Applied Psycholinguistics (2022), 1–23
doi:10.1017/S0142716422000194

CAMBRIDGE UNIVERSITY PRESS

ORIGINAL ARTICLE

Clarifying links to literacy: How does morphological awareness support children's word reading development?

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(Received 2 March 2021; revised 4 January 2022; accepted 29 May 2022; first published online 20 July 2022)

Abstract

We know a great deal about children's first steps into reading. Here, we explore how they become more sophisticated readers, learning to read complex words. Theoretical accounts predict that one key factor is morphological awareness, or awareness of the minimal units of meaning in language. And yet empirical studies have yet to clarify whether morphological awareness has a stronger relation to the development of reading skill for words with multiple morphemes in particular (i.e., morphological decoding) or to the reading of a whole range of words. We examined this question in this study by contrasting the role of morphological awareness in the development of morphological decoding and of broader word reading skill. Participants were 197 English-speaking children who were followed from Grade 3 to 4. We conducted longitudinal analyses that included stringent autoregressive controls to capture the determinants of gains over time, as well as controls for vocabulary and phonological awareness. Structural equation modeling (SEM) path analysis with this set of controls revealed that morphological awareness predicted significant unique gains in morphological decoding from Grade 3 to 4 with no such unique contributions to broader word reading skill. These findings clarify the role of morphological awareness in supporting children in developing the ability to read morphologically complex words, supporting a more targeted role for morphology in theories of word reading development.

Keywords: morphological awareness; morphological decoding; word reading; reading development; children; longitudinal

A core challenge for theories of word reading development is to explain how children transition from effortful, letter-by-letter decoding to fast and accurate identification of individual words. Many prominent models of reading development point to phonological awareness as central in establishing letter-sound correspondences, which in turn propel children's learning to read individual words (e.g., Ehri, 2005). And yet phonological awareness is unlikely to be the only factor in this development. A word such as *dishonest*, for instance, would be mispronounced by reference to phonology alone, reflecting the fact that English is a morphophonemic orthography (e.g., Venezky, 1967). Morphological awareness, or the awareness of and ability to manipulate the smallest units of meaning in language (Carlisle, 2000), has been gaining momentum as a second predictor (e.g., Castles et al., 2018; Deacon & Kirby, 2004). Indeed, there is now over a decade of theoretical advocacy for a role of morphological awareness in supporting children in reading morphologically complex words such as *dishonest* (e.g., Kuo & Anderson, 2006; Levesque et al., 2021). These could be words with several base morphemes (i.e., compound words) or with a base morpheme and one or more affixes (i.e., prefixed and suffixed words). Morphologically complex words are incredibly prevalent in children's texts (Anglin, 1993; White et al., 1989). And yet, most empirical studies have evaluated, and confirmed, a role for morphological awareness in children's broader word reading skill, assessed by standardized measures of word reading that include both morphologically complex and simple words (e.g., Deacon & Kirby, 2004). The mismatch between available evidence and theoretical predictions fact has led to repeated calls for research to clarify the role of morphological awareness in word reading development (Carlisle, 2010; Nagy et al., 2014; Sénéchal & Kearnan, 2007). We report here on a longitudinal study designed to do so by contrasting the relative role of morphological awareness in developing skill in reading morphologically complex words and in broader word reading skill.

Theoretical context

Multiple theories (e.g., Perfetti & Stafura, 2014; see also Reichle & Perfetti, 2003; Schreuder & Baayan, 1995) advocate a targeted role for morphological awareness in morphological decoding, or what has been defined as the use of morphemes in word reading (Deacon et al., 2017; Nagy et al., 2006; see also morphological decomposition, Verhoeven & Perfetti, 2011). Morphological decoding is a reading strategy in which children leverage individual morphemes to facilitate the reading of multimorphemic words (Carlisle & Stone, 2005; Deacon et al., 2017; Goodwin et al., 2017). For instance, children could use morphological decoding to read the word *dishonest*, helping them to decide to pronounce *sh* by the morpheme boundary (*dis*+*honest*) rather than its more frequent pronunciation as a digraph (e.g., /⊠/ in *dishes*). Accumulating research shows that English-speaking children use morphemes to read words (e.g., Carlisle & Stone, 2005; Deacon et al., 2011; Goodwin et al., 2017; Goodwin, Gilbert, & Cho, 2013). This finding resonates with results from priming paradigms (e.g., Rabin & Deacon, 2008; Deacon, Campbell, Tamminga, & Kirby, 2010; McCutchen, Logan, and Biangardi-Orpe, 2009), several of which suggest a temporally late role for morphosemantic processing (e.g., Quémart, Casalis, & Colé, 2011; Quémart, Gonnerman, Downing, & Deacon, 2018). Awareness of the morphological structure of words is argued to give developing readers insight into the morphemic structure of their writing system (Kuo & Anderson, 2006) and make morpheme boundaries more salient when reading (Carlisle, 2010). This enables the parsing of words into their constituent morphemes, which facilitates faster and more accurate reading of morphologically complex words. From this view, morphological awareness should have a stronger role in the development of children's morphological decoding.

These ideas form the conceptual foundation for a recent model, Morphological Pathways Framework (Levesque et al., 2021). In this framework, morphological awareness predominately influences reading processes by facilitating the recognition and use of morphemes in reading words. Accordingly, the Morphological Pathways Framework predicts that morphological awareness has a targeted effect on morphological decoding. This prediction adds mechanistic detail to prior models, such as the Reading Systems Framework (Perfetti & Stafura, 2014). In the Reading Systems Framework, as a part of the linguistic system (Perfetti et al., 2005), morphology connects to both the orthographic system and the lexicon, and thereby to word reading (see also Reichle & Perfetti, 2003; Schreuder & Baayen, 1995). The Morphological Pathways Framework builds on this deep foundation to make a specific prediction for the role of morphological awareness in morphological decoding.

Empirical research to date

In contrast to these theoretical predictions of a targeted and/or stronger role in morphological decoding, most empirical studies have evaluated the role of morphological awareness in broader word reading skill. We use this term—broader word reading skill—here and throughout this manuscript to refer to measurement of word reading ability with standardized assessments. Standardized tests of word reading are designed to capture broad word reading skill in their strategic inclusion of a wide variety of words, including ones that with a single (e.g., *forest*) or multiple morphemes (e.g., *courageous*), that are regular and irregular, and also nonwords. Most studies to date on the effects of morphological awareness have included such standardized measures (e.g., Apel et al., 2013; Deacon & Kirby, 2004; Kirby et al., 2012). Indeed, a large set of cross-sectional studies have demonstrated a relation between morphological awareness and performance on these measures of broader word reading skill (e.g., Choi et al., 2017; Goodwin et al., 2013; Roman et al., 2009). For instance, Kirby and colleagues (2012) demonstrated significant relations between children's morphological awareness and their performance on several standardized tests of word reading, including Word Identification (Woodcock, 1998) and the Test of Word Reading Efficiency (TOWRE; Torgesen et al., 1999).

