consists of segmenting a string of phonemes, converting each phoneme into its corresponding grapheme, and assembling the resulting string of graphemes. This procedure is expected to work optimally for languages with highly regular phoneme-to-grapheme relations (e.g., Finnish). None of the three languages included in the present study strictly meets this requirement (Ziegler, Jacobs, & Stone, 1996; Ziegler & Stone, 1997; Protopapas & Vlahou, 2009). It is estimated that over 50% of English and French words are morphologically complex (Anglin, 1993; Berthiaume et al., 2010; Nagy & Anderson, 1984); derivation is also a productive word formation procedure in Greek (Holton et al., 2004). Thus, morphological awareness should be a unique predictor of spelling over and above phonological awareness. Our findings are in line with this expectation and consistent with those of previous studies in English (Deacon et al., 2009; Nunes et al., 1997; Wolter et al., 2009), French (Casalis et al., 2011; Plaza & Cohen, 2004; Sanchez et al., 2012; Sénéchal, 2000), and Greek (Bryant et al., 1999; Grigorakis & Manolitsis, 2016; Nunes et al., 2006). Importantly, this contribution was detected as early as in Grade 2, while other studies have not reported this link before Grade 3 (Angelelli, Marinelli, & Burani, 2014; Casalis et al., 2011; Deacon et al., 2009; Pittas & Nunes, 2014; Sénéchal et al., 2006). Despite important differences in morphological complexity between English, French, and Greek, the multi-group analysis did not reveal any significant differences in the strength of the relation between morphological awareness and spelling performance across these languages. This suggests that the morphological complexity of the language of instruction did not moderate the relationship between morphological awareness and spelling performance in these samples of Grade 2 children.

The contribution of morphological awareness, phonological awareness and RAN

The present study highlighted the longitudinal contribution of morphological awareness to the development of word reading (accuracy and fluency), spelling, and reading comprehension when important predictors are controlled for. The extent of this contribution, however, can only be estimated in comparison to other variables. Relative to phonological awareness and RAN, the contribution of morphological awareness was more modest but significant for several outcome measures. The main reason for this modest contribution is likely that the development of morphological awareness is not nearly as advanced in Grade 2 as that of phonological awareness or RAN (Grigorakis, 2014). There is some evidence, however, that the developmental trajectory of morphological awareness has a much longer span than that of phonological awareness (Berninger, Abbott, Nagy, & Carlisle, 2010) and that the strength of its relationship to reading increases with grades (Carlisle, 1995; Nagy, Berninger, & Abbott, 2006; Singson et al., 2000).

Limitations of the present study

Cross-linguistic research exacerbates the methodological challenges faced in single-language studies. For instance, the population of words in different alphabetic languages may vary along many attributes such as the range of phonemes represented by graphemes, how phonemes are mapped onto graphemes, typical word length, or the number of root words. In the present study, we found it difficult to strictly match the word samples for the word reading tasks across languages because monosyllabic words are far more common in English than they are in French and, particularly, in Greek. Moreover, these three languages vary significantly in morphological complexity. The number inflection system of English and French nouns, for example, is considerably simpler than that of Greek with its 41 different inflectional suffixes (Kalamboukis, 1995). Equating morphological features for cross-linguistic comparisons often results in the sampling of a relatively narrow range of features from more morphologically complex languages, which necessarily occurred in the construction of the morphological awareness tasks in the present study. A second limitation concerns the risk of confound between the language of instruction and curriculum or reading/spelling instruction practices in different language communities. Caution is therefore in order in the interpretation of cross-linguistic results since it is typically difficult to sort the influence of language characteristics from that of teaching practices. A related third limitation concerns the difficulty of equating the amount of school learning achieved across language groups when the predictors and the outcome variables were measured. Children studying under different curricula may not have reached the same stage on their learning trajectory when these measures were taken. This issue is relevant because the predictive sensitivity of some indicators, such as for morphological awareness, is known to vary along this trajectory (Carlisle, 1995; Nagy et al., 2006). Finally, our study is correlational in nature and any effects do not necessarily imply causation.

Conclusion

The present study provides empirical evidence for the importance of morphological awareness in different aspects of literacy learning across three languages varying in orthographic consistency. Specifically, morphological awareness was found to contribute uniquely to spelling and reading comprehension performance across all three languages beyond the effects of phonemic awareness and RAN, which are known to be key predictors of early literacy learning (e.g., Caravolas et al., 2012; Georgiou et al., 2008; Ziegler et al., 2010). We argue that morphological knowledge is particularly useful for spelling words constructed from inconsistent phoneme-to-grapheme relations because morphemes are often more orthographically regular and predictable. Reading comprehension also benefits from morphological awareness because morphological segmentation highlights units of meaning in word and sentence processing. Finally, the results reported in the present study are consistent with the claim that the contribution of morphological awareness in early word reading accuracy and fluency (i.e., before Grade 3) is language specific. This contribution was observed in word reading accuracy and/or fluency in English and French, two languages with grapheme-to-phoneme correspondences that are less consistent than those of Greek. Future studies may verify these claims over a longer developmental span, with languages representing different writing systems, and with larger samples of participants.

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