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Contributions of Morphology Beyond Phonology to Literacy Outcomes of Upper Elementary and Middle-School Students

William Nagy
Seattle Pacific University

Virginia W. Berninger and Robert D. Abbott
University of Washington

Using structural equation modeling the authors evaluated the contribution of morphological awareness, phonological memory, and phonological decoding to reading comprehension, reading vocabulary, spelling, and accuracy and rate of decoding morphologically complex words for 182 4th- and 5th-grade students, 218 6th- and 7th-grade students, and 207 8th- and 9th-grade students in a suburban school district. Morphological awareness made a significant unique contribution to reading comprehension, reading vocabulary, and spelling for all 3 groups, to all measures of decoding rate for the 8th/9th-grade students, and to some measures of decoding accuracy for the 4th/5th-grade and 8th/9th-grade students. Morphological awareness also made a significant contribution to reading comprehension above and beyond that of reading vocabulary for all 3 groups.

Keywords: morphology, literacy, phonology, vocabulary, reading

It has long been recognized that knowledge of morphology—how words are built by combining smaller meaningful parts, such as prefixes, roots, and suffixes—is correlated with reading ability (e.g., Brittain, 1970; Freyd & Baron, 1982; Tyler & Nagy, 1990). However, the relationships underlying this correlation are complex; knowledge of morphology may contribute to reading ability in a number of ways. Because a substantial proportion of the words in English have meanings that are predictable from the meanings of their parts (Nagy & Anderson, 1984), knowledge of morphology is believed to play an important role in vocabulary growth (Anglin, 1993), which in turn impacts reading comprehension. Because deviations from a consistent mapping between letters and phonemes generally reflect a consistency in the spelling of morphemes (Venezky, 1999), knowledge of morphology is essential for understanding the writing system and for accuracy in spelling (Bear, Invernizzi, Templeton, & Johnston, 2004; Bryant, Nunes, & Bindman, 1997b; Henry, 1989). Because almost all longer words in the language are made up of several morphemes, knowledge of morphology should contribute to fluency in the recognition of such words (Berninger, Abbott, Billingsley, & Nagy, 2001).

William Nagy, School of Education, Seattle Pacific University; Virginia W. Berninger and Robert D. Abbott, Department of Educational Psychology, University of Washington.

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Correspondence concerning this article should be addressed to William Nagy, School of Education, Seattle Pacific University, 3307 Third Avenue West, Seattle, WA 98119-1950. E-mail: wnagy@spu.edu

To understand the contribution of morphological knowledge to reading, we also need to know to what extent this contribution is distinct from that of phonological abilities. Two contrasting pictures of the relationship of phonology, morphology, and reading comprehension have been suggested. In one of these, the contribution of morphological knowledge is seen as secondary to, and derivative of, phonological abilities (Fowler & Liberman, 1995; Shankweiler et al., 1995). In the other, morphology is seen as making an independent contribution to reading, the relative importance of which increases with age (Deacon & Kirby, 2004; Singson, Mahony, & Mann, 2000). In the present study we looked for evidence bearing on these two positions, with students older (fourth through ninth grades) than those participating in earlier studies. We also looked at a variety of literacy outcomes, because the appropriateness of each picture may depend on which aspect of reading is examined.

Morphology, Reading Vocabulary, and Reading Comprehension

More than half of the words in English are morphologically complex (Anglin, 1993; Goulden, Nation, & Read, 1990; Nagy & Anderson, 1984). Morphologically complex words are more common in written language (and especially academic language) than in spoken language (Chafe & Danielewicz, 1987), and the proportion of such words increases as frequency decreases (Nagy & Anderson, 1984). Thus, with each grade children encounter an increasing number of morphologically complex words. The majority of these have meanings that can be inferred from the meanings of their component parts (Nagy & Anderson, 1984), and so recognizing the morphological structure of words should aid children in interpreting and learning them. And in fact, children's awareness of the morphological structure of words has been found to be correlated with their vocabulary knowledge (Carlisle & Fleming, 2003; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003; Singson et al., 2000) and reading comprehension (Brittain, 1970; Carlisle, 2000; Champion, 1997; Freyd & Baron, 1982; Tyler & Nagy, 1990).

Morphological knowledge increases throughout children's schooling (Nagy, Diakidoy, & Anderson, 1993; Tyler & Nagy, 1989), but there may be periods of especially marked growth for specific aspects of morphology. Anglin (1993) found that students' knowledge of derived (prefixed and suffixed) words increased sharply between Grades 3 and 5. In this interval, the increase in number of derived words known was three and a half times greater than the increase in the number of root words known. Some of this striking increase in knowledge of derived words is presumably due to greater exposure to such words, but much of the increase also appears to reflect an increased awareness of the internal structure of words.

Nagy et al. (2003) found that for second-grade at-risk readers, when orthographic and phonological abilities and oral vocabulary had been controlled for, morphological awareness made a significant unique contribution to reading comprehension. For the fourth-grade students in that study, morphological awareness did not make a significant unique contribution to any of the outcome measures. However, these results may reflect the high correlation found between morphological awareness and oral vocabulary ($r =$ .78 for the fourth-grade students) rather than a lack of relationships between morphological awareness and literacy outcomes. It may be that morphological awareness is emerging as the strongest predictor of vocabulary growth at this stage of development.

Although Nagy et al. (2003) did not find that morphological awareness made a significant unique contribution to reading comprehension in fourth-grade at-risk writers, the zero-order correlation between the two constructs was very strong ($r = .80$). Ku and Anderson (2003) found that even when vocabulary knowledge was statistically controlled for, morphological awareness significantly predicted reading comprehension for both Chinese and American second-, fourth-, and sixth-grade students reading in their respective languages. Deacon and Kirby (2004) found that morphological awareness measured in second grade predicted reading comprehension in fourth and fifth grade, even when second-grade reading comprehension, intelligence, and phonological awareness had been statistically controlled for. Given that the morphological complexity of text continues to increase and that some aspects of morphological knowledge continue to grow through high school (Nagy et al., 1993), one might expect the relative contribution of morphological knowledge to reading comprehension to increase after Grade 6.

Morphology, Decoding, and Spelling

The English writing system is primarily alphabetic. That is, the basic elements of the writing system, letters, typically map most directly onto phonemes. However, our writing system is not exclusively alphabetic. Elements of print represent not only phonemes but also morphemes, word boundaries, intonation, and sentence boundaries. One way to appreciate the nonalphabetic aspects of the writing system is to try to do without them. Imagine a writing system that was exclusively alphabetic—that is, one that represented language exclusively in terms of regular, one-to-one mapping between letters and phonemes. What would such a writing system look like? The following is a purely phonemic transcription, based on the international phonetic alphabet:

ðɩsɩznatðəkaindəvraitiŋ
sɩstmwiaryustuɩtwɩltekwaitəbɩtəvprækɩɩstəridɩtfluəntli

("This is not the kind of writing system we are used to. It will take quite a bit of practice to read it fluently.") This example illustrates how much we depend on the information provided by spaces between words, capitalization, and punctuation—conventions of writing that go beyond the alphabetic principle, and that, historically speaking, are relatively recent innovations. These conventions capture elements of linguistic structure such as word boundaries and intonation that are not directly represented by the phonemes in the speech stream.

A ruthlessly alphabetic writing system would also obscure morphological relationships that are represented in conventional English spelling. For example, the past tense marker in *hoped, hummed,* and *hunted,* which is consistently represented by *ed* in conventional spelling, would have to be written differently: /hopt, həmd, həntɩd/. Likewise, the spellings of *finite, infinite,* and *infinity* would have different vowels (e.g., *fainait, ɩnfənɩt, ɩnfɩnəti*), obscuring the historical and semantic relationships among these words. There would be no *g* in *sign,* thus obscuring its relationship with *signature,* as well as obscuring the distinction between *sign* and *sine*. As writers, we would not have to worry about the distinction among *their, they're,* and *there*—but as readers, we would miss the information this distinction provides.

To learn how print represents language, the child needs to be aware of the linguistic units at several different levels and how each is represented. To learn the most fundamental principle of the writing system, that letters (singly or in combination) represent phonemes, the child must become aware of the phonemic structure of spoken language. Because the mapping between print and speech in our writing system involves multiple linguistic levels, other types of metalinguistic awareness are also necessary.

At the word level, the bulk of deviations from the alphabetic principle in English spelling reflect the principle of maintaining a consistent spelling for morphemes (Chomsky & Halle, 1968; Venezky, 1970, 1999). Because our writing system is morphophonemic rather than exclusively phonemic, one would expect morphological awareness to be related to phonological decoding ability. However, the strength of the relationship should depend on the type of words and on the age of the student. It may be, for example, that morphological awareness is more strongly related to the decoding of words with less transparent morphological relationships (e.g., *pronounce/pronunciation*) than those with more regular relationships (e.g., *run/runs*). It may be that the impact of morphological awareness on decoding will be found only for older students. Nagy et al. (2003) did not find morphological awareness to be a significant predictor of decoding ability in at-risk second-grade readers or at-risk fourth-grade writers. Deacon and Kirby (2004) found that morphological awareness predicted pseudoword reading in Grades 4 and 5 but not in Grade 3.

