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Growth in Phonological, Orthographic, and Morphological Awareness in Grades 1 to 6

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Abstract Growth curve analyses showed that (a) word-level phonological and orthographic awareness show greatest growth during the primary grades but some additional growth thereafter, and (b) three kinds of morphological awareness show greatest growth in the first three or four grades but one—derivation—continues to show substantial growth after fourth grade. Implications of the findings for the role of three kinds of linguistic awareness—phonological, orthographic, and morphological—in learning to read and spell words are discussed. A case is made that phonological awareness, while necessary, is not sufficient for learning to read English—all three kinds of linguistic awareness that are growing during the primary grades need to be coordinated and applied to literacy learning. This finding and a review of the research on linguistic awareness support the conclusion that the recommendations of the National Reading Panel need to be amended so that the research evidence supporting the importance of both orthographic and morphological awareness, and not only phonological awareness, is acknowledged. Moreover, evidence-based strategies for teaching each of these kinds of linguistic awareness and their interrelationships need to be disseminated to educational practitioners.

Keywords Phonological awareness · Orthographic awareness · Morphological awareness · Growth curves · Reading acquisition

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Three kinds of linguistic awareness—phonological, orthographic, and morphological—have been studied in cross-sectional studies. Little is known about their longitudinal growth. The current longitudinal study was designed to address that issue. First, we define linguistic awareness. Second, we review research evidence about the contribution of each kind of linguistic awareness to literacy learning. Third, we describe the measures of each kind of linguistic awareness used and other aspects of the methods. Finally, after reporting the results of the growth modeling of linguistic awareness, we consider alternative models of how these different kinds of linguistic awareness might be coordinated in learning to read and spell words.

Defining and Operationalizing Linguistic Awareness

Mattingly (1972) proposed that the ability to treat words as objects of reflection about their properties is critical in reading acquisition. Although phonological awareness of the sound units in spoken words—syllables, phonemes, and rimes—is related to learning to read and spell, orthographic and morphological awareness are also related to literacy learning (e.g., Seymour 1997).

Linguistic awareness can be operationalized as performance on tasks that require conscious awareness and reflection about a spoken or written word and its parts or its relationships to other words. To assess phonological awareness, words are presented orally and the task is to repeat the heard word and then repeat it again after deleting a syllable, phoneme, or rime. To assess orthographic awareness, an individual is asked to remember a briefly displayed written word and then decide if it matches another word exactly or contains a designated letter or letter group. To assess morphological awareness, words are presented orally and visually, so that reading is not required, and the task is to make judgments about semantic or semantic-syntactic relationships that depend upon the form of the word or its parts.

Evidence for Phonological Awareness

Following Bruce's (1964) seminal insight that learning to read requires analysis of sounds in spoken words, Liberman and Shankweiler and colleagues (e.g., Liberman et al. 1974, 1977) and Rosner (1974) reported evidence for a developmental progression from syllable awareness to phoneme awareness. Bradley and Bryant (1983) then demonstrated a causal connection between phonological awareness of rhymes and phonemes during the preschool years and learning to read in the early school years. Treiman (1985) subsequently extended the construct of phonological awareness to include analysis of rimes (the portion of the syllable after the onset phoneme or phoneme blend). Wagner and Torgesen (1987) reviewed the early research on phonological awareness and concluded that converging evidence validated three separate constructs: phonological awareness, phonological memory, and phonological decoding, which is translating written words into spoken words. Recent research on phonological awareness has focused on phonotactics—the permissible sound sequences in the spoken language (Apel et al. 2006; Kessler and Treiman 1997); but clinical measures were not available for this kind of phonological awareness at the time the current study commenced.

Evidence for Orthographic Awareness

Berninger (1987) adapted Johnson's (1978, 1986) paradigm for study of orthographic coding and awareness in adults for use with children from the end of kindergarten to the end of first grade. This computerized task required children to view briefly displayed words on a computer monitor and then make judgments about whether a second word matched exactly or a letter or a letter group was in the written word. Because items were selected so that correct responses could not be made solely on the basis of phonology, conclusions could be reached about orthographic awareness. Initially, children were aware of the series of all the letters in a word, but subsequently they could selectively attend to and remember a single letter in the word or a letter group in the word (Berninger 1987).