A smaller set of longitudinal studies have shown that morphological awareness makes a unique contribution to gains in broader word reading skill over time by including stringent autoregressive controls (Deacon et al., 2013; Kirby et al., 2012; Kruk & Bergman, 2013). For instance, Deacon and colleagues (2013) showed that morphological awareness assessed in Grade 2 predicted children's gains in broader word reading skill between Grades 2 and 3. Kruk and Bergman (2013) showed similar unique relations between Grades 1 and 3, including after controls for vocabulary and phonological awareness. Together, these studies provide evidence that morphological awareness supports the development of broader word reading skill.

This association with broader word reading skill fits with some views that morphological awareness supports word reading skill across a whole range of words. It has been argued to do so by facilitating the mappings between print and meaning (Perfetti, 2007; Rastle, 2018) or by binding letters, sounds, and meaning of words in memory (Kirby & Bowers, 2017). Others have suggested morphological awareness reflects a broad form of linguistic awareness encompassing elements of meaning, syntax, and phonology, which together could have a widespread influence on word reading development (Carlisle, 2003; Kuo & Anderson, 2006). And indeed, just as phonological awareness initially serves to secure regular words in memory through robust letter-sound connections which then supports memory for both phonologically regular and irregular words (e.g., Ehri, 2014), the influence of morphological awareness could certainly extend beyond just the reading of morphologically complex words (see also Deacon & Kirby, 2004).

And yet, the use of standardized measures of word reading in prior studies also means that the possibility that morphological awareness has a stronger influence on morphological decoding has not been directly tested. Roughly one-third of the words included on standardized assessments are morphologically complex (e.g., Deacon et al., 2013; Goodwin et al., 2013), with most of these toward the end of the test. The use of stop rules means that readers reach these words to differing degrees, both within and across studies. Given this variability, it is not clear the extent to which performance on standardized tests captures, or is confounded by, morphological decoding. Indeed, it seems more likely that the effects of morphological awareness would be stronger for words with a morphological structure than for broader measures of word reading; effects on morphological decoding are in effect "near transfer," while those for broader word reading constitute "far transfer."[1]

Testing the theoretically based prediction that effects of morphological awareness on word reading outcomes are stronger to morphological decoding requires more targeted measurement of morphologically complex words. A handful of studies have done so, providing evidence of relations between morphological awareness and morphological decoding (Carlisle, 2000; Mann & Singson, 2003; Nagy et al., 2006). For instance, in a cross-sectional study with students in Grades 4 to 9, Nagy and colleagues (2006) found that morphological awareness was uniquely related to multiple measures of morphological decoding, beyond phonological skills. These studies did not include measures of broader word reading skill though, limiting their ability to evaluate unique effects.

Three recent studies with mid- to upper elementary school aged children included measures of morphological decoding as well as of broader word reading skill (Goodwin et al., 2013; Kearns, 2015; Levesque et al., 2017). This is an important step forward, as it enables a direct contrast of the relative size of the contributions of morphological awareness to reading of morphologically complex words and to broader word reading skill. With this approach, Goodwin et al. (2013) and Kearns (2015) showed that morphological awareness predicted morphological decoding above and beyond standardized assessments of word reading skills in their studies. Similar findings emerged with SEM modeling with children in Grade 3; Levesque and colleagues (2017) found that morphological awareness was related to morphological decoding, with no direct unique link to broader word reading skill;

there were, however, indirect effects of morphological awareness on morphological decoding and in turn on broader word reading skill. Taken together, these studies support the idea that morphological awareness is more strongly related to morphological decoding than to broader word reading skill.

The next key step in this line of research is to assess whether morphological awareness supports gains in morphological decoding over time, an important move beyond demonstrating associations at a single point in time. This can be done by controlling for prior performance on word reading tests (i.e., the autoregressor) when evaluating the contributions of earlier levels of morphological awareness on later word reading performance. In this way, autoregressive models identify factors that determine change over time (Raudenbush, 2001; Selig & Little, 2012). This approach has been used to demonstrate that morphological awareness is related to children's gains in broader word reading skill (e.g., Deacon et al., 2013; Kruk & Bergman, 2013). We apply this approach here to test the theoretically driven prediction that morphological awareness has a stronger role in the development of morphological decoding skill by contrasting its effects on the development of broader word reading skill.

The current study

In this study, we evaluate whether morphological awareness has a stronger role in supporting gains in morphological decoding or in broader word reading skill. We did so in a longitudinal study of children from Grade 3 to 4. At Grade 3, we assessed morphological awareness with two orally presented and widely used tasks: the Word Analogy Task (Kirby et al., 2012) and the Test of Morphological Structure (Carlisle, 2000). We also included vocabulary and phonological awareness, measured with standardized tests, as controls in our models given their well-established connections to reading-related skills (e.g., Deacon & Kirby, 2004). At both Grades 3 and 4, we included multiple measures of morphological decoding (Levesque et al., 2017; Nunes et al., 2012) and standardized tests of word reading skill at both grades (Torgesen et al., 1999). The standardized measures include morphologically complex words (e.g., *factories* and *straighten*) and so they likely capture morphological decoding to some extent. This means that models that contrast effects on morphological decoding with those in gains in broader word reading skill offer a particularly stringent test of the prediction that morphological awareness is more strongly related to gains in morphological decoding.

The mid-elementary grades are a highly relevant time period to evaluate these effects. In line with developmental phases of word reading, progress in word reading efficiency during this period is driven by the use of salient, recurring letter patterns such as morphemes (Ehri, 2014). Moreover, texts during these grades are replete with morphologically complex words (Anglin, 1993; White et al., 1989), and children are also rapidly developing knowledge of derivational morphology (Carlisle, 2003; Foorman et al., 2012). Within this context, we tested whether children's morphological awareness in Grade 3 has stronger unique effects on gains in morphological decoding or in broader word reading skill between Grades 3 and 4.

https://doi.org/10.1017/S0142716422000194 Published online by Cambridge University Press

Answering this question requires distinguishing between morphological decoding and broader word reading skill. And yet, skill in morphological decoding is likely to be related to broader word reading skill; reading single- and multimorphemic words and nonwords engages the same lexical architecture for word identification (Perfetti & Stafura, 2014). In this context, we begin our analyses by contrasting a two-factor model separating measures of morphological decoding from standardized measures of word reading with a unidimensional model in which all tasks converge as a single "word reading" factor. Establishing separability of morphological decoding from broader word reading skill is a necessary first step toward answering our primary research question. In doing so, we build on the small set of prior work showing the empirical separability of morphological decoding from broader word reading skill (Levesque et al., 2017; Nunes et al., 2012).