In a series of studies, Bryant, Nunes, and their colleagues (e.g., Bryant, Nunes, & Bindman, 1997a, 1997b, 2000; Nunes, Bryant, & Bindman, 1997a, 1997b; Nunes, Bryant, & Olsson, 2003) have explored children's acquisition of the morphological aspects of English spelling. Several of their studies have explored children's acquisition of the spelling *ed* for the regular past tense—a spelling that is morphological, in that this same morpheme has different pronunciations depending on the final sound of the word to which it is added. Perhaps the most interesting finding is that although children acquire the regular past tense fairly early in oral language, their spellings do not reliably reflect its status as a morpheme until about third grade. Treiman and Cassar (1996), on the other hand, found that children make some use of very basic morphological knowledge as early as first grade. For example, the children were less likely to omit the *r* in *bars* than the *r* in *Mars*, because in the former case, the *r* was the final consonant of the stem. However, the fact that these children would sometimes omit the *r* in *bars* even when they had correctly spelled the stem indicates that their use of morphology in spelling was still fragile.

Students who have been taught phonics and may have learned letter–sound correspondences in alphabetic principle, word family patterns (e.g., *-at* in *pat, bat,* etc.), and syllable types (e.g., open and closed, vowel teams, silent *e, r*-controlled, and *-le*) may need additional strategies to deal with the complexity in English orthography (Schlagal, 1992), especially in content-area texts, which may have spellings unique to word origin (Anglo-Saxon, Latinate, or Greek), complex word structures, and unfamiliar, low-frequency words (Henry, 2003). Research showed that third, fourth, and fifth graders given only phonics instruction had letter–sound knowledge but little knowledge of syllable or morpheme patterns, but those who received the morphophonemic training linked to word origin improved significantly more in reading and spelling than those who received only basic phonics (Henry, 1988, 1989, 1993). Lovett (e.g., Lovett, 1999; Lovett, Lacerenza, & Borden, 2000) compared PHAB/DI (direct instruction in sound analysis, blending skills, and letter–sound correspondences), WIST (four word identification strategies: using analogy, seeking the part of the word you know, attempting variable vowel pronunciations, and peeling off affixes), and combined PHAB/DI and WIST (Phonological and Strategy Training Program [PHAST]) and showed positive gains in reading both trained and untrained (transfer) words for combined training (Lovett et al., 2000).

Brain imaging studies showed that morphological, phonological, and orthographic word forms have unique neural signatures (Richards, Aylward, et al., in press; Richards, Berninger, et al., 2005). Crossover effects were observed (Richards, Aylward, et al., in press; Richards, Berninger, et al., 2005): Individuals who received morphological treatment showed significant changes in *phoneme* mapping during brain scans, whereas individuals who received phonological treatment showed significant changes in *morpheme* mapping during brain scans. Berninger et al. (2003) showed that morphological awareness training improved efficiency (rate) of phonological decoding; Richards et al. (2002) showed that such training led to greater metabolic efficiency in neural processing during phonological judgment while the brain was scanned than did training in only phonological awareness. Taken together, these results are consistent with a model of written word learning that draws on computations of the interrelationships among phonological, morphological, and orthographic word forms and their parts (Berninger et al., 2001).

Morphological Knowledge and the Recognition of Morphologically Complex Words

Readers use their knowledge of morphological structure in recognizing complex words. For example, the word *sadness* is not processed in the same way as the word *harness,* because only the former can be broken down into two morphemes. The role of morphological structure in word recognition has been demonstrated in numerous studies using a variety of experimental techniques. One of the most common involves the frequency effect, the well-documented fact that words that are encountered more frequently tend to be recognized more quickly. In the case of the role of morphology in word recognition, the question is whether the speed with which the word *preview* is recognized, for example, is a function simply of the frequency of the whole word (base + affix) or also the frequency of the base word *view* in the affixed word (e.g., Taft, 1979). Another common technique is priming, which assesses the effect of exposure to one word on the speed of recognition of a later similar word. For example, one might compare the extent to which prior exposure to the word *pain* facilitates later recognition of an orthographically overlapping word (*paint*) as compared with a morphologically related word (*pained*) (e.g., Napps, 1989). Effects of morphological structure have been documented in a variety of languages, including English (e.g., Nagy, Anderson, Schommer, Scott, & Stallman, 1989; Taft, 1979); Dutch (e.g., Assink, Vooijs, & Knuijt, 2000; De Jong, Schreuder, & Baayen, 2000; Verhoeven, Schreuder, & Baayen, 2003); Hebrew (e.g., Feldman, Frost, & Pnini, 1995); and Italian (e.g., Laudanna, Badecker, & Caramazza, 1989).

Although different models have been proposed to explain exactly how the morphological structure of words contributes to word recognition, there is a consensus that this structure is represented in some way in the internal lexicon (Verhoeven & Perfetti, 2003). Furthermore, there is evidence that morphology per se is important; the effects associated with morphology cannot be reduced simply to similarities of form and meaning (De Jong et al., 2000; Napps, 1989).

Analysis of morphologically complex words into their component morphemes should lead to more fluent recognition of long words for at least two reasons. First, the frequency of the component morphemes is necessarily greater than the frequency of the morphologically complex word as a whole. The speed with which a low-frequency complex word (e.g., *unthankfulness*) is processed depends at least to some extent on the frequencies of its familiar parts and not simply on the fact that that particular combination of morphemes may be very rare. Second, chunking a word into morphemes (rather than onsets and rimes or individual letters) usually results in larger, and hence fewer, units that need to be processed. We therefore expect morphological awareness to contribute to both the speed and the accuracy with which complex words are decoded.

Morphology and Phonology

One of the major theoretical advances in reading research in the last 50 years has been recognition of the crucial role that phonological processes play in learning to read. An increasing body of research has documented how a variety of symptoms of reading disability can be traced to a basic phonological deficit (e.g., Adams, 1990; Morris et al., 1998; Olson, Wise, Conners, Rack, & Fulker, 1989; Shankweiler et al., 1995; Stanovich, 1986). A crucial question concerning the role of morphological awareness in reading is therefore whether it makes an independent contribution to reading ability or whether its correlation with literacy skills simply reflects the fact that morphological awareness, like many other aspects of literacy, is highly dependent on phonological abilities.

As already mentioned, the English writing system, though primarily alphabetic in nature, is not exclusively alphabetic. Rather, conventions of the writing system represent linguistic information at a number of levels, including morphology and syntax. Hence it is quite reasonable to hypothesize that morphological awareness would make an independent contribution to reading ability. However, an alternative hypothesis—that effects of morphological awareness can be traced back solely to phonological abilities—is also plausible.

Fowler and Liberman (1995) and Shankweiler et al. (1995) have argued in favor of the alternative hypothesis. Two types of evidence are offered. The first is that in hierarchical regression analyses, when a measure of morphological awareness is entered after measures of phonological awareness, the measure of morphological awareness accounts for relatively little unique variance—about 4% (Carlisle & Nomanbhoy, 1993; Singson et al., 2000) or 5% (Shankweiler et al., 1995). According to Shankweiler et al., the amount of unique variance accounted for by morphological awareness is about half that accounted for by phonological awareness (.051 and .109, respectively, when each was entered last).

The second argument involves the distinction between two types of morphological relationships: those that are phonologically transparent, where the pronunciation of a stem is not modified by the addition of a suffix (e.g., *dark/darkness; act/active*), and those that involve a phonological shift, where the pronunciation of the stem is altered (*nation/national; relate/relation*). Tests of morphological awareness using items with phonological shifts may be more strongly related to reading ability than those using phonologically transparent items (Carlisle, 2000; Carlisle, Stone, & Katz, 2001; Fowler & Liberman, 1995; Shankweiler et al., 1995), at least at certain developmental levels (Shankweiler et al. studied students between 7.5 and 9.5 years of age). If the phonological complexity, and not the morphological relationships per se, is the crucial factor, then phonological rather than morphological abilities should account for the relationship between tests of morphological awareness and reading ability. However, there are several reasons why these arguments do not rule out the possibility that morphological awareness makes an important independent contribution to reading ability.

The first challenge has to do with the amount of unique variance accounted for by morphological awareness. The fact that phonological awareness makes a greater unique contribution to reading than morphological awareness does not prove the latter to be unimportant. Although morphological awareness is not the largest contributor to success in learning to read, it is not necessarily an insignificant one. Nor should one assume that the variance shared by phonological and morphological awareness is exclusively phonological. Some of the shared variance between these two constructs may be metalinguistic in a more general sense rather than tied specifically to morphology or phonology. Moreover, the unique variance accounted for by a construct does not determine its instructional importance. The fact that morphological awareness accounts for relatively little unique variance does not mean that instruction in morphological awareness cannot have a positive impact on literacy development. Instruction in morphological awareness has in fact been found to have a significant impact on reading ability (e.g., Arnbak & Elbro, 2000; Berninger et al., 2003; Nunes, Bryant, & Olsson, 2003).