Using a non-computerized version of the task similar to the one used in the current study, Berninger and colleagues reported a comparable developmental trend and evidence that receptive orthographic awareness explained unique variance in reading (Berninger et al. 1991) and handwriting, spelling, and composing (Berninger et al. 1992) in first, second, and third graders. Because typically developing children reached or approached ceiling on the receptive orthographic awareness task by third grade, Berninger et al. (1994) introduced an expressive orthographic awareness task requiring that, after viewing a written word, the child had to write it or a designated letter or letter group in it; this expressive task also explained unique variance in handwriting, spelling, and composing as well as reading in typically developing fourth, fifth, and sixth grade children.

Another research approach to assessing orthographic awareness is related to precise, word-specific spellings in long-term memory equated for phonology so that conclusions can be drawn about orthographic representations apart from phonological representations (Manis et al. 1990; Olson et al. 1999, 1994a,b). Children are asked which spelling is a real, correctly spelled word in a pair of real words and pseudohomonyms (made up words that were pronounced the same but spelled differently). This word choice task also contributed uniquely to reading and writing acquisition in fourth, fifth, and sixth grade children (e.g., Berninger et al. 1994).

Another valuable approach to assessment of orthographic awareness evaluates orthotactic knowledge of the regularities in spelling, including probable letter sequences and positions of specific letters (e.g., Apel et al. 2006; Pacton et al. 2001, 2005). Orthographic awareness (Barker et al. 1992), knowledge of permissible letter sequences (e.g., Apel et al. 2006; Pacton et al. 2001, 2005), and attention to the 1- and 2-letter graphemes in written words that correspond to the phonemes in alphabetic principle (Venezky 1970, 1999) may affect students' implicit learning of the statistical regularities of orthographic and phonological representations of words (and their covariance). Orthographic memory for specific visual/spelling patterns that identify individual words or word parts increasingly contributes to skill in reading words beginning in the elementary years and continuing thereafter (Windsor 2000). At the time this longitudinal study commenced, clinical measures of orthotactic awareness were not available in English.

Evidence for Morphological Awareness

Berko (1958) used oral pseudowords (e.g. kug) to show that children aged 5.5–7 are aware of *inflectional suffixe*s for representing plurals (e.g., kugs) and past tense (e.g., kugged). Anglin (1993) concluded, based on third graders knowing more derivational suffixes than first graders, that *derivational suffixes*, which change the part of speech of the base word, for example, from a noun as in love to an adverb as in lovely, are acquired gradually and relatively late. However, Carlisle and Nomanbhoy (1993) showed that, if real words without phonological shifts in the pronunciation of the base word (e.g. fun) when a suffix is added (e.g. funny) were used, first graders had some knowledge of derivational suffixes and more than kindergarteners did.

Both Berko (1958) and Carlisle and Nomanbhoy (1993) used a production task in which children had to transform a base word and add a suffix to make the affixed word fit a specific syntactic context. This kind of task assesses morphological awareness related to awareness of syntax. Examples of two kinds of tasks that require morphological transformations are the derivation and decomposition tasks developed by Carlisle (1995, 2000). For derivation, a child is given a base word (e.g. humor) and asked to tranform it for the syntactic context (e.g., The story is quite _________). For decomposition, the child is given a word with a suffix (e.g., humorous) and asked to remove it to make the base word fit the syntactic context (e.g., The man has a sense of _________). In a K to 2 longitudinal study (Carlisle 1995), first graders were better than kindergarteners on both the derivation and decomposition task; and performance on these tasks in first grade predicted word analysis and reading comprehension in second grade, but phonological awareness was a better predictor of word analysis and morphological awareness was a better predictor of reading comprehension. In a study of third and fifth graders (Carlisle 2000), the combined derivation and decomposition tasks were significantly related to reading comprehension in fifth, but not third, grade; both tasks were related to decoding morphologically complex words in third and fifth grade.

Singson et al. (2000) used another morphological awareness task related to awareness of syntax—choose from four choices (affixed words) the one that fits a sentence context, thus assessing morphological awareness of the relationships between morphology and syntax. Whether the choices were real words or pseudowords, performance improved on this task from third to sixth grade and in the upper elementary grades contributed uniquely to decoding.

In contrast, the Derwing (1976) and Derwing et al. (1995) tasks required children to make judgments about the semantic relatedness of word pairs, one with a suffix and one without a suffix, that are (e.g. builder and build) and are not (e.g., mother and moth) semantically related. Children showed improvement over time on this task especially when phonological shifts (e.g. nation becomes national) were also involved. Tyler and Nagy (1989) showed that morphological awareness on the semantic relatedness task and on other measures of processing derivational suffixes improve significantly from fourth to sixth grade. Mahony et al. (2000) used the semantic relatedness judgment task with derivational suffixes and found that, whether administered orally or in writing, children improved from third to sixth grade; even when phonological awareness was taken into account, this morphological awareness task contributed significantly to word decoding.