Based on the Morphological Pathways Framework (Levesque et al., 2021), we predicted that children's morphological awareness would predict unique variance in gains in their morphological decoding between Grades 3 and 4, beyond its effects on broader word reading. This finding would also be in keeping with the limited cross-sectional research testing these questions (e.g., Goodwin et al., 2013; Kearns, 2015). It offers a critical extension to these findings by testing effects on change in skill level over time.

Methods

Participants

Participants were 197 children (106 girls) who were followed from Grade 3 to 4 as a part of a larger study. Data for these children at Grade 3 were reported in Levesque et al. (2017), and we report here on data from both Grades 3 and 4. Participants were on average 8 years and 10 months old ($SD_{\text{age}} = 3.91$ months) in Grade 3 (Grade 4: $M_{\text{age}} = 9$y;10m, $SD_{\text{age}} = 3.84$ months). Ninety-three percent of children spoke English as their first language, and most of the participants (85%) were English monolingual speakers. Participants were recruited from 13 elementary schools. The children's instruction was entirely in English at Grade 3 and in the schools in which recruitment occurred, literacy instruction generally integrates both whole-language and phonics instruction. Children were in the average range for their age on standardized assessments of phonological awareness, vocabulary, and word reading (see Table 1), suggesting that the sample was representative of typically developing children. On average, households in the catchment areas for the schools are in the middle to upper-middle SES class (Statistics Canada, 2017).

Measures

Standardized tasks were administered and scored as per manual instructions. Task reliability estimates (Cronbach's alpha) are provided in Table 1.

Morphological decoding

Morphological decoding was measured with three tasks evaluating children's accuracy in reading aloud morphologically complex words and pseudowords.

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Table 1. Descriptive statistics for Grade 3 and Grade 4 measures

Measures (maximum raw score)	*M* raw score (*SD*)	*M* std. score (*SD*)	Reliability	Skewness	Kurtosis	Factor loadings
Grade 3 measures						
Broader word reading skill factor						
Sight Word Efficiency (104)	61.71 (11.61)	107.42 (12.36)[a]	>.93[b]	−1.02	1.53	.86
Phonemic Decoding Efficiency (63)	27.05 (12.00)	101.48 (14.33)[a]	>.93[b]	−0.09	−0.56	.92
Morphological decoding factor						
Morphologically Derived Word Reading (40)	20.51 (8.04)	–	.92[c]	−0.45	−0.54	.96
Use of Morphological Units in Real Words (19)	9.50 (5.29)	–	.91[c]	−0.16	−1.08	.93
Use of Morphological Units in Pseudowords (15)	4.11 (3.23)	–	.81[c]	0.52	−0.78	.82
Morphological awareness factor						
Word Analogy Task (20)	15.24 (5.24)	–	.86[c]	−0.41	−0.09	.91
Test of Morphological Structure (28)	11.29 (3.97)	–	.79[c]	−0.31	−0.45	.76
Vocabulary (228)	146.09 (15.83)	106.47 (12.33)[a]	>.97[b]	−0.80	2.95	–
Phonological awareness (20)	12.21 (4.82)	9.88 (2.95)[d]	.79[b]	0.02	−1.49	–
Grade 4 measures						
Broader word reading skill factor						
Sight Word Efficiency (104)	66.25 (11.46)	105.19 (12.43)[a]	>.93[b]	−1.12	1.89	.84
Phonemic Decoding Efficiency (63)	30.68 (12.27)	100.57 (16.00)[a]	>.93[b]	−0.36	−0.38	.90
Morphological decoding factor						
Morphologically Derived Word Reading (40)	23.26 (7.56)	–	.91[c]	−0.79	0.36	.95
Use of Morphological Units in Real Words (19)	13.09 (4.80)	–	.90[c]	−0.83	−0.19	.92
Use of Morphological Units in Pseudowords (15)	6.16 (3.36)	–	.78[c]	0.04	−0.93	.78

Note. M = mean. SD = standard deviation. [a]Age-based standard score with a mean of 100 ($SD = 15$). [b]Reliability from manual. [c]Cronbach's alpha reliability. [d]Age-based standard score with a mean of 10 ($SD = 3$).

These tasks were designed to engage morphological processes in reading. Together, these tasks gauge participants' ability to use the structure and morpheme boundaries within written multimorphemic words to produce their correct pronunciation.

Morphologically Derived Word Reading. For this morphological decoding task (taken from Levesque et al., 2017), participants read aloud 40 derived words (*questionable*). These multimorphemic words consisted of a base morpheme (*question*) and a derivational suffix among the 20 most common English suffixes (*-able*, *-al*, *-ly*, *-ment*, *-ful*, *-less*, *-ness*, and *-ous*; Blevins, 2001). All derived words had a low whole-word frequency (<5 occurrences per million words in text, *U*, based on Zeno et al., 1995; $M_{surface\ U} = 1.60$). Critically, derived words had a high-frequency base morpheme ($U \geq 48$; $M_{base\ U} = 148.18$). The high-frequency base provides an opportunity for morphological decoding to occur while children are reading these infrequent morphologically complex words (see e.g., Hay, 2001; McCutchen & Logan, 2011). About half of the derived words were phonologically and orthographically transparent with their base morpheme (e.g., *reasonless*); the remaining half had either a phonological change (e.g., *publicity*), an orthographic change (e.g., *heaviness*), or both a phonological-orthographical change (e.g., *studious*) between the base and the derive word (see Appendix).

Use of morphemes in reading real words. Taken from Nunes and colleagues (2012), the second morphological decoding task assessed children's use of morphemes in reading individual words (19 items). In this task, the correct pronunciation of the words depends on their segmentation into morphemes (Nunes et al., 2012). For instance, the words *unusual* and *uniform*, both beginning with *un*, are pronounced differently based on their morphological structure. Segmenting the words at their correct morpheme boundary (*un* + *usual* vs. *uni* + *form*) enables readers to arrive at the accurate pronunciation. In contrast, identifying the wrong morpheme boundary to segment the word leads to incorrect responses (e.g., pronouncing the prefix *un* in *uniform*).