The second challenge concerns the distinction between phonologically transparent and phonologically shifted morphological relationships. The fact that measures of morphological awareness involving phonologically shifted relationships are more predictive of reading ability does not mean that such measures are simply measures of phonological awareness. Phonological complexity tends to mask morphological relationships; students may be less likely to discern the morphological relationship between *courage* and *courageous,* for example, than that between *mountain* and *mountainous*. But the additional difficulty posed by the phonological shift may make the former pair a better measure of morphological awareness and not simply a measure of phonological awareness. Significant correlations do not prove identity—only predictability from one construct to another. By way of analogy, one can consider the distinction between orthographically transparent and orthographically complex morphological relationships. The pairs *ignite/ignition* and *divide/division* reflect the same amount of difference in pronunciation, but the latter involves a greater change in spelling. If items representing the latter type of relationship were found to be more highly correlated with reading ability, should they therefore be considered tests of orthographic knowledge rather than morphological awareness?

The third challenge has to do with the likelihood of developmental shifts in their relative contribution to reading ability. Grasping the alphabetic principle is a crucial part of the early stages of learning to read. Insight into the morphological aspects of the writing system comes later (Bryant et al., 1997b; Templeton & Morris, 2000). One might expect, then, that the contribution of morphological awareness would increase with age, a trend in fact reported by Singson et al. (2000). They found that in third grade, only phonological awareness made a unique contribution to reading ability. However, in fourth through sixth grade, the contribution of morphological awareness relative to that of phonological awareness increased. Given the age (a mean of 8.4 years) of Shankweiler et al.'s (1995) sample, the proportion of unique variance attributed to morphological awareness by Shankweiler et al. may underrepresent the contribution of morphological awareness to reading and other literacy outcomes in older readers. That is, the results of Shankweiler et al. may not generalize beyond the early stages of literacy development. For two of their dependent measures (reading comprehension and pseudoword reading), Deacon and Kirby (2004) found that morphological awareness made a significant unique contribution beyond that of phonological awareness for Grades 4 and 5 but not for Grade 3.

The relative contributions of morphology and phonology to reading also depend on the nature of the outcome measures. For example, morphological awareness might make more of a contribution to spelling than to decoding, because spelling rules often involve the nature of the last letter or last two letters in a base word that affect whether any letter is dropped or added when adding a suffix (e.g., dropping final *e* when adding *ing* to *refine* to create *refining* or adding a vowel when adding *tion* to *add* to create *addition*). The relative contribution of morphology and phonology to different literacy outcomes is also likely to change with development in different ways for different literacy outcomes.

The Present Study

This study addressed three primary research questions: (a) whether morphological awareness makes a significant contribution to literacy outcomes when the shared variance between phonological and morphological abilities has been controlled for in a structural equation model, (b) whether the contribution of morphological awareness to literacy outcomes is greater for students in Grades 4 and above than was previously reported for at-risk students in Grades 2 and 4, and (c) whether the relative contribution of morphological awareness is different for various literacy outcomes. For the first research question, two kinds of phonological skills were considered: phonological short-term memory and phonological decoding (Wagner & Torgesen, 1987). For the second research question, previous research on the contributions of morphological skills to literacy achievement in elementary students (e.g., Bryant, Nunes, & Bindman, 2000; Carlisle, 2003; Carlisle & Fleming, 2003; Carlisle & Stone, 2004; Mahony, Singson, & Mann, 2000; Singson et al., 2000) or in at-risk populations (e.g., Nagy et al., 2003) was extended. In the present study, participants were all the fourth- to ninth-grade students in the general education program of a school district and thus should have included the range of normal variation in the population at these grade levels. For the third research question, in contrast to past research, a variety of literacy outcomes were examined. This approach makes it possible to determine not only whether the size of the unique contribution of morphological awareness changes across literacy development but also whether the unique contribution of morphological awareness is a function of the nature of the literacy outcome as children reach higher grade levels.

Method

Participants

Participants were 607 students in Grades 4 through 9 in a suburban school district in the northwestern United States. There were 5 Asian Americans, 2 Arab Americans, 3 Hispanics, and 2 East Indians; the remaining 595 students were White. Overall, 51.6% of the students were male, and 48.4% were female. Only 8% of the students qualified for free or reduced lunch. There were 96 students in fourth grade, 86 in fifth, 116 in sixth, 102 in seventh, 105 in eighth, and 102 in ninth. The percentage of boys in individual grade levels ranged from 43.8% in eighth grade to 62.7% in seventh grade. The participants were all of the students at these grade levels in general education in a small school system near a large metropolitan area.

Measures of Morphological Awareness

Suffix Choice Test (Nagy et al., 2003). This test was based on prior research by Mahony et al. (2000), Singson et al. (2000), Nagy et al. (1993), and Tyler and Nagy (1989, 1990). The first task (five items) was to choose among four words with different suffixes that signaled part of speech (e.g., *directs, directions, directing,* or *directed*), only one of which fit into a context sentence (e.g., "Did you hear the ________?"), on the basis of its inflectional or derivational suffix. The second task (five items) was to choose one of four sentences that correctly used a plausible but novel suffixed word created by adding a derivational suffix to a familiar word (e.g., *dogless*). A correct response indicated understanding the grammatical information signaled by the suffix (e.g., "When he got a new puppy, he was no longer dogless" but not "He was in the dogless"). The third task (four items) was to choose which of four nonword options (e.g., *jittling, jittles, jittled,* or *jittle*) fit the context of a sentence composed of real words ("Our teacher taught us how to ______ long words"). A correct response indicated understanding of grammatical information conveyed by suffixes independent of their semantic content.

For all three tasks, the items were presented visually for the child to read silently while the examiner read them aloud to the child; thus, correct responding did not require decoding ability—only morphological understanding of how suffixes in lexical items signal grammatical information in sentence context. The score was the total correct summed over the three tasks.

Morphological Relatedness Test (adaptation of a measure used in Nagy et al., 2003). This test was based on research by Berko (1958); Carlisle (1995); Derwing (1976); Derwing, Smith, and Wiebe (1995); Mahony and Mann (1992); and Mahony et al. (2000). Children were presented with pairs of words and asked to decide whether the second word was derived ("comes from") the first word. An example of a correct "yes" response is *quick* and *quickly*. An example of a correct "no" response is *moth* and *mother*. The score was the total correct across 80 word pairs. Again, items were presented visually for the child to look at while the examiner read the items to the child, whose responses reflected morphological knowledge rather than decoding ability.

Measures of Phonological Abilities

Oral nonword repetition. We used the prepublication version of the Nonword Repetition test of the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999), which has a reliability coefficient of .80. Performance on a nonword repetition task can be interpreted as a measure of phonological short-term memory (Gathercole, Service, Hitch, Adams, & Martin, 1999; Metsala, 1999). In this test, the child listens to a pseudoword and repeats it; the pseudowords are increasingly complex and less wordlike in terms of English phonology. We did not use a measure of phonological awareness because this task is typically mastered during the beginning reading stage as children become aware of phonemes in spoken words while learning to apply alphabetic principles. Raw scores were used because published norms were not available; however, these were grade-corrected by creating z scores for students based on the mean and standard deviation of their grade level.

Phonological decoding of written words. The Word Attack subtest of the *Woodcock Reading Mastery Tests—Revised* (Woodcock, 1987) served as a measure of phonological decoding. In this test, children read a list of pseudowords of increasing difficulty. Raw scores based on total correct responses were transformed using age norms in the test manual. These have a mean of 100 and a standard deviation of 15. This test has an average reliability coefficient of .87.

Measures of Literacy Outcomes

Reading vocabulary. Reading vocabulary was measured using the Vocabulary subtest of the Stanford Diagnostic Reading Test (4th ed.; Karlsen & Gardner, 1994, 1995, 1996). This test measures reading vocabulary through written multiple-choice items in which students are supposed to choose a word or phrase that means the same or about the same as the underlined word in the item stem. In the levels of this test used in the present study, internal consistency reliabilities range from .84 to .90. Scores for this test are based on a Rasch measurement Item Response Theory (IRT) scale. The items are scaled on a continuous scaling metric that tracks results across grades.

Reading comprehension. Reading comprehension ability was measured using the Comprehension subtest of the Stanford Diagnostic Reading Test. Comprehension was tested with multiple-choice items following passages. Internal consistency reliabilities for the levels used range from .91 to .93. This test has the same Rasch scaling metric as the reading vocabulary measure.

Spelling. Spelling was assessed using the prepublication version of the Spelling Test of the Wechsler Individual Achievement Test—Second Edition (Psychological Corporation, 2001). The task is to write single words of increasing difficulty that are dictated by the tester. Raw scores were used because published norms were not available; however, these were grade-corrected by creating *z* scores for students based on the mean and standard deviation of their grade level.