Ku and Anderson (2003) studied four kinds of morphological awareness, one of which was Derwing's (1976) judgment task involving semantic similarity. The others were (a) discriminating among morphemes by choosing the odd word part in a set of three that shared spelling but only two were real morphemes (e.g. classroom, bedroom, mushroom); (b) selecting interpretations from multiple choice definitions of what an affixed word means; and (c) judging whether pseudowords could be real, plausible words (even if improbable) or not, showing knowledge of the word formation process for longer, more complex but less frequent words. Children improved from the second to the fourth to the sixth grade on all four morphological awareness tasks, which when pooled together were significantly correlated with reading achievement.

Morphological awareness may also be related to specific reading disabilities. Tyler and Nagy (1990) reported that good readers make better use of grammatical information in words with derivational suffixes than do poor readers. Students with dyslexia given morphological awareness treatment improved more than controls without dyslexia on one morphological awareness task but also in reading comprehension and spelling on some measures of morphologically complex words (Arnback and Elbro 2000).

Although most of the research on morphological awareness has focused on its contribution to reading, the relationship of morphological awareness to spelling (Carlisle 1994) and composing (Green et al. 2003) has also been examined. Carlisle found that at the second to third grade level good spellers differed from poor spellers with learning disabilities in number of words and quality of imagination in the stories they wrote, but not in their use of morphologically complex words. Green and colleagues found that third and fourth graders' use of morphology in spelling during composing mirrored the pattern of acquisition of oral morphology—from inflectional suffixes, which are mastered by age 9 or 10, to derivational suffixes, which continue to develop in middle childhood.

Bryant et al. (1997) conducted a 3-year longitudinal study and found evidence that knowledge of letter-sound correspondences is necessary but not sufficient for learning to read. Specifically, they identified five phases in the acquisition of the spelling of inflectional suffixes that were independent of IQ. They concluded that learning to read and write requires syntactic awareness, coded in the morphemes at the end of written words, as well as phonological awareness. In other programmatic research on morphological awareness (e.g., Nunes and Bryant 1995; Nunes et al. 1997, 2003), they studied acquisition of understanding and using morphological marking of the possessive. Letter sequences in English that appear irregular based on alphabetic principle are often regular in their spelling for morpheme units (e.g., suffixes like *tion*) (Nunes and Bryant 2006). Bourassa et al. (2006) reported similar findings for spellings of base words resolving phonological problems.

To summarize, morphological awareness has been shown to contribute to reading achievement, in some studies to word decoding and in other studies to reading comprehension or both word decoding and comprehension, and also to writing achievement, especially spelling (e.g., Berninger et al. 2008b).

Growth Curve Analyses of Longitudinal Data

Much of what is known about orthographic and morphological awareness has been based on cross-sectional studies. To add to understanding of the longitudinal development of all three kinds of linguistic awareness, measures of phonological, orthographic, and morphological awareness were administered annually for 4 years. An overlapping dual cohort design, also referred to as an accelerated cohort design, was used in which the first cohort began the study in first grade and the second cohort began the study in third grade. The goal of the growth curve analyses was to model the longitudinal data for the first through fourth grades in the younger cohort and the longitudinal data for third through sixth grades in the older cohort, and then to examine whether the two growth models can be combined in the accelerated cohort design. Developments in statistical analysis now allow this type of investigation to be conducted while simultaneously controlling for the multiple layers of data: repeated measures nested within persons and persons nested within cohorts (Raudenbush et al. 2004).

Research Aims

A central research question was whether growth (as indexed by the slope) from first to fourth was continued at the same rate in fourth to sixth grade. Piecewise growth models (e.g., Raudenbush and Bryk 2002) provide a direct test of this question. Phonological and orthographic growth curves were analyzed because they are thought to contribute to learning alphabetic principle and applying it to decoding unknown words and spelling words.

Morphological growth curves were analyzed because they are thought to contribute to reading and spelling words with affixed morphemes and to linking single words to syntactic structures and to semantic concepts during word identification, reading comprehension, vocabulary learning, spelling, and composing.