Use of morphemes in reading pseudowords. Also taken from Nunes and colleagues (2012), the third morphological decoding task assessed children's use of morphemes in reading pseudowords (15 items). Pseudowords were items with real morphemes put together to form nonwords (e.g., prefix *uni* + base *match* to form the pseudoword *unimatch*). As with the previous task with real words, the correct pronunciation of pseudowords words depends on their segmentation at the correct morpheme boundary (Nunes et al., 2012). For instance, both *mishope* and *unishaped* include *sh*; correct pronunciation of these pseudowords requires distinguishing that the digraph *sh* is treated differently based on whether it aligns with a morpheme boundary (*mis* + *hope* vs. *uni* + *shaped*). In this sense, this pseudoword task strongly elicits morphological decoding processes in reading, because the whole-word forms do not exist in spoken or written language.

DirectRT software (Jarvis, 2008) displayed the stimuli for the three morphological decoding tasks. The three tasks were administered separately, with items within each task appearing in a random order. Single words were displayed in the center of the screen in black 40-point Arial font. Words were preceded by a 1-s central

https://doi.org/10.1017/S0142716422000194 Published online by Cambridge University Press

fixation and appeared for a maximum of 5 s. Participants read the words aloud, and the experimenter recorded the accuracy of responses.

Broader word reading skill

Sight Word Efficiency. The Sight Word Efficiency subtest of the Test of Word Reading Efficiency (Torgesen et al., 1999) includes a list of real words printed in order of increasing difficulty (e.g., *bat*, *plates*, and *forest*). The subtest measures children's ability to recognize words as whole units quickly and accurately (i.e., sight word reading).

Phonemic Decoding Efficiency. The Phonemic Decoding Efficiency subtest presents a list of pronounceable nonwords in order of increasing difficulty (e.g., *daf*, *shloo, straler*; Torgesen et al., 1999). This subtest evaluates children's ability to decode, or sound out, printed nonwords quickly and accurately.

In keeping with prior literature, we chose the Sight Word Efficiency and Phonemic Decoding Efficiency subtests in an effort to capture children's broader word reading skill. Together, these two standardized subtests provide a reliable index of word reading accuracy and fluency. Roughly, 30% of words on the Sight Word Efficiency subtest are morphologically complex (e.g., *factories* and *straighten*), and some nonwords have prefix- and suffix-resembling letter patterns (e.g., *de-* in *depate*; *-er* in *debmer*). In keeping with best practices, the children took a different form of the TOWRE in Grade 3 than in Grade 4.

Morphological awareness

We assessed morphological awareness with two widely used tasks: the Word Analogy Task (Kirby et al., 2012) and the Test of Morphological Structure (Carlisle, 2000). Both were administered orally, in keeping with standard practice (e.g., Kirby et al., 2012).

Word Analogy Task. As in Kirby et al. (2012), the Word Analogy Task presented pairs of morphologically related words in an analogy format (A:B::C:D). Participants heard a pair of words (A:B), followed by the first word of a second pair (C). Participants were then asked to complete the pattern by providing the missing word of the second pair (D) (e.g., *help*: *helped*:: *say*: [*said*]). Participants completed five practice and 20 test items. Of the 20 test items, half were inflected words and half were derived. Both inflected and derived items included phonologically transparent (*walk-walked*) and phonological opaque transformations (*stood-stand*).

Test of Morphological Structure. For the Test of Morphological Structure (Carlisle, 2000), a target item was presented followed by an incomplete sentence. Participants were asked to change the target word to complete the sentence (e.g., *Farm. My uncle is a ___* [*farmer*]). Feedback was provided for three practice items. The task included 28 target items. Half involved the production of a derived word from a base word (e.g., *protect* to *protection*) and half the decomposition of a derived form to its base form (e.g., *growth* to *grow*). Further, half of the items were phonologically transparent transformations (e.g., *accept–acceptance*) and half were phonologically opaque (e.g., *revise–revision*).

Controls

We included vocabulary and phonological awareness as controls given their well-established connections to reading-related skills (e.g., Deacon & Kirby, 2004).

Vocabulary. Using the Peabody Picture Vocabulary Test—Fourth Edition (Dunn & Dunn, 2007), participants heard individual words of increasingly difficulty spoken by the experimenter. They were shown four pictures and asked to indicate the picture that best represented the word.

Phonological awareness. We used the Elision subtest of the Comprehensive Test of Phonological Processing (Wagner et al., 1999). Participants heard up to 20 words presented one at a time by the experimenter. Children repeated each target word verbatim and again without a specific sound (e.g., "Say *stale*. Now say *stale* without saying /t/"; [*sale*]).

Procedure

This study was approved by the institutional and school board ethics committees. Written consent was obtained from parents, and oral assent was obtained from each child at every testing session. In each of Grades 3 and 4, testing took place from February to May with approximately 12 months separating the two testing points for any given participant.

The measures were administered within a battery of tasks as part of a larger longitudinal study, in which measures of morphological decoding and broader word reading skill were administered in Grades 3 and 4. Measures of morphological awareness, vocabulary, and phonological awareness were administered in Grade 3. All tasks were administered individually in a fixed order by a research assistant in a quiet location in the child's school across two or more sessions based on the child's interest and the school's schedule.

Data analysis

We used structural equation modeling to test the contribution of morphological awareness to morphological decoding and to broader word reading skill from Grade 3 to 4. Analyses were conducted with participants' raw scores using Mplus 8.0 (Muthén & Muthén, 2017). We used full-information maximum likelihood robust (MLR) to account for missing data (Enders, 2013) and guard against bias due to non-normality and non-independence of observations (Finney & DiStephano, 2013). MLR necessitates the Satorra–Bentler scaled chi-square difference test when comparing the goodness of fit across competing theoretical models (Bryant & Satorra, 2012). Model fit was evaluated across several indices, such as the chi-square statistical test, comparative fit index, Tucker–Lewis index, root mean square error of approximation, and standardized root mean residual, as per Kline, 2016 (see also Hooper et al., 2008; Schreiber, 2017). Across all analyses, our modeling decisions considered fit statistics and guidance from theory and prior research.