Decoding inflected words (Nagy et al., 2003). In this task, children were asked to read item sets that contained specific kinds of suffixes as accurately and as quickly as they could. Ten items had inflectional endings that were all spelled the same (*ed*) but were associated with three different pronunciations (/d/, /t/, or /əd/). Ten items had plural suffixes spelled either *s* or *es* but pronounced /s/, /z/, or /əs/. Ten items had a suffix indicating comparison (*er* or *est*). The accuracy score was the total correct summarized across the three item sets. Time was also recorded for each item set, and the total time score is the sum of these three item sets. Accuracy and time were used as separate outcome measures.

Decoding prefixed and pseudoprefixed words. This test was based on work by Pillon (1998) on true prefixes and foils. Children were asked to read accurately and quickly a list of items that began with the same orthographic units (e.g., *mis, re, de, pre, dis, in, un,* or *im*) but varied as to whether these were true prefixes (e.g., *misuse*) or were foils (e.g., *mister*). Of the 14 items, 7 contained true prefixes and 7 contained foils. Total accuracy across these 14 items and recorded time for these items served as separate outcome measures.

Decoding prefixed irregular stems. Ten stems were selected that were only partially decodable and thus may be learned as a lexical unit (in addition to partial decoding where possible) and retrieved automatically as a single unit (e.g., *tongue*). Real prefixes were added to the stems to form novel or rare words (e.g., *betongue*) that could not be easily decoded without recognizing the stem. Thus, accurate decoding indicated that the novel word had been analyzed into a prefix and stem. Children were asked to name 10 of these items as accurately and as quickly as possible. Accuracy scores and time scores were separate outcome measures.

Decoding suffixed irregular stems. Ten stems were selected that were only partially decodable and thus may be learned as a lexical unit (in addition to partial decoding where possible) and retrieved automatically as a single unit (e.g., *ocean*). Real suffixes were added to the stems to form novel or rare words (e.g., *oceanward*) that could not be easily decoded without recognizing the stem. Children were asked to name 10 of these items as accurately and as quickly as possible. Accuracy scores and time scores were separate outcome measures.

Decoding sets of morphologically related words. This test had 40 items, 10 root words each followed by 3 words formed from that root by adding a derivational or inflectional suffix. This test requires repeated morphological transformation of the same stem. For this test as a whole, accuracy and time scores were separate outcome measures. Two additional variables were also derived from these items: phonologically transparent accuracy and phonological shift accuracy. *Phonologically transparent accuracy* was defined as the number of accurate responses for those 18 suffixed words for which the suffix did not produce a change in the pronunciation of the stem. *Phonological shift accuracy* was defined as the number of accurate responses for those 12 words for which addition of the suffix produced a change in the pronunciation of the stem. Only accuracy data were available for these two subsets of items.

Procedures

The test battery was given in three 1-hr sessions at each school during the regular school day. During the first session, students were tested in groups and completed the Reading Comprehension and Vocabulary subtests of the Stanford Diagnostic Reading Test appropriate for their grade level. In a second group session, morphological awareness tests were administered. These were read to students, who also saw the test items in written form in front of them. The spelling dictation test was also given in this session. In addition, each student participated in an individual testing session in which the oral nonword repetition, phonological decoding, and morphological decoding tests were given.

Data Analyses

First, means and standard deviations and zero-order correlations among measures were examined. Inspection of the mean scores indicated that morphological skills showed changes that spanned more than a single grade level. Linear trends in the data were more evident when children were grouped by combining pairs of adjacent grade levels (fourth and fifth, sixth and seventh, and eighth and ninth).

Morphology and phonology. Second, structural equation modeling of covariance structures was applied to a multivariate data set in which the suffix choice test and morphological relatedness test were used to model the latent factor underlying morphological awareness; then morphological awareness, phonological memory, and phonological decoding were used as predictors for a number of literacy outcomes. This approach allowed evaluation of whether the contribution of morphology is unique, that is, independent of the contribution of the phonological factors when the shared variance among them is statistically controlled.

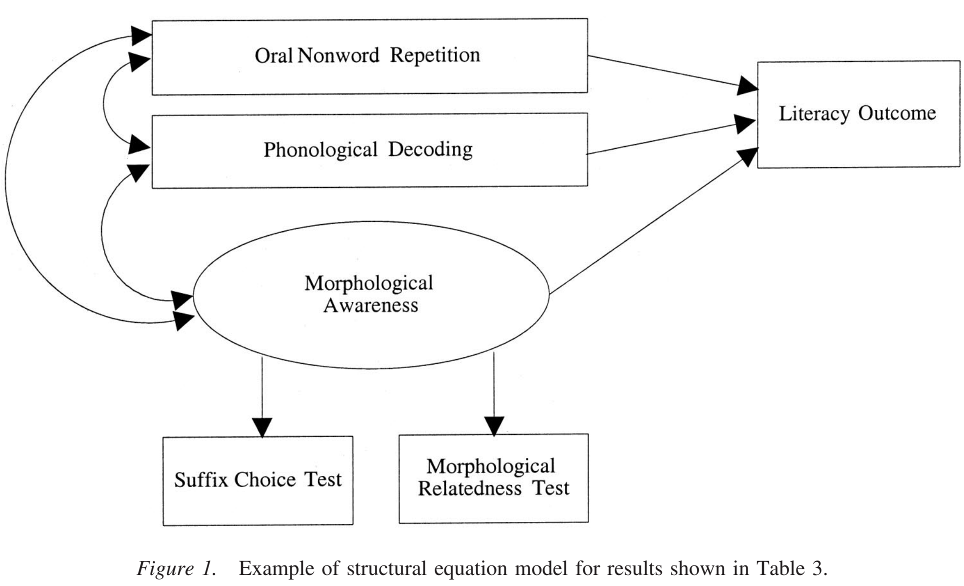

Figure 1. Example of structural equation model for results shown in Table 3.

These analyses were based on the model depicted in Figure 1. In this model, we assume that morphological awareness, phonological decoding, and oral nonword repetition each contribute to the literacy outcomes. Morphological awareness is a latent variable based on two measures, the Suffix Choice Test and the Morphological Relatedness Test. Phonological decoding and oral nonword repetition are each represented by one measure.

Morphology and vocabulary. Our data also allow a comparison with the findings of Ku and Anderson (2003), so we did additional structural equation modeling to further examine the roles of morphological awareness and vocabulary knowledge in reading comprehension. The analyses were based on the model depicted in Figure 2. In this model, we assume that morphological awareness contributes to vocabulary growth (Anglin, 1993), that vocabulary knowledge contributes to reading comprehension (Stahl & Fairbanks, 1986), and that morphological awareness may make an independent contribution to reading comprehension, above and beyond its contribution via vocabulary (Ku & Anderson, 2003).

Results

Means and Correlations

Table 1 contains the means and standard deviations for each measure. Performance on the morphological awareness tasks increased consistently over the range of grade levels examined, and each of the differences between the three grade-level groups was statistically significant. These results are consistent with those of other studies (e.g., Nagy et al., 1993; Nagy & Scott, 1990; Tyler & Nagy, 1989) showing that morphological knowledge continues to increase at least through high school.

Table 2 contains correlations for each of the three groups defined in terms of grade level (fourth/fifth, sixth/seventh, and eighth/ninth) for the three predictor variables (a latent factor for morphological awareness based on suffix choices and morphological relatedness, phonological working memory based on oral nonword repetition, and phonological decoding based on Word Attack) and for reading vocabulary. All correlations among morphological awareness, oral nonword repetition, phonological decoding, and reading vocabulary were significant at all grade levels. Correlations involving oral nonword repetition were generally lower than those among the other three variables. The highest correlations were between morphological awareness and reading vocabulary and between morphological awareness and phonological decoding. Morphological awareness was highly correlated with reading vocabulary at all grade levels, with the correlation being highest for the fourth/fifth-grade group (r = .83) and somewhat lower for the sixth/seventh-grade group (r = .72) and eighth/ninth-grade group (r = .67). Although morphological awareness and vocabulary are closely—and probably reciprocally—related, the two constructs also appear to separate to some degree as students get older. On the other hand, the correlation between morphological awareness and phonological decoding was highest in the sixth/seventh-grade group (r = .76) and a little lower in the other two groups (rs = .63 for fourth/fifth and .67 for eighth/ninth, respectively). The high correlation between morphological awareness and phonological decoding in the sixth/seventh-grade group is probably the reason why morphological awareness did not make a significant unique contribution to the decoding outcome variables for that group.