Method

Participants

Data for 241 children in the longitudinal study were used for this analysis. The first cohort had been tested in first, second, third, and fourth grades and the second cohort had been tested in the third, fourth, fifth, and sixth grades when this study was completed. According to parent reports, 65.1% of the participants were Caucasian, 22.4% were Asian American, 7.9% were African American, 1.2% were Native American, .08% were Hispanic, and 2.5% of the sample did not fall into the above categories. Mother's highest level of education was also obtained as a general measure of socioeconomic status. Less than .4% had not obtained a high school diploma, 6.7% earned a high school degree, 11.6% reported some college or vocational training, 47.7% reported earning a college degree, and 32% reported obtaining a graduate degree. Less than 2% of the sample did not report education level.

Measures

Measures were chosen that allowed assessment of linguistic awareness rather than production in spontaneous or independent language and that did not require reading or writing. These tasks did require that children store spoken and/or written words in working memory, analyze and reflect upon them, and answer questions posed by the researchers. Children completed the following measures in their annual visit to the university during the second, third, or fourth month of the school year and the two cohorts were equally distributed throughout these months. All raw scores were converted to (a) z-scores for grade based on means and SDs for each grade in a national norming sample for the phonological and orthographic measures (Berninger 2001) or research samples (Nagy et al. 2006, 2003), or (b) scaled scores for age for published tests (Wagner et al. 1999). Reliabilities are internal consistency coefficients unless noted otherwise; ranges indicate values reported across grades and single values represent reported averages across grades or ages.

Phonological—Syllable Deletion

This task requires children to listen to a polysyllabic real (e.g. jungle) or pseudoword (e.g. mungle), repeat it, and then repeat it without a designated syllable (e.g. /∂l/. Reliability coefficients range from .62 to .80.

Phonological—Phoneme Deletion

This task requires children to listen to a real (e.g. red) or pseudoword (e.g. raf), repeat it, and then repeat it without a designated phoneme (e.g., /r/). Reliability coefficients range from .78 to .92.

Phonological—Rime Deletion

This task requires children to listen to a real word (e.g. bend) or pseudoword (e.g. brend), repeat it, and then repeat it without a designated rime unit—the part of the syllable remaining when an onset phoneme or blend is omitted (e.g.,/end/). Reliability coefficients range from .76 to .83.

Phonological—Nonword Memory

The CTOPP (Wagner et al. 1999) Nonword Memory subtest requires the child to listen to one spoken pseudoword at a time on an audio tape. The pseudowords increase in length and the child's task is to reproduce the pseudoword exactly. Test–retest reliability is .70. This pseudoword repetition task was given because ability to hold word-like sound patterns in working memory may be a requisite skill for developing phonological awareness, that is, ability to store the spoken word while the sounds in it are analyzed.

Orthographic—Receptive Coding

This task requires judgment about the identity and order of letters in briefly exposed written real words (e.g. word) or pseudowords (e.g. wirf) that are encoded into temporary memory storage. The child has to decide, after the word is no longer displayed, whether or not (a) the next word matches it exactly (e.g., werd or wirf), (b) a given letter was in it (e.g. o or i), or (c) a given letter group was in it in exactly the same order (e.g., ow or ir). Stimulus items were designed so that correct answers could not be based solely on phonology—attention to letters that had no phonological equivalent or alternative sounds was required. Reliability coefficients range from .61 to .76.

Orthographic—Expressive Coding

This subtest requires the child to code written words or pseudowords into temporary memory and reproduce all or parts of them in writing. The task is then to reproduce (a) the whole word (wirf), (b) a letter in a designated position (e.g., last), or (c) letters in a designated position (e.g., 2nd and 3rd). Reliability coefficients range from .86 to .88.

Morphological—Comes From (Nagy et al. 2006, Adaptation of Derwing 1976, and Mahony et al. 2000)

This 80-item task, which was given in years 2, 3, and 4, requires deciding whether or not a word is derived from a base word and thus is semantically related to it. (Does *corner* come from *corn*? Does *builder* come from *build*?) Test–retest reliability over a 1-year period was .62.

Morphological—Signals (Nagy et al. 2003; Adaptation of Singson et al. 2000; and Tyler and Nagy 1989, 1990)

This 14-item task, which was given in first, second, and third year of the study, requires selecting one of four choices (real words or pseudomorphs) that contains an inflectional or derivational suffix that fits a sentence context. For example, choose the one-wibbled, wibbling, wibbler, wibbly—that fits in the sentence context: *The ________ really enjoys sharing his sport with others*. Test–retest reliability over a 1-year period was .71.