Table 2. Correlations between measures

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Gr3 Sight Word Efficiency	–													
2. Gr3 Phonemic Decoding Efficiency	.78	–												
3. Gr3 Morphologically Derived Word Reading	.83	.84	–											
4. Gr3 Use of Morphological Units in Real Words	.77	.81	.88	–										
5. Gr3 Use of Morphological Units in Pseudowords	.61	.68	.74	.82	–									
6. Gr3 Word Analogy Task	.46	.48	.52	.52	.50	–								
7. Gr3 Test of Morphological Structure	.52	.51	.57	.58	.43	.69	–							
8. Gr3 Vocabulary	.44	.45	.50	.53	.40	.58	.72	–						
9. Gr3 Phonological awareness	.36	.48	.46	.47	.41	.32	.31	.26	–					
10. Gr4 Sight Word Efficiency	.86	.71	.78	.71	.55	.46	.53	.48	.39	–				
11. Gr4 Phonemic Decoding Efficiency	.81	.89	.87	.85	.71	.48	.51	.46	.48	.77	–			
12. Gr4 Morphologically Derived Word Reading	.83	.81	.90	.86	.72	.52	.61	.57	.45	.78	.87	–		
13. Gr4 Use of Morphological Units in Real Words	.79	.76	.84	.77	.73	.53	.56	.51	.43	.73	.82	.86	–	
14. Gr4 Use of Morphological Units in Pseudowords	.65	.66	.75	.87	.73	.47	.45	.39	.44	.60	.71	.75	.77	–

Note. $N = 197$. Gr3 = Grade 3. Gr4 = Grade 4. All correlations are significant, $p < .01$.

Results

Preliminary analyses

Table 1 presents descriptive statistics. Inspection of the data (e.g., outliers and skewness) showed no indication of non-normality or other concerns (Field, 2009). The amount of missing data was small, averaging less than 2% across measures ($M = 1.97\%$; $SD = 2.36\%$). MLR enabled the use of data from the full sample (Brown, 2006; Enders, 2013). Correlations are presented in Table 2. Brief inspection of this table reveals that morphological awareness at Grade 3 has a stronger relation to vocabulary than to phonological awareness at the same grade (see e.g., Sparks & Deacon, 2015). Critically, there were significant relations of morphological awareness at Grade 3 to both morphological decoding and broader word reading at Grade 4, with stronger relations to morphological decoding than to broader word reading. Stable correlations between each of morphological decoding and broader word reading between Grades 3 and 4 support the use of autoregressor controls to examine these relations.

Building an autoregressive SEM model

As a foundation for a theoretically justified autoregressive model (Agresti & Finlay, 2009), we assessed the theoretical structure among latent variables by fitting a two-

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Table 3. Model fit statistics for the two-factor and unidimensional word reading models in Grade 3 and 4

Model	χ^2	df	p	CFI	TLI	RMSEA	SRMR	BIC	Satorra–Bentler scaled χ^2 difference test
Grade 3									
2-factor model	25.00	4	<.05	.97	.94	.16	.03	5672.03	
1-factor model	32.55	5	<.05	.96	.93	.17	.03	5675.85	7.36 (1), p < .01
Grade 4									
2-factor model	11.71	4	<.05	.99	.98	.10	.02	5687.96	
1-factor model	15.07	5	<.05	.99	.98	.10	.02	5686.28	3.34 (1), $p = .06$

Note. The Satorra–Bentler scaled χ^2 difference test, which uses a scaled correction factor, compared the fit of the 2-factor and 1-factor models at each grade. CFI = comparative fit index. TLI = Tucker–Lewis index. RMSEA = root mean square error of approximation. SRMR = standardized root mean square residual. BIC = Bayesian information criterion.

factor model consisting of a morphological decoding factor and a broader word reading skill factor at both grades. The indicators for these factors and their loadings are listed in Table 1. At each grade, we contrasted this two-factor model with a unidimensional word reading factor (i.e., all tasks converging as a single construct). Model fit estimates for the two-factor model and unidimensional model for Grade 3 and 4 are presented in Table 3. Contrasting the two-factor and single-factor models tests whether morphological decoding is separable from broader word reading skill.

The two-factor model was a better fit than the unidimensional model; this difference was significant in Grade 3, Satorra–Bentler $\Delta\chi^2 = 7.36$, $\Delta df = 1$, $p < .01$, and a near-significant trend in Grade 4, Satorra–Bentler $\Delta\chi^2 = 3.34$, $\Delta df = 1$, $p = .06$. These findings suggest that morphological decoding is separable from broader word reading skill. The two-factor model was retained in both grades given these results as well as the a priori theoretically driven goal to evaluate contributions of morphological awareness to morphological decoding and broader word reading skill simultaneously. We were further motivated to keep the two-factor model in both grades to evaluate measurement invariance between constructs over time, as this is key to longitudinal autoregressive modeling.

We evaluated measurement invariance of morphological decoding and broader word reading skill from Grade 3 to 4. Establishing measurement invariance is important in longitudinal modeling with latent variables to ensure that the same constructs are being measured over time (MacCallum & Austin, 2000). As is typical, residuals of corresponding indicators were correlated across time points. Next, progressively constrained models were tested such that factor loadings, followed by indicator intercepts, and finally indicator residual variances were fixed to be equal over time (as per Brown, 2006; Little, 2013; Putnick & Bornstein, 2016). Partial strict invariance was attained following this process, $\chi^2(33) = 70.44$, $p = < .01$, comparative fit index (CFI) = .98, Tucker–Lewis index (TLI) = .98, root mean square error of approximation (RMSEA) = .08, SRMR = .05, supporting the evaluation of change in the latent variable means over time (Little, 2013). In our case, “partial” refers to a single intercept, that of Morphologically Derived Word Reading in Grade 4, which was permitted to vary.

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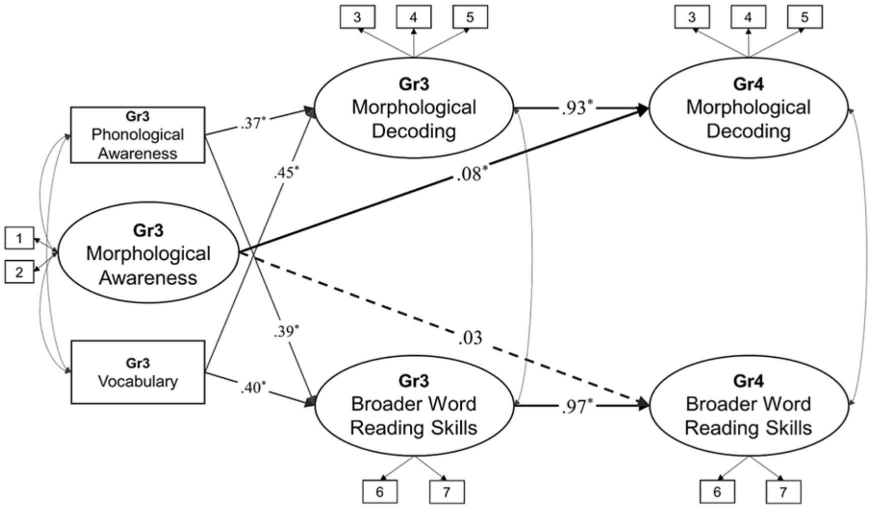

Figure 1. Structural longitudinal model testing the contribution of morphological awareness to gains in morphological decoding and broader word reading skill from Grade 3 to 4.