Structural Equation Modeling

Structural equation modeling was used to evaluate the contribution of morphological awareness, phonological decoding, and phonological memory to literacy outcomes for the three grade-level groups of students. All structural equation modeling analyses used EQS (Bentler, 1995) and were based on the covariance matrix of the measures. A significant path from a given predictor factor to an outcome factor means that that predictor factor contributes unique variance in explaining the outcome factor over and beyond its shared covariance with other predictor factors. If a path fails to reach statistical significance, it does not mean that the predictor factor is unrelated to the outcome factor. It may in fact have a significant correlation with the outcome factor but also a significant correlation with other predictor factors in the model, thus reducing its unique contribution to the prediction of the outcome. Table 3 displays the results for structural equation models for each of the three grade levels. For each grade-level group, outcome variable, and predictor variable, three numbers are given: the simple correlation between the predictor variable and the outcome variable for that group; the path weight, reflecting the strength of the unique contribution made by that predictor variable to that outcome variable; and a Z value associated with the unstandardized weight. Z values greater than 1.96 are significant at the .05 level (Bentler, 1995).

Morphological awareness made a significant unique contribution at all grade levels for reading comprehension, reading vocab-

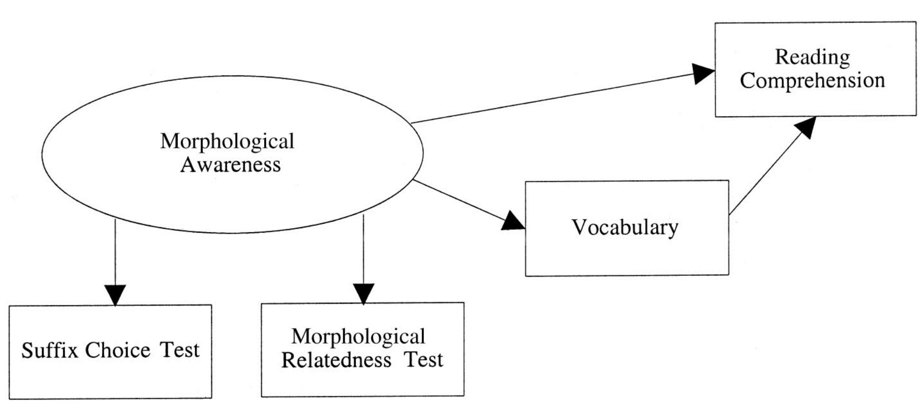

Figure 2. Example of structural equation model for results shown in Table 4.

Table 1
Means and Standard Deviations for Study Measures

Measure	Grade level: *M* (*SD*) 4–5	6–7	8–9
Suffix Choice Test[a]	11.8 (1.7)	12.6 (1.5)	13.1 (1.1)
Morphological Relatedness Test[a]	69.5 (10.6)	74.0 (7.6)	76.5 (4.0)
Oral nonword repetition[a]	19.2 (2.9)	30.3 (3.0)	21.1 (2.5)
Phonological decoding[b]	102.5 (10.8)	101.9 (11.4)	100.3 (10.1)
Reading vocabulary[c]	677.0 (43.4)	699.2 (46.7)	736.2 (44.3)
Reading comprehension[c]	669.9 (38.7)	690.7 (41.7)	714.9 (37.6)
Spelling[a]	31.0 (6.2)	35.8 (5.8)	39.9 (5.3)
Decoding inflected words			
Accuracy[a]	26.8 (3.2)	28.0 (2.3)	28.5 (1.2)
Time (s)[a]	30.1 (19.2)	23.4 (14.6)	18.7 (6.2)
Decoding prefixed and pseudoprefixed words			
Accuracy[a]	6.3 (1.4)	6.7 (1.2)	7.2 (0.9)
Time (s)[a]	12.3 (9.7)	9.1 (5.8)	6.9 (3.5)
Decoding prefixed irregular stems			
Accuracy[a]	7.2 (1.9)	8.0 (1.9)	8.8 (1.3)
Time (s)[a]	21.7 (13.9)	15.8 (7.8)	12.5 (4.7)
Decoding suffixed irregular stems			
Accuracy[a]	8.4 (1.7)	9.0 (1.6)	9.0 (1.5)
Time (s)[a]	17.6 (13.6)	12.5 (7.3)	10.0 (4.8)
Decoding sets of morphologically related words			
Accuracy[a]	35.8 (4.8)	37.9 (3.6)	38.8 (1.8)
Time (s)	53.6 (34.6)	39.1 (15.4)	31.8 (10.6)
Phonologically transparent accuracy[a]	16.4 (1.9)	17.0 (1.6)	17.3 (1.0)
Phonological shift accuracy[a]	10.0 (2.6)	11.0 (1.8)	11.5 (1.0)

[a] Raw score, but analyses used grade-corrected *z* score based on mean and standard deviation for each grade level.
[b] Standard score ($M = 100$, $SD = 15$).
[c] Scale score (see test manual; Karlsen & Gardner, 1996).

ulary, and spelling. The path weight for morphological awareness was also significant for decoding accuracy variables at some grade levels, suggesting that Grades 4 to 9 are a developmental period in which students are discovering, and refining their knowledge of, morphological aspects of the writing system. There was a significant unique contribution of morphological awareness at the fourth/fifth-grade level for accuracy of decoding inflectionally suffixed words and decoding prefixed and pseudoprefixed words, and at both the fourth/fifth- and eighth/ninth-grade levels for decoding prefixed irregular stems, decoding suffixed irregular stems, decoding sets of morphologically related words, and decoding accuracy for phonological shift items. The path weight from morphological awareness to decoding rate measures was significant at the eighth/ninth-grade level for all decoding rate measures. At the fourth/fifth-grade level, the path from morphological awareness to decoding rate was significant only for decoding prefixed and pseudoprefixed words.

Table 2
Correlations Among Variables

Grade level	1	2	3	4
Grades 4 & 5				
1. Oral nonword repetition	—	.24**	.30***	.35**
2. Phonological decoding	.24**	—	.63***	.61***
3. Morphological awareness	.30***	.63***	—	.83***
4. Vocabulary	.35***	.61***	.83***	—
Grades 6 & 7				
1. Oral nonword repetition	—	.34***	.53***	.44***
2. Phonological decoding	.34***	—	.76***	.62***
3. Morphological awareness	.53***	.76***	—	.72***
4. Vocabulary	.44***	.62***	.72***	—
Grades 8 & 9				
1. Oral nonword repetition	—	.52***	.50***	.42***
2. Phonological decoding	.52***	—	.62***	.49***
3. Morphological awareness	.50***	.62***	—	.67***
4. Vocabulary	.42***	.49***	.67***	—

** $p < .01$. *** $p < .001$.

Of relevance to the primary research questions, sometimes only the latent morphological awareness factor contributes unique variance to a literacy outcome at a particular grade level, and the size of the *z* statistic is often larger for the latent morphological awareness factor than for any of the phonological factors. However, the most striking finding is that for morphological decoding with phonological shifts, the *z* statistic is larger for the latent morphological factor than for either of the latent phonological factors at the fourth/fifth-grade and eighth/ninth-grade developmental levels; phonology is not explaining more of the unique variance when decoding requires both morphological and phonological processing. Overall, at the fourth/fifth-grade level, morphological awareness contributed uniquely to five of the nine literacy outcomes; at the sixth/seventh-grade level, to three of the nine literacy outcomes; and at the eighth/ninth-grade level, to all nine of the literacy outcomes. This developmental discontinuity is a typical pattern in developmental research—following an initial period of

Table 3
Structural Equation Modeling Results

Grade	Predictor variable	Correlation	Path	Z
	Outcome variable: Reading comprehension			
4–5	Oral nonword repetition	.27**	.05	0.69
	Phonological decoding	.38***	−.18	−1.18
	Morphological awareness	.76***	.86	5.02***
6–7	Oral nonword repetition	.36***	.03	0.24
	Phonological decoding	.53***	.08	0.36
	Morphological awareness	.65***	.57	2.17*
8–9	Oral nonword repetition	.47***	.16	2.26*
	Phonological decoding	.53***	.21	2.30*
	Morphological awareness	.59***	.38	3.56***
	Outcome variable: Reading vocabulary			
4–5	Oral nonword repetition	.35***	.10	1.49
	Phonological decoding	.61***	.13	1.02
	Morphological awareness	.83***	.72	5.05***
6–7	Oral nonword repetition	.44***	.09	0.95
	Phonological decoding	.62***	.19	1.09
	Morphological awareness	.72***	.52	2.30*
8–9	Oral nonword repetition	.42***	.09	1.22
	Phonological decoding	.49***	.09	0.90
	Morphological awareness	.67***	.57	5.15***
	Outcome variable: WIAT2 Spelling			
4–5	Oral nonword repetition	.33***	.11	2.06*
	Phonological decoding	.76***	.57	6.42***
	Morphological awareness	.66***	.27	2.77**
6–7	Oral nonword repetition	.36***	−.10[a]	−0.99
	Phonological decoding	.80***	.33	1.69
	Morphological awareness	.85***	.65	2.63**
8–9	Oral nonword repetition	.43***	.02	0.23
	Phonological decoding	.71***	.54	6.30***
	Morphological awareness	.60***	.26	2.76**