Morphological—Decomposition Carlisle (2000)

This 28-item task requires the child to transform an affixed word into its base word. For example, the child might be given the word farmer and asked to fit it into the blank in a sentence context such as *The plowed fields are on the* __________. Test–retest reliability over a 1-year period was .62.

Morphological—Derivation Carlisle (2000)

This 28-item task requires the child to generate an affixed word from a base word, that is, transform it by adding a suffix, rather than deleting a suffix as in decomposition, to fit a grammatical context rather. For example, the child is given a base word such as *farm* and is asked to add a word part to make it fit the blank in a sentence context such as *The ____________ is plowing his fields*. Test–retest reliability over a 1-year period was .61.

Oral Vocabulary—WISC IV vocabulary

The *Weschler Intelligence Scale for Children, 3rd Edition* (WISC-3) vocabulary subtest (Wechsler 1991) requires children to explain what words mean. Average test–retest reliability across ages is .89.

Data Analysis

To model the trajectories for phonological, orthographic, and morphological awareness, hierarchical linear modeling (Raudenbush and Bryk 2002) was conducted. Maximum likelihood estimates of parameters were used and all estimates of standard errors were based on robust estimation. All analyses for phonological growth and for orthographic growth applied a piecewise time coding that placed the intercept at third grade in each cohort, thus allowing test of the hypotheses that (a) intercepts at third grade were equal in the two cohorts, and (b) slopes of the trajectories in the two cohorts are equal (Raudenbush and Chan 1993). One exception was expressive orthographic coding that was not given until grade 4, based on past research indicating that this skill begins to emerge around fourth grade (Berninger et al. 1994) when receptive coding has reached ceiling (Berninger et al. 1991). Analyses of morphological coding used time coding that placed the intercept at 4th grade.

Results

Phonological Growth

Table 1 shows the means and standard deviations (SD) at each grade level for the younger and older cohorts for syllables, phonemes, and rimes. Piecewise growth models results for syllables, phonemes, and rimes are shown in Table 2. Results of the related analyses with nonword memory as a predictor, which may predict individual differences in intercept and/or growth in various phonological skills, are also shown in Table 2.

Table 1 Means and standard deviations of phonological measures by cohort

	Grade	Mean	SD
Syllables[a]			
Younger	1	5.84	1.84
Younger	2	6.90	1.91
Younger	3	7.45	1.73
Younger	4	14.43	1.20
Older	3	7.73	1.66
Older	4	14.66	1.16
Older	5	14.68	1.11
Older	6	15.02	1.03
Phonemes[b]			
Younger	1	20.41	7.51
Younger	2	23.65	5.06
Younger	3	24.64	4.83
Younger	4	34.02	1.54
Older	3	26.29	3.50
Older	4	34.43	2.44
Older	5	34.49	1.21
Older	6	34.77	1.24
Rimes[c]			
Younger	1	4.55	2.62
Younger	2	5.35	2.21
Younger	3	5.88	2.47
Younger	4	13.94	1.60
Older	3	6.72	2.16
Older	4	14.25	1.51
Older	5	14.37	1.48
Older	6	14.84	1.31

[a] Possible range of scores 0–16

[b] Possible range of scores 0–36

[c] Possible range of scores 0–16

Table 2 Parameter estimates, standard errors (SE), and associated *t*-values from growth modeling of phonological outcome with predictors

	Intercept		Slope (SE)	
	Value (SE)	*t*	Value (SE)	*t*
Syllables	9.71(.08)	120.33***	2.30(.03)	62.90***
nonword memory	0.16(.03)	5.00***	−0.04(.02)	−2.44*
Phonemes	27.71(.21)	129.40***	3.25(.11)	29.49***
nonword memory	0.37(.09)	3.93***	−0.15(.05)	−3.29**
Rimes	8.72(.10)	83.63***	2.59(.05)	52.02***
nonword memory	0.16(.04)	3.80***	−0.03(.02)	−1.57

* $p < .05$; ** $p < .01$; *** $p < .001$

The first set of analyses modeled the trajectories for syllables. In the piecewise growth model, the intercepts at third grade for the two cohorts were not significantly different $t(232) = -1.23$, $p > .05$, but cohorts were significantly different in slope, $t(232) = -5.73$, $p < .001$. This result indicated that growth for syllables was steeper in the first three grades than in the next three grades when there was a statistically significant negative effect (decrement) on the slope. Results in Table 2 also indicate that nonword memory significantly predicted individual differences in the intercept and slope for syllables.