Note. Standardized path coefficients are shown in the figure. *$p < .05$. Latent variable indicators are as follows: 1 = Word Analogy Task. 2 = Test of Morphological Structure. 3 = Morphologically Derived Word Reading. 4 = Use of morphemes in reading real words. 5 = Use of morphemes in reading pseudowords. 6 = Sight Word Efficiency. 7 = Phonemic Decoding Efficiency.

Testing the contribution of morphological awareness to gains over time

Our research question lies in whether morphological awareness contributes more strongly to unique gains in morphological decoding versus in broader word reading skill between Grades 3 and 4. To examine gains in abilities over time, we included autoregressive factors of both morphological decoding and broader word reading skill in Grade 3, which accounts for prior levels of abilities in these constructs. Vocabulary and phonological awareness were added as control variables in the model (see Figure 1). A latent factor of morphological awareness was created from the Test of Morphological Structure and Word Analogy Task (factor loadings in Table 1). Two key predictive paths were added: one between Grade 3 morphological awareness and Grade 4 morphological decoding and another between Grade 3 morphological awareness and Grade 4 broader word reading skill. The paths between Grade 3 morphological awareness and Grade 3 factors of morphological decoding and broader word reading skill were fixed to zero so that the influence of morphological awareness was not subsumed within the autoregressive paths; without doing so in this study, the contributions of morphological awareness on gains in morphological decoding and broader word reading skill are conflated across direct and indirect effects. Using this targeted autoregressive modeling approach enabled us to more precisely test and contrast the cross-lagged effects between morphological awareness in Grade 3 and each of morphological decoding and broader word reading skill in Grade 4. Recall that for a specific influence of morphological awareness, we expected an effect on morphological decoding only.

The resulting model (Figure 1) showed good fit to the data, χ^2 (69) = 168.63, $p = < .05$, CFI = .96, TLI = .95, RMSEA = .08, SRMR = .07. Standardized path

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coefficients (β) are included in the figure. As reflected in the large autoregression effects, morphological decoding (β = .93, 95% CI [.75, .89]) and broader word reading skill (β = .97, 95% CI [.85, 1.02]) were highly stable from Grade 3 to 4. And yet, beyond the autoregressive effect and controls for vocabulary and phonological awareness, morphological awareness had a small significant effect on Grade 4 morphological decoding (β = .08, 95% CI [.01, .18]). In contrast, morphological awareness had no statistically detectable unique effect on word reading efficiency in Grade 4, beyond the other variables in the model (β = .03, 95% CI [−.06, .14]. Together, these findings suggest that morphological awareness contributed uniquely to gains across Grades 3 to 4 in children's morphological decoding skills with no such unique effects on their broader word reading skill.

Discussion

This study was designed to provide much-needed empirical clarity (Rastle, 2018) as to how morphological awareness contributes to word reading development (e.g., Kuo & Anderson, 2006; Nagy et al., 2014). We evaluated the relative size of the unique contribution of morphological awareness to morphological decoding with that to broader word reading skill. We tested this in a developmental framework, with highly conservative latent autoregressive modeling of longitudinal data for children followed from Grade 3 to 4 and with controls for phonological awareness and vocabulary levels. This is a time period during which children's texts are rife with morphologically complex words (e.g., White et al., 1989), and their morphological awareness skill is increasing rapidly (e.g., Carlisle, 2003). We found that morphological awareness in Grade 3 was a significant unique predictor of gains from Grade 3 to 4 in morphological decoding, but not of broader word reading skill. These findings point to a stronger effect of morphological awareness on the development of morphological decoding than for broader word reading skill for English-speaking children in the mid-elementary grades.

Building on other cross-sectional studies with mid-elementary school children (e.g., Goodwin et al., 2013; Kearns, 2015; Levesque et al., 2017), our findings suggest that morphological awareness contributes to unique gains in morphological decoding when contrasted against broader word reading skill. Accordingly, we extend this prior work by showing that morphological awareness contributes to the *development* of morphological decoding between Grades 3 and 4; we did not detect unique effects on gains in broader word reading skill across this year. These findings provide empirical support for morphological awareness as a foundational metalinguistic skill that provides mid-elementary school aged readers with critical insight into the morphological structure of written words, which in turn facilitates the reading of words with a complex morphological structure (Carlisle, 2003, 2010; Kuo & Anderson, 2006).

As we consider our positive findings, we also need to discuss what we did not find; there was no unique effect of morphological awareness on gains in broader word reading skill. At first glance, this null finding is inconsistent with the small set of longitudinal studies showing that morphological awareness supports the development of word reading skill when assessed across a wide range of words for readers early in the elementary years and up (Deacon et al., 2013; Kirby et al., 2012; Kruk & Bergman, 2013). In these studies, word reading was measured with standardized tests (much like our study). Critically, these prior longitudinal studies did not include measures of morphological decoding. When both metrics are included, our results specify that, at least for English-speaking children at the mid-elementary level, the contribution of morphological awareness is stronger to the development of morphological decoding than to broader word reading skill. This finding converges with the concept of larger (and more easily detectable) effects on the "near-transfer" task of morphological decoding than on the "far-transfer" task of broader word reading.

Theoretical and educational implications

Our results specify that morphological awareness plays a critical role in word reading development, one that is strongest for the reading of morphologically complex words in the mid-elementary school years. We think that this stronger role emerged because readers' sensitivity to the structure of words in the oral language enables them to segment morphologically complex words into smaller morpheme constituents (Carlisle, 2003; Nagy et al., 2014; Sénéchal & Kearnan, 2007), which then facilitates their ability to use written morphemes as units to support their reading (Carlisle, 2010; Kuo & Anderson, 2006; Rastle, 2018). These interpretations are consistent with the recent Morphological Pathways Framework (Levesque et al., 2021), which explicitly articulates a role for morphological awareness in reading multimorphemic words. These ideas also likely reflect in part the morphophonemic nature of the English writing system (e.g., Venezsky, 1967); both these components need to be fully integrated into reading theory and instruction. Certainly, it is possible that these effects spill over to broader word reading, particularly over time; to this point, this possibility was tested in Levesque et al.'s (2017) cross-sectional study but truly requires three time point longitudinal modeling. That said, between Grades 3 and 4, the unique effects of morphological awareness are stronger for morphological decoding than on word reading processes broadly defined (Perfetti & Stafura, 2014).