		Transparent			Phonological shift		
		r	Path	Z	r	Path	Z
	Outcome variable: Accuracy for transparent and phonological shift items						
4–5	Oral nonword repetition	.30***	.11	1.81	.32***	.06	1.10
	Phonological decoding	.68***	.56	6.14**	.74***	.40	3.83***
	Morphological awareness	.55***	.17	1.68	.79***	.52	4.48***
6–7	Oral nonword repetition	.31***	−.04	−0.41	.35***	.04	0.45
	Phonological decoding	.67***	.35	1.98*	.70***	.48	3.12**
	Morphological awareness	.68***	.44	1.96*	.67***	.28	1.43
8–9	Oral nonword repetition	.33***	.05	0.61	.41***	.06	0.86
	Phonological decoding	.53***	.42	4.18***	.57***	.28	3.02**
	Morphological awareness	.43***	.14	1.21	.62***	.41	3.94***

		Accuracy			Rate		
		r	Path	Z	r	Path	Z
	Outcome variable: Decoding inflected words						
4–5	Oral nonword repetition	.26**	.05	0.85	.21**	.05	0.82
	Phonological decoding	.71***	.53	5.81***	.62***	.54	5.79***
	Morphological awareness	.61***	.27	2.62**	.44***	.11	1.00
6–7	Oral nonword repetition	.33***	−.01	−0.12	.31***	.04	0.38
	Phonological decoding	.69***	.38	2.28**	.59***	.35	2.06*
	Morphological awareness	.69***	.40	1.86	.58***	.29	1.34
8–9	Oral nonword repetition	.33***	.05	0.62	.31***	−.05	0.69
	Phonological decoding	.52***	.38	3.79***	.56***	.39	4.26****
	Morphological awareness	.44***	.17	1.57	.53***	.32	3.12**
	Outcome variable: Decoding prefixed and pseudoprefixed words						
4–5	Oral nonword repetition	.23**	.00	−0.02	.20**	.03	0.38
	Phonological decoding	.70***	.47	4.62***	.56***	.37	3.45***
	Morphological awareness	.67***	.38	3.26**	.54***	.32	2.37**

Table 3 (*continued*)

		Accuracy			Rate		
		r	Path	*Z*	*r*	Path	*Z*
		Outcome variable: Decoding prefixed and pseudoprefixed words (*continued*)					
6–7	Oral nonword repetition	.32***	.08	0.87	.41***	.09	0.94
	Phonological decoding	.58***	.39	2.42*	.62***	.24	1.31
	Morphological awareness	.56***	.21	1.02	.68***	.45	1.94
8–9	Oral nonword repetition	.29**	.03	0.38	.29**	−.06	0.83
	Phonological decoding	.46***	.35	3.39***	.52***	.34	3.68***
	Morphological awareness	.38***	.14	1.25	.53***	.36	3.50**
		Outcome variable: Decoding prefixed irregular stems					
4–5	Oral nonword repetition	.03	−.20	−2.96**	.19**	.03	0.45
	Phonological decoding	.60***	.36	3.13**	.58***	.48	4.87***
	Morphological awareness	.63***	.46	3.51***	.46***	.16	1.39
6–7	Oral nonword repetition	.29**	−.01	−0.14	.29**	.07	0.85
	Phonological decoding	.55***	.23	1.25	.64***	.59	4.11***
	Morphological awareness	.58***	.41	1.72	.52***	.04	0.21
8–9	Oral nonword repetition	.18*	−.21[a]	−2.72**	.29**	−.14	2.03*
	Phonological decoding	.50***	.34	3.38**	.64***	.51	6.16***
	Morphological awareness	.52***	.42	3.62***	.57***	.35	3.81***
		Outcome variable: Decoding suffixed irregular stems					
4–5	Oral nonword repetition	.25**	.02	0.29	.19**	.03	0.43
	Phonological decoding	.67***	.37	3.37***	.63***	.55	5.75***
	Morphological awareness	.71***	.47	3.74***	.47***	.13	1.15
6–7	Oral nonword repetition	.36***	.05	0.52	.34***	.04	0.45
	Phonological decoding	.61***	.28	1.58	.65***	.40	2.51*
	Morphological awareness	.65***	.41	1.82	.64***	.31	1.53
8–9	Oral nonword repetition	.33**	.04	0.57	.38***	.01	0.12
	Phonological decoding	.48***	.30	2.99**	.65***	.49	5.77***
	Morphological awareness	.47***	.26	2.34*	.56***	.28	3.00**
		Outcome variable: Decoding sets of morphologically related words					
4–5	Oral nonword repetition	.31***	.07	1.19	.24**	.08	1.20
	Phonological decoding	.76***	.50	5.31***	.64***	.52	5.33***
	Morphological awareness	.73***	.40	3.71***	.51***	.18	1.59
6–7	Oral nonword repetition	.36***	.01	0.05	.37***	.10	1.30
	Phonological decoding	.73***	.41	2.47*	.70***	.54	3.81*
	Morphological awareness	.73***	.41	1.94	.63***	.16	0.90
8–9	Oral nonword repetition	.46***	.07	1.04	.38***	.04	0.50
	Phonological decoding	.67***	.42	4.89***	.58***	.39	4.26***
	Morphological awareness	.63***	.33	3.41***	.54***	.30	2.83**

[a]Suppressor effect, because sign of path is negative and total correlation is positive.
* $p < .05$. ** $p < .01$. *** $p < .001$.

relative developmental gains in a skill (e.g., morphological awareness and its relationship to literacy learning), there is a period of relatively little growth, followed by a growth spurt or even mastery (Emde & Harmon, 1984).

The results of the structural equation modeling analyses used to compare our results with those of Ku and Anderson (2003) are summarized in Table 4. As expected, morphological awareness is strongly related to vocabulary knowledge in all three grade-level groups. Likewise, as predicted, morphological awareness made an independent contribution to reading comprehension, over and above that of vocabulary, at all three levels. The lack of a significant direct path from vocabulary to comprehension for the fourth/fifth-grade group reflects the strong relationship between vocabulary and morphological awareness. The correlation between these two variables is so high at this level ($r = .85$) that it is not surprising that vocabulary does not contribute a statistically significant amount of unique variance.

Discussion

Results showed that when the shared variance among morphological awareness, phonological working memory, and phonological decoding are controlled statistically, morphological awareness contributes uniquely to all outcome measures for at least one of the three grade-level groups we examined. It made a significant unique contribution at all grade levels to reading comprehension, reading vocabulary, and spelling. The unique contribution of morphological awareness to decoding accuracy was strongest in the fourth/fifth-grade group, and to decoding rate in the eighth/ninth-grade group. With the exception of spelling, there was a general lack of significant unique effects of morphological awareness on literacy outcomes for the sixth/seventh-grade group, presumably due (as previously mentioned) to the high correlation between morphological awareness and phonological decoding at this grade level.

Table 4
Structural Equation Modeling Results: Total and Direct Effects of Morphological Awareness on Comprehension

Grade	Path	Total effect	Direct path	*Z*
4–5	Morphology → Vocabulary	.85	.85	10.07***
	Vocabulary → Comprehension	.66	.03	0.11
	Morphology → Comprehension	.76	.74	2.33*
6–7	Morphology → Vocabulary	.72	.72	8.35***
	Vocabulary → Comprehension	.72	.54	5.22***
	Morphology → Comprehension	.65	.26	2.14*
8–9	Morphology → Vocabulary	.67	.67	8.98***
	Vocabulary → Comprehension	.67	.51	6.13***
	Morphology → Comprehension	.58	.24	2.56*

$^{*}p < .05$. $^{***}p < .001$.

For decoding accuracy variables, the unique effect of morphological awareness was significant for those categories of words that would be considered more difficult: phonological shift items, decoding prefixed irregular stems, and decoding suffixed irregular stems. The unique contribution of morphological awareness was not significant for the decoding accuracy items that would be considered easier: phonologically transparent words, decoding inflected words, and decoding prefixed and pseudoprefixed words.

Morphological awareness made a significant contribution to decoding accuracy at both the fourth/fifth-grade level and the eighth/ninth-grade level, whereas it made a significant contribution to decoding rate only at the eighth/ninth-grade level. This could be interpreted as indicating that morphological awareness contributes first to accuracy of decoding and only later to fluency. On the other hand, the relationship of morphological awareness to vocabulary and spelling was significant at all of the grade levels investigated here.

Oral nonword repetition only seldom made a significant unique contribution to literacy outcomes at the developmental levels studied—to reading comprehension for the eighth/ninth-grade group, to spelling for the fourth/fifth-grade group, to accuracy of decoding prefixed irregular stems for the fourth/fifth- and eighth/ninth-grade groups, and to rate of decoding prefixed irregular stems for the eighth/ninth-grade groups. Phonological decoding made a significant unique contribution to reading comprehension for the eighth/ninth-grade group, to spelling for the fourth/fifth- and eighth/ninth-grade groups, and to the decoding rate and accuracy measures for all three groups, with only three exceptions. For reading comprehension, reading vocabulary, and spelling, morphological awareness was by far the strongest and most consistent predictor. On the other hand, for the decoding measures, phonological decoding was the most consistent in making a significant unique contribution. However, morphological awareness also made a significant unique contribution to decoding accuracy for most measures for the fourth/fifth- and eighth/ninth-grade groups and to all decoding rate measures for the eighth/ninth-grade groups.