The second set of analyses modeled the trajectories for phonemes. The intercepts at third grade for the two cohorts were significantly different $t(232) = 2.40$, $p < .05$, and cohorts differed significantly in slope, $t(232) = -7.83$, $p < .001$. This result indicated that growth for phonemes was not the same across cohorts, but steeper in the first three grades. Again, the related analyses in Table 2 indicated that nonword memory significantly predicted individual differences in the intercept and slope for phonemes.

The third set of analyses modeled the trajectories for rimes. The intercepts at third grade for the two cohorts were not significantly different $t(232) = 0.03$, $p > .05$, but cohorts differed significantly in slope, $t(232) = -3.87$, $p < .001$. This result indicated that growth for rimes was significantly steeper in the younger cohort. The related set of analyses shown in Table 2 indicated that nonword memory predicted individual differences in the intercept but not the slope for rimes.

Orthographic Growth

Table 3 shows the means and standard deviations (SD) for receptive orthographic coding and expressive orthographic coding. Results for the piecewise linear growth models of the trajectories for receptive coding are shown in Table 4. The intercepts at third grade for the two cohorts were not significantly different $t(239) = -1.15$, $p > .05$, but the cohorts differed significantly in slope $t(239) = -14.43$, $p < .001$. This result indicated that growth for receptive orthographic coding is steeper in the younger cohort (grades one to four) than in the older cohort (grades three to six).

Results for the piecewise linear growth models that modeled trajectories of expressive orthographic coding are shown in Table 5. Time was coded so that the intercept was at fourth grade, which was the first time when expressive coding was measured; this measure was pooled across the two cohorts for fourth grade. As shown in Table 5, the overall slope for expressive coding was significant. Cohort was not significantly related to the intercept $t(239) = 0.52$, $p > .05$. Again, significant variability in the slope indicated heterogeneity among the students in growth in expressive coding $\chi^2 = 173.50$, $p < 0.001$. Table 5 also shows the results of predicting the individual differences in intercept and slope of the individual trajectories for expressive coding from receptive coding in fourth grade and above. Receptive coding did not predict slope of expressive coding, showing that factors other than ability to store and analyze letters in written words in temporary memory are probably influencing that ability to express the results of those analyses in writing (expressive task), rather than by speaking (receptive yes/no task).

Morphological Growth

Table 6 shows the means and standard deviations (SD) for the four morphological measures at each grade when the measures were given. Table 7 shows the overall results of the piecewise linear growth modeling for each measure. In Table 7, results from two models are

Table 3 Means and standard deviations of receptive and expressive orthographic coding measures by cohort

	Grade	Mean	SD
Receptive[a]			
Younger	1	30.49	5.50
Younger	2	34.68	4.32
Younger	3	37.32	3.62
Younger	4	31.20	3.72
Older	3	38.10	3.19
Older	4	31.00	3.77
Older	5	32.92	3.29
Older	6	34.13	2.90
Expressive[b]			
Younger	1	ng	ng
Younger	2	ng	ng
Younger	3	ng	ng
Younger	4	11.56	4.00
Older	3	ng	ng
Older	4	11.67	4.11
Older	5	14.27	3.22
Older	6	15.62	2.38

[a] Possible range of scores 0–42

[b] Possible range of scores 0–18

Table 4 Parameter estimates, standard errors (SE), and associated *t*-values from growth modeling of receptive orthographic coding outcome

	Intercept		Slope	
	Value (SE)	*t*	Value (SE)	*t*
Receptive coding	0.90(.01)	115.49***	0.08(.01)	14.96***
Cohort	−0.01(.01)	−1.15	−0.10(.01)	−14.43***

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 5 Parameter estimates, standard errors, and associated *t*-values from growth modeling of expressive orthographic coding outcome with predictor receptive coding

	Intercept		Slope	
	Value (SE)	*t*	Value (SE)	*t*
Expressive coding	11.72(.29)	40.35***	1.95(.14)	14.96***
Expressive coding	11.17(.25)	44.64***	2.05(.15)	13.28***
Receptive coding	2.57(.25)	10.19***	−0.43(.24)	−1.76

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 6 Means and standard deviations of morphological measures by cohort