Our finding that morphological decoding is distinguishable from other aspects of word reading has a further implication for theory. We found that a two-factor model—one that distinguished morphological decoding from broader word reading skill—fit the data better than a model with a unidimensional word reading model, a difference that was significant at Grade 3 and marginal at Grade 4. These results point to morphological decoding as empirically separable from measures of word reading efficiency, as has emerged in a few prior studies (see also Nunes et al., 2012). These findings run counter to the predictions of phase theory (Ehri, 2014) and other conceptualizations (e.g., Grainger & Ziegler, 2011) which make no distinction in the utility of morphemes units (e.g., *dis-* and *-able*) from other recurring grapho-syllabic units (e.g., *-ight* and *-ump*) in supporting word reading. This prediction has long been surprising to us and others (e.g., Kirby & Bowers, 2017) given that morphemes are semantically and syntactically rich, features absent in other letter patterns. Morphemes in print are meaningful orthographic units that bring a considerable degree of consistency to opaque orthographies such as English

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(Rastle, 2018). Our findings and those of others (e.g., Nunes et al., 2012) suggest that the use of morphemes in reading is a distinct dimension in children's word reading. The priority of morphemes over other letter patterns merits inclusion in reading theory, and it also has strong implications for the development of reading instruction.

Our finding of unique effects of morphological awareness on gains in morphological decoding leads us to speculate that explicit instruction in morphological awareness is likely to have its strongest effects on students' skill in morphological decoding in the mid-elementary school years. This idea has some empirical support from existing intervention studies (Bowers et al., 2010; Goodwin & Ahn, 2013). Such intervention studies have included activities whereby students create banks of word families that share the same morphemes (roots and affixes) or break apart larger complex words into their component morphemes. Other "construction" activities could be created that teach children how to combine roots and affixes together into morphological complex words (e.g., Casalis & Colé, 2009). Perhaps more speculatively, we think that targeted instruction in morphological decoding would be appropriate given its separability from children's broader word reading skill, at least during the mid-elementary grades. Such instruction in morphological decoding has been integrated into a few reading programs. The PHAST program (Lovett et al., 2000), for instance, includes targeted instruction on identifying common, productive affixes such as *un-* and *-less* and "peeling them off" (p. 464) words, thereby supporting reading of complex words through these component parts (see also Gaskins et al., 1988; Gaskins, Downer, & Gaskins, 1986). Building on these ideas, children could also be taught that the pronunciation of some letter patterns, such as *-ive*, is based on their status as morphemes (e.g., *detective* and *arrive*, respectively). Determining the relative emphasis on rime versus morpheme patterns will be critical, though there is some precedent for including both in instruction (e.g., Lovett et al., 2000). All these suggestions await further empirical testing, including the extent to which such instruction needs to include other aspects of literacy instruction (Bowers et al., 2010).

Limitations and future directions

An important limitation of our work lies in measurement. It is remarkably challenging to identify comparable metrics of morphological decoding and broader word reading skill. In our work, we used some of the few available measures of morphological decoding (Levesque et al., 2017; Nunes et al., 2012), along with, in keeping with prior studies (e.g., Kirby et al., 2012), an established standardized measure (TOWRE; Torgesen et al., 1999) of broader word reading skill. These measures were reasonably comparable; both were age-appropriate, had good reliability, and included real words and nonwords. This relative similarity means that we need to take seriously findings of unique effects of morphological awareness on morphological decoding and not on broader word reading. That said, other differences need to be acknowledged. One is that our measures of morphological decoding were based on accuracy, whereas the TOWRE evaluates both accuracy and speed. Slight differences in the processes involved in timed word reading tests might explain, at least in part, why morphological awareness accounted for unique

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gains in morphological decoding but not broader word reading skill. And yet, we think that this explanation is unlikely because the design was in fact weighted toward finding effects for broader word reading skill; TOWRE has higher reliability and includes some morphologically complex words and captures morphological decoding to some extent. That said, our measures of morphological decoding focused predominantly on complex words with accessible morphological structures (e.g., high-frequency base words, common suffixes and prefixes). This may have fortified children's ability to exploit their morphological awareness in decoding these multimorphemic words. Further still, in the absence of an available parallel form, we used the same tests of morphological decoding in Grades 3 and 4 (see e.g., Bowers et al., 2010) and alternate forms for TOWRE in Grades 3 and 4. Any of these differences might account, at least in part, for different results between morphological decoding and broader word reading development. Clearly, there are several ways in which task development remains important for future research.

As with all studies, our findings are specific to the age range and reading level in our study. The link between morphological awareness and morphological decoding might be particularly strong in Grades 3 and 4, when children's reading strategies become increasingly attuned to consolidated units like morphemes (Ehri, 2014) and when there is a steep increase in the morphological complexity of texts (Anglin, 1993; Nagy & Anderson, 1984; White et al., 1989). Earlier in development, effects of morphological awareness might be detected on children's broader word reading skill because children encounter fewer morphologically complex words, both in texts and in standardized tests. Certainly, any influence of morphological awareness to word reading development prior to Grade 3 is likely subsumed in our findings, and thus, it is impossible to untangle prior developmental effects in this study of children in Grades 3 to 4. Beyond developmental differences, there might be different findings across reading levels. Recent findings point to the possibility that reading ability may moderate the impacts of morphological awareness on literacy skills (e.g., see Gilbert et al., 2013; Goodwin et al., 2013; Kearns, 2015). Kearns and colleagues (2016), for instance, reported a stronger effect of morphological awareness on morphological decoding for children with early- rather than late-emerging reading difficulties (see also Beyersmann et al., 2015). This finding converges with earlier suggestions of stronger effects of morphological interventions for poorer readers (e.g., Bowers et al., 2010). Clearly exploring moderation by reading and developmental level are important steps forward.