The structural equation modeling analyses of the relationships among morphological awareness, vocabulary, and reading comprehension showed that much of the contribution of morphological awareness to reading comprehension is via its impact on vocabulary growth. However, Table 4 also shows that morphological awareness makes a significant contribution to comprehension above and beyond that of vocabulary. Findings from the analyses in Table 3 suggest one of the additional connections between morphological awareness and comprehension: Higher levels of morphological awareness are associated with greater accuracy and fluency in decoding morphologically complex words, which would in turn contribute to greater comprehension. Another potential connection between morphology and comprehension is the role of morphological awareness in syntactic parsing. Suffixes provide one type of signal of the syntactic structure of a sentence, a signal that becomes increasingly important as the proportion of morphologically complex words in text increases. There is already evidence that the ability to utilize the information provided by suffixes is associated with reading ability (Tyler & Nagy, 1990); further research is needed to explore the nature and strength of this connection.

Because this is a cross-sectional study, we must be tentative in our interpretation of differences among the three grade-level groups. However, the relative homogeneity of our sample, which is in other regards a serious limitation of this study, somewhat decreases the risk that differences between grade levels are the result of extraneous variables. Some patterns are evident that, if confirmed by longitudinal research, have implications for how instruction in morphology might differ in focus for different grade levels.

First of all, both the zero-order correlations and path weights show that morphological awareness has the strongest relationship with vocabulary for the fourth/fifth-grade group. This finding is consistent with the results of Nagy et al. (2003), who found the relationship between morphological awareness and vocabulary knowledge to be stronger in fourth grade than in second grade. The finding is likewise consistent with the sharp increase in students' knowledge of derived words between third and fifth grade reported by Anglin (1993). It is at this level, then, that the application of morphology to word learning is the growing edge for many students.

The pattern for spelling is strikingly different, with both zero-order correlations and path weights showing the strongest effects of morphological awareness for the sixth/seventh-grade group. It appears, then, that the role of morphology in the writing system is grasped later than basic insight that new words can be analyzed as combinations of familiar parts. This pattern is consistent with Bear et al.'s (2004) developmental approach to spelling, which recognizes the layer of meaning (i.e., morphology) as the last aspect of the spelling system to be acquired.

The fact that morphology has an impact on spelling later than it does on vocabulary suggests a possible need for differentiation in the nature and timing of instruction. For example, the kind of morphology instruction described by Graves (2004) or White and his colleagues (White, Power, & White, 1989; White, Sowell, & Yanagihara, 1989) focuses on figuring out the meanings of new words and on a small number of prefixes and suffixes that have minimal, if any, impact on the spelling of words to which they are added. Such instruction would look different, and could presumably start at an earlier grade level, than instruction on more complex morphology–spelling connections such as that described in Bear et al. (2004).

Conclusion

The interplay between morphological and phonological skills is best evaluated at a developmental stage when morphology begins to make a reliable independent contribution to reading and writing. Although morphological awareness may make a significant unique contribution to some aspects of literacy as early as second grade (Nagy et al., 2003), the unique contribution of morphological awareness to some literacy skills, such as decoding rate, is consistently evident only by Grades 8 and 9.

There are multiple ways by which morphological awareness may contribute to reading and writing. Morphological awareness makes a significant unique contribution, over and above shared variance with phonological working memory and phonological decoding, to reading vocabulary, spelling, decoding accuracy, and decoding rate in Grades 4 through 9. Each of these may in turn explain some of the consistent relationship between morphological awareness and reading comprehension. Thus, reading words for meaning, reading text for understanding, spelling, and accuracy and rate of decoding morphologically complex words (which are common in the upper elementary and middle-school grades) cannot be explained solely on the basis of phonological skills. Further research is needed on the most effective instructional techniques for teaching general education and special education students in these grade levels about morphology and its relationship to phonology.

References

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society of Research in Child Development, 58*(10, Serial No. 238).

Arnbak, E., & Elbro, C. (2000). The effects of morphological awareness training on the reading and spelling skills of young dyslexics. *Scandinavian Journal of Educational Research, 44,* 229–251.

Assink, E., Vooijs, C., & Knuijt, P. (2000). Prefixes as access units in visual word recognition: A comparison of Italian and Dutch data. *Reading and Writing: An Interdisciplinary Journal, 12,* 149–168.

Bear, D. R., Invernizzi, M., Templeton, S., & Johnston, F. (2004). *Words their way: Word study for phonics, vocabulary, and spelling instruction* (3rd ed.). Upper Saddle River, NJ: Pearson.

Bentler, P. M. (1995). *EQS structural equations program manual*. Encino, CA: Multivariate Software.

Berko, J. (1958). The child's learning of English morphology. *Word, 14,* 150–177.

Berninger, V., Abbott, R., Billingsley, F., & Nagy, W. (2001). Processes underlying timing and fluency: Efficiency, automaticity, coordination, and morphological awareness. In M. Wolf (Ed.), *Dyslexia, fluency, and the brain* (pp. 383–414). Baltimore: York Press.

Berninger, V., Nagy, W., Carlisle, J., Thomson, J., Hoffer, D., Abbott, S., et al. (2003). Effective treatment for dyslexics in Grades 4 to 6. In B. Foorman (Ed.), *Preventing and remediating reading difficulties: Bringing science to scale* (pp. 382–417). Timonium, MD: York Press.

Brittain, M. M. (1970). Inflectional performance and early reading achievement. *Reading Research Quarterly, 6,* 34–48.

Bryant, P., Nunes, T., & Bindman, M. (1997a). Backward readers' awareness of language: Strengths and weaknesses. *European Journal of Psychology of Education, 12,* 357–372.

Bryant, P., Nunes, T., & Bindman, M. (1997b). Children's understanding of the connection between grammar and spelling. In B. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 219–240). Mahwah, NJ: Erlbaum.

Bryant, P., Nunes, T., & Bindman, M. (2000). The relations between children's linguistic awareness and spelling: The case of the apostrophe. *Reading and Writing: An Interdisciplinary Journal, 12,* 253–276.

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Erlbaum.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing: An Interdisciplinary Journal, 12,* 169–190.

Carlisle, J. F. (2003). Morphology matters in learning to read: A commentary. *Reading Psychology, 24,* 291–322.

Carlisle, J. (2004). Morphological processes that influence learning to read. In A. Stone, E. Silliman, B. Ehren, & K. Apel (Eds.), *Handbook of language and literacy: Development and disorders* (pp. 318–339). New York: Guilford Press.

Carlisle, J. F., & Fleming, J. (2003). Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading, 7,* 239–253.

Carlisle, J. F., & Nomanbhoy, D. M. (1993). Phonological and morphological awareness in first graders. *Applied Psycholinguistics, 14,* 177–195.

Carlisle, J. F., & Stone, C. A. (2004). The effects of morphological structure on children's reading of derived words. In E. Assink & D. Santa (Eds.), *Reading complex words: Cross-language studies* (pp. 27–52). Amsterdam: Kluwer.

Carlisle, J., Stone, C. A., & Katz, L. (2001). The effects of phonological transparency on reading derived words. *Annals of Dyslexia, 51,* 249–274.

Chafe, W., & Danielewicz, J. (1987). Properties of spoken and written language. In R. Horowitz & S. J. Samuels (Eds.), *Comprehending oral and written language* (pp. 83–113). San Diego, CA: Academic Press.

Champion, A. (1997). Knowledge of suffixed words: A comparison of reading disabled and nondisabled readers. *Annals of Dyslexia, 47,* 29–55.

Chomsky, N., & Halle, M. (1968). *The sound pattern of English.* New York: Harper & Row.

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics, 25,* 223–238.

De Jong, N., Schreuder, R., & Baayen, R. H. (2000). The morphological family size effect and morphology. *Language and Cognitive Processes, 15,* 329–365.

Derwing, B. L. (1976). Morpheme recognition and the learning of rules for derivational morphology. *Canadian Journal of Linguistics, 21,* 38–66.

Derwing, B. L., Smith, M. L., & Wiebe, G. E. (1995). On the role of spelling in morpheme recognition: Experimental studies with children and adults. In L. Feldman (Ed.), *Morphological aspects of language processing* (pp. 3–27). Hillsdale, NJ: Erlbaum.

Emde, R. N., & Harmon, R. S. (1984). *Continuities and discontinuities in development.* New York: Plenum Press.

Feldman, L., Frost, R., & Pnini, T. (1995). Decomposing words into their constituent morphemes: Evidence from English and Hebrew. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 947–960.

Fowler, A. E., & Liberman, I. Y. (1995). The role of phonology and orthography in morphological awareness. In L. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Erlbaum.

Freyd, P., & Baron, J. (1982). Individual differences in acquisition of derivational morphology. *Journal of Verbal Learning and Verbal Behavior, 21,* 282–295.