	Grade	Mean	SD
Comes from			
Younger	1	ng	ng
Younger	2	ng	ng
Younger	3	68.14	8.81
Younger	4	72.72	5.62
Older	3	ng	ng
Older	4	71.89	9.59
Older	5	74.79	3.69
Older	6	76.37	4.60
Signals			
Younger	1	6.88	2.79
Younger	2	9.21	2.57
Younger	3	10.51	2.19
Younger	4	ng	ng
Older	3	11.27	2.12
Older	4	11.83	1.85
Older	5	12.39	1.67
Older	6	ng	ng
Decomposition			
Younger	1	ng	ng
Younger	2	ng	ng
Younger	3	20.93	4.29
Younger	4	23.47	3.52
Older	3	21.61	4.18
Older	4	24.23	3.27
Older	5	25.69	2.21
Older	6	26.69	1.85
Derivation			
Younger	1	ng	ng
Younger	2	ng	ng
Younger	3	15.89	5.03
Younger	4	19.34	4.33
Older	3	14.31	4.25
Older	4	19.90	4.03
Older	5	22.49	3.72
Older	6	24.28	3.10

ng not given

shown for each outcome. The first model is the overall growth model for the measure. The second model is the overall growth model with cohort and WISC 3 vocabulary as predictors of intercept and slope. The parameterization of the piecewise model provides a test of whether or not the decrement (negative value) associated with the older cohort is statistically significant.

Table 7 Parameter estimates, standard errors (SE), and associated *t*-values from growth modeling of morphological outcomes with predictors

	Intercept		Slope	
(1) Signals	10.65(.20)	54.59***	1.81(.11)	16.36***
Signals	10.82(.17)	62.78***	1.80(.10)	17.71***
Cohort	0.24(.25)	0.98	−1.23(.15)	−8.26***
WISC verbal	0.26(.03)	8.69***	−.03(.02)	−1.68
(2) Comes from	72.75(.51)	114.55***	4.63(.64)	7.24***
Comes from	73.33(.63)	117.30***	4.51(.61)	7.34***
Cohort	−2.07(.90)	−2.29*	−2.05(.75)	−2.71**
WISC verbal	0.82(.12)	6.99***	−0.18(.08)	−2.24*
(3) Decomposition	23.49(.32)	72.76***	2.53(.25)	10.23***
Decomposition	23.88(.27)	86.86***	2.46(.25)	9.98***
Cohort	−0.71(.35)	−2.02*	−0.67(.28)	−2.44*
WISC verbal	0.54(.05)	10.56***	−0.11(.03)	−3.78***
(4) Derivation	19.35(.40)	48.54***	3.40(.31)	11.11***
Derivation	19.81(.33)	59.53***	3.37(.31)	10.90***
Cohort	−1.91(.43)	−4.40***	−0.10(.33)	−0.31
WISC verbal	0.66(.05)	12.07***	−0.03(.03)	−1.30

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 7 shows the results from modeling the trajectories for the comes from task, which was given in years two, three, and four. The intercepts at grade four for the two cohorts were significantly different, $t(232) = -2.29$, $p < .05$, and cohorts were significantly different in slope $t(232) = -2.71$, $p < .01$. These results indicated that growth for the comes from task is steeper in grades two to four than in grades four to six. The next related set of analyses examined whether WISC 3 vocabulary can explain individual differences in the intercept and slope. The results shown in Table 7 indicate that, even after taking cohort into account, vocabulary knowledge was significantly related to intercept and slope for this measure of morphological awareness related to semantic meaning.

The analyses modeled the trajectories for the morphological signals task at time three because this measure was given only in years one, two, and three. The intercepts at third grade for the two cohorts were not significantly different $t(232) = 0.98$, $p < .05$; however, cohorts differed significantly in slope, $t(232) = -8.26$, $p < .001$. This result indicated that growth for morphological signals is steeper in grades one to three than in grades three to five. The results shown in Table 7 indicate that, even after taking cohort into account, vocabulary knowledge was significantly related to individual differences in intercept but not to growth for this measure of morphological awareness related to syntax, but which did not require morphological transformation to form a new word by adding a suffix.

Table 7 also shows the results for the decomposition task. The intercepts at fourth grade for the two cohorts were significantly different $t(232) = -2.02$, $p < .05$, and cohorts differed significantly in the slope $t(232) = -2.44$, $p < .05$. This result indicated that growth for decomposition was steeper in grades 3 to 4 than in grades 4 to 6. The next related set of analyses showed that, even after taking cohort into account, vocabulary knowledge was significantly related to intercept and slope for this measure of morphological awareness, which unlike morphological signals, did require morphological transformation to form a new word by removing a suffix to fit a syntactic context.