Further still, we interpret our findings specifically within the language studied here: English. It is not clear that similar effects would emerge in more phonologically transparent orthographies. Evidence of relations between morphological awareness and broader word reading have emerged in studies of children learning to read in languages represented with more phonologically transparent orthographies such as Portuguese and Greek (de Freitas et al., 2018; Rothou & Padeliadu, 2015). These studies have not, to our knowledge, tested links of morphological awareness to morphological decoding, though children learning to read in more transparent languages are clearly capable of morphological decoding (e.g., Angelelli et al., 2014). Future research needs to test the contribution of morphological awareness to gains in morphological decoding for children learning to read in different languages.

In conclusion, our findings clarify the role of morphological awareness in children's reading development, unique effects that are strongest in supporting gains in children's morphological decoding over time. Given the prevalence of morphologically complex words in the texts that elementary children read, we think that such effects are educationally important and theoretically relevant. We hope that these findings inspire detailed inclusion of morphology in models of word reading development as well as in comprehensive programs of literacy instruction.

Availability of data and material. Available upon request.

Declarations.

Financial Support. This research was supported by the Social Sciences and Humanities Research Council of Canada (grant 435- 2012- 0630) to S. Hélène Deacon and a Joseph-Armand Bombardier Canada Graduate Scholarship to Kyle C. Levesque.

Conflict of interest. The authors report no conflicts of interest.

Ethical approval (include appropriate approvals or waivers). This research was approved by the Social Sciences & Humanities Research Ethics Board at Dalhousie University, REB #: 2012-2861.

Note

1. We thank an anonymous reviewer for this helpful conceptual analogy.

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Appendix

Morphological decoding task: Morphologically Derived Word Reading

	Derived Word	Length (letters)	Surface Freq (*U*)	Base word Freq (*U*)	MorphoLexSegm	NMorph	Transp	Accuracy Gr3 (%)	Accuracy Gr4 (%)
1.	additive	8	0.56	70.00	{add}>itive>	2	T	24.87	27.13
2.	advantageous	12	2.00	48.00	{advantage}>ous>	2	P	9.14	12.23
3.	bottomless	10	0.35	125.00	{bottom}>less>	2	T	92.89	93.62
4.	breathless	10	3.00	57.00	{breath}>less>	2	T	87.31	92.02
5.	broadly	7	2.00	53.00	{broad}>ly>	2	T	37.06	53.19
6.	centrally	9	0.89	108.00	{centr–al}>ly>	3	T	44.16	51.06
7.	containment	11	0.29	78.00	{con–tain}>ment>	3	T	51.27	63.30
8.	corrective	10	1.00	57.00	{correct}>ive>	2	T	61.93	81.38
9.	effortful	9	0.14	68.00	{effort}>ful	2	T	43.15	63.30
10.	heaviness	9	0.93	162.00	{heavy}>ness>	2	O	52.28	57.98
11.	inclusion	9	0.72	116.00	{in–clude}>ion>	3	P-O	57.36	65.43
12.	laborious	9	1.00	87.00	{labor}>ious>	2	P	11.68	17.02

(*Continued*)

https://doi.org/10.1017/S0142716422000194 Published online by Cambridge University Press

(*Continued*)

	Derived Word	Length (letters)	Surface Freq (*U*)	Base word Freq (*U*)	MorphoLexSegm	NMorph	Transp	Accuracy Gr3 (%)	Accuracy Gr4 (%)
13.	longitude	9	3.00	990.00	{long–itude}	2	P	11.17	10.11
14.	magician	8	4.00	52.00	{magic}>ian>	2	P	60.41	73.40
15.	medicinal	9	0.69	50.00	{medicine}>al>	2	P-O	6.60	2.66
16.	memorable	9	3.00	48.00	{memor–able}	2	P-O	58.88	65.43
17.	musician	8	4.00	59.00	{music}>ian>	2	P	65.99	77.13
18.	objection	9	1.00	118.00	{ob–ject}>ion>	3	P	73.10	82.45
19.	originality	11	1.00	62.00	{origin}>al>>ity>	3	P	21.83	22.87
20.	pictureless	11	0.02	242.00	{pict–ure}>less	3	T	87.31	92.55
21.	popularly	9	1.00	68.00	{popul–ar}>ly>	3	T	13.71	18.62
22.	powerless	9	2.00	303.00	{power}>less>	2	T	96.45	97.34
23.	publicity	9	5.00	196.00	{public}>ity>	2	P	43.65	48.94
24.	reasonless	10	0.02	182.00	{reason}>less	2	T	68.53	75.53
25.	regularity	10	1.00	71.00	{regul–ar}>ity>	3	P	34.01	40.43
26.	scholar	7	3.65	579.00	{schol–ar}	2	P-O	22.84	53.72
27.	signature	9	5.00	101.00	{sign}>ature>	2	P	71.57	81.91
28.	similarity	10	3.00	125.00	{simil–ar}>ity>	3	P	56.85	62.77
29.	sociable	8	0.89	172.00	{soci–able}	2	P-O	51.78	70.74
30.	soundly	7	1.00	241.00	{sound}>ly>	2	T	91.88	94.68
31.	speciality	10	0.48	314.00	{special}>ity>	2	P	4.57	7.98
32.	squarely	8	2.00	77.00	{square}>ly>	2	T	62.44	68.09
33.	strangeness	11	1.00	119.00	{strange}>ness>	2	T	53.81	72.87
34.	studious	8	0.43	250.00	{stud–y}>ous>	3	P-O	17.26	22.87
35.	supportive	10	2.00	124.00	{support}>ive>	2	T	77.66	88.83
36.	totality	8	0.72	101.00	{total}>ity>	2	P	6.09	4.79
37.	vastness	8	0.96	50.00	{vast}>ness	2	T	58.38	69.68
38.	wasteful	8	2.00	58.00	{waste}>ful>	2	T	85.79	92.55
39.	wonderment	10	0.54	73.00	{wonder}>ment	2	T	90.36	96.28
40.	wondrous	8	1.00	73.00	{wondr–ous}	2	P-O	70.05	68.09

Note. *U* = frequency of occurrence per million words in text; *U* frequency values obtained from Zeno et al. (1995). MorphoLexSegm = morphological segmentation of the lexical item, where each morpheme is represented by its canonical form (Sánchez-Gutiérrez et al., 2017). Nmorph = number of morphemes contained in the morphological segmentation of the lexical item (Sánchez-Gutiérrez et al., 2017). Transp = transparency between base morpheme and derived word: T = transparent. P = phonological change. O = orthographic change.

Cite this article: Levesque KC and Deacon Sé. Clarifying links to literacy: How does morphological awareness support children's word reading development? *Applied Psycholinguistics*. https://doi.org/10.1017/S0142716422000194