Gathercole, S. E., Service, E., Hitch, G., Adams, A., & Martin, A. (1999). Phonological short-term memory and vocabulary development: Further evidence on the nature of the relationship. *Applied Cognitive Psychology, 13,* 65–77.

Goulden, R., Nation, P., & Read, J. (1990). How large can a receptive vocabulary be? *Applied Linguistics, 11,* 341–363.

Graves, M. F. (2004). Teaching prefixes: As good as it gets? In J. Baumann & E. Kame'enui (Eds.), *Vocabulary instruction: Research to practice* (pp. 81–99). New York: Guilford Press.

Henry, M. K. (1988). Beyond phonics: Integrated decoding and spelling instruction based on word origin and structure. *Annals of Dyslexia, 38,* 259–275.

Henry, M. K. (1989). Children's word structure knowledge: Implications for decoding and spelling instruction. *Reading and Writing: An Interdisciplinary Journal, 2,* 135–152.

Henry, M. K. (1993). Morphological structure: Latin and Greek roots and affixes as upper grade code strategies. *Reading and Writing: An Interdisciplinary Journal, 5,* 227–241.

Henry, M. (2003). *Unlocking literacy: Effective decoding and spelling instruction.* Baltimore: Brookes Publishing.

Karlsen, B., & Gardner, E. (1994). *Stanford Diagnostic Reading Test* (4th ed.). Blue level (Grades 9.0 to 12.9). San Antonio, TX: Harcourt Brace Educational Measurement.

Karlsen, B., & Gardner, E. (1995). *Stanford Diagnostic Reading Test* (4th ed.). Brown level (Grades 6.5 to 8.9). San Antonio, TX: Harcourt Brace Educational Measurement.

Karlsen, B., & Gardner, E. (1996). *Stanford Diagnostic Reading Test* (4th ed.). Purple level (Grades 4.5 to 6.5). San Antonio, TX: Harcourt Brace Educational Measurement.

Ku, Y., & Anderson, R. C. (2003). Development of morphological awareness in Chinese and English. *Reading and Writing: An Interdisciplinary Journal, 16,* 399–422.

Laudanna, A., Badecker, W., & Caramazza, A. (1989). Priming homographic stems. *Journal of Memory and Language, 28,* 531–546.

Lovett, M. W. (1999). Redefining and remediating the core deficits of developmental dyslexia: Lessons from remedial outcome research with reading disabled children. In R. Klein & P. McMullen (Eds.), *Converging methods for understanding reading and dyslexia.* Cambridge, MA: MIT Press.

Lovett, M. W., Lacerenza, L., & Borden, S. L. (2000). Putting struggling readers on the PHAST track: A program to integrate phonological and strategy-based remedial reading instruction and maximize outcomes. *Journal of Learning Disabilities, 33,* 458–476.

Mahoney, D. I., & Mann, V. A. (1992). Using children's humor to clarify the relationship between linguistic awareness and early reading ability. *Cognition, 45,* 163–186.

Mahony, D., Singson, M., & Mann, V. (2000). Reading ability and sensitivity to morphological relations. *Reading and Writing: An Interdisciplinary Journal, 12,* 191–218.

Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology, 91,* 3–19.

Morris, R. D., Stuebing, K. K., Fletcher, J. M., Shaywitz, S. E., Lyon, G. R., Shankweiler, D. P., et al. (1998). Subtypes of reading disability: Variability around a phonological core. *Journal of Educational Psychology, 90,* 347–373.

Nagy, W. E., & Anderson, R. C. (1984). The number of words in printed school English. *Reading Research Quarterly, 19,* 304–330.

Nagy, W. E., Anderson, R., Schommer, M., Scott, J., & Stallman, A. (1989). Morphological families in the internal lexicon. *Reading Research Quarterly, 24,* 262–282.

Nagy, W., Berninger, V., Abbott, R., Vaughan, K., & Vermeulen, K. (2003). Relationship of morphology and other language skills to literacy skills in at-risk second-grade readers and at-risk fourth-grade writers. *Journal of Educational Psychology, 95,* 730–742.

Nagy, W., Diakidoy, I., & Anderson, R. (1993). The acquisition of morphology: Learning the contribution of suffixes to the meaning of derivatives. *Journal of Reading Behavior, 25,* 155–170.

Nagy, W. E., & Scott, J. (1990). Word schemas: Expectations about the form and meaning of new words. *Cognition and Instruction, 7,* 105–127.

Napps, S. E. (1989). Morphemic relationships in the lexicon: Are they distinct from semantic and formal relationships? *Memory & Cognition, 17,* 729–739.

Nunes, T., Bryant, P., & Bindman, M. (1997a). Learning to spell regular and irregular verbs. *Reading and Writing: An Interdisciplinary Journal, 9,* 427–449.

Nunes, T., Bryant, P., & Bindman, M. (1997b). Morphological spelling strategies: Developmental stages and processes. *Developmental Psychology, 33,* 637–649.

Nunes, T., Bryant, P., & Olsson, J. (2003). Learning morphological and phonological spelling rules: An intervention study. *Scientific Studies of Reading, 7,* 289–307.

Olson, R., Wise, B., Conners, F., Rack, J., & Fulker, D. (1989). Specific deficits in component reading and language skills: Genetic and environmental influences. *Journal of Learning Disabilities, 22,* 339–348.

Pillon, A. (1998). The pseudoprefixation effect in visual word recognition: A true—neither strategic nor orthographic—morphemic effect. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 51A,* 85–120.

Psychological Corporation. (2001). *Wechsler Individual Achievement Test, 2nd ed. (WIAT–II).* San Antonio, TX: Author.

Richards, T., Aylward, E., Raskind, W., Abbott, R., Field, K., Parsons, A., et al. (in press). Converging evidence for triple word form theory in child dyslexics. *Developmental Neuropsychology*.

Richards, T., Berninger, V., Aylward, E., Richards, A., Thomson, J., Nagy, W., et al. (2002). Reproducibility of proton MR spectroscopic imaging: Comparison of dyslexic and normal reading children and effects of treatment on brain lactate levels during language tasks. *American Journal of Neuroradiology, 23,* 1678–1685.

Richards, T., Berninger, V., Nagy, W., Parsons, A., Field, K., & Richards, A. (2005). Brain activation during language task contrasts in children with and without dyslexia: Inferring mapping processes and assessing response to spelling instruction. *Educational and Child Psychology, 22,* 62–80.

Schlagal, R. C. (1992). Patterns of orthographic development into the intermediate grades. In S. Templeton & D. Bear (Eds.), *Development of orthographic knowledge and the foundations of literacy: A memorial festschrift for Edmund H. Henderson* (pp. 31–52). Hillsdale, NJ: Erlbaum.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. E., Brady, S. A., et al. (1995). Cognitive profiles of reading disabled children:

Comparisons of language skills in phonology, morphology and syntax. *Psychological Science, 6,* 149–156.

Singson, M., Mahony, D., & Mann, V. (2000). The relation between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing: An Interdisciplinary Journal, 12,* 219–252.

Stahl, S., & Fairbanks, M. (1986). The effects of vocabulary instruction: A model-based meta-analysis. *Review of Educational Research, 56,* 72–110.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21,* 360–407.

Taft, M. (1979). Lexical access via an orthographic code: The basic orthographic syllable structure (BOSS). *Journal of Verbal Learning and Verbal Behavior, 18,* 21–39.

Templeton, S., & Morris, D. (2000). Spelling. In M. Kamil, P. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 525–543). Mahwah, NJ: Erlbaum.

Treiman, R., & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology, 63,* 141–170.

Tyler, A., & Nagy, W. (1989). The acquisition of English derivational morphology. *Journal of Memory and Language, 28,* 649–667.

Tyler, A., & Nagy, W. (1990). Use of derivational morphology during reading. *Cognition, 36,* 17–34.

Venezky, R. L. (1970). *The structure of English orthography.* The Hague, the Netherlands: Mouton.

Venezky, R. L. (1999). *The American way of spelling: The structure and origins of American English orthography.* New York: Guilford Press.

Verhoeven, L., & Perfetti, C. (2003). Introduction to this special issue: The role of morphology in learning to read. *Scientific Studies of Reading, 7,* 209–217.

Verhoeven, L., Schreuder, R., & Baayen, H. (2003). Units of analysis in reading Dutch bisyllabic pseudowords. *Scientific Studies of Reading, 7,* 255–271.

Wagner, R., & Torgesen, J. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101,* 191–212.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1999). *Comprehensive Test of Phonological Processing.* Austin, TX: PRO-ED.

White, T., Power, M., & White, S. (1989). Morphological analysis: Implications for teaching and understanding vocabulary growth. *Reading Research Quarterly, 24,* 283–304.

White, T., Sowell, M., & Yanagihara, A. (1989). Teaching elementary students to use word-part clues. *Reading Teacher, 42,* 302–308.

Woodcock, R. W. (1987). *Woodcock Reading Mastery Tests—Revised.* Circle Pines, MN: AGS Publishing.

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