The last analyses shown in Table 7 modeled the trajectories for the Derivation task. The intercepts at fourth grade for the two cohorts were not significantly different $t(239) = -1.91$, $p > .05$, and cohorts did not differ significantly in slope $t(239) = -0.31$, $p > .05$. This pattern of results suggests that morphological awareness as assessed on this task does not show its primary growth during the early grades and continues to develop beyond grade 4. Even after taking cohort into account, vocabulary knowledge was significantly related to intercept but not to growth for this measure of morphological awareness related to syntax, which does require morphological transformation to form a new word by adding a suffix. Thus, for some (comes from and decomposition) but not all morphological awareness tasks, vocabulary predicted growth in morphological awareness.

Discussion

First, an overview of what the current study found about growth in three kinds of linguistic awareness is provided. Next, we consider (a) whether one kind of linguistic awareness is sufficient for learning to read, and (b) what the implications of the current findings are for literacy instruction. Then, we relate the current findings to previous findings for competing theories of linguistic awareness—whether the different kinds of linguistic awareness develop in stages or develop in tandem conjointly. Finally, we propose future directions for literacy research that build on the current findings for linguistic awareness.

Growth in Three Kinds of Linguistic Awareness

Phonological Awareness Growth

At third grade, the cohorts were not significantly different in syllable or rime awareness but were in phoneme awareness, pointing to considerable individual variability in this phonological awareness skill in the second, third, and fourth months of third grade. However, across the three kinds of phonological awareness, which vary in the unit of sound analyzed, the most growth took place before and not after third grade. Of substantial interest, a nonword repetition measure, which assesses ability to hold novel sound patterns in working memory, analyze them, and reproduce them, predicted growth in phonological awareness for all three units—syllables, phonemes, and rimes. This finding suggests that phonological working memory underlies development of phonological awareness: Children need to store spoken words in working memory while they analyze and reflect upon them.

Orthographic Awareness Growth

The two cohorts were comparable at overlapping times in third grade for receptive orthographic awareness and in fourth grade for expressive orthographic awareness. However, the slopes differed between the cohorts, consistent with receptive orthographic development occurring at a faster rate in the early elementary years, grades one to three, and slower rate during the later elementary years. This finding based on a longitudinal study parallels that of the cross-sectional studies, which were reviewed in the introduction, that showed receptive coding reached asymptote by third grade and that thereafter expressive orthographic coding continued to grow. Of interest, receptive coding predicted intercept (where they started) but not slope (growth over the past years) on expressive orthographic coding. This finding suggests that the prior growth in receptive orthographic coding may create foundational knowledge (referred to as the orthographic framework by Seymour 1997), but that from fourth grade and beyond, the orthographic loop, which coordinates orthographic representations in memory with output by hand, underlies further orthographic growth (e.g., Richards et al. 2009).

Morphological Awareness Growth

For three morphological awareness tasks, the steepest growth was in the first three grades but growth did not reach ceiling and some additional growth occurred in fourth grade and above: comes from, signals, and decomposition. For one morphological awareness task, some growth occurred in the first three grades but was not steeper in the first three grades and continued to grow in fourth grade and beyond. Thus, although morphological awareness begins to develop early in schooling, its overall developmental trajectory has a much longer span than the other kinds of linguistic awareness (e.g.,Nagy et al. 1989, 2006).

Next, we address the issue of whether morphological awareness is simply a matter of vocabulary knowledge. On the one hand, for two morphological awareness tasks, vocabulary knowledge did predict growth in morphological awareness: comes from and decomposition. The first task requires comparison of semantic relatedness for a pair of words that may differ only in a suffix or that is unrelated in meaning. The second task requires deletion of a suffix to make a word fit a syntactic context. On the other hand, for the other two morphological awareness tasks, vocabulary did not predict growth in morphological awareness: Signals and Derivations. The first task requires selection of an affixed word to fit a syntactic context. The second task requires transformation of a base by adding a suffix to fit a syntactic context. To summarize, although vocabulary knowledge may predict two kinds of morphological awareness, it does not predict all kinds of morphological awareness. When a suffix has to be selected or added to a base word to make the suffixed word fit a particular syntactic context, vocabulary knowledge alone, while necessary, is not sufficient—additional knowledge of the word formation process is needed to support further growth in morphological awareness. Word formation and vocabulary knowledge are not identical processes (Nagy 2007; Stahl and Nagy 2006).

The ongoing development of ability to transform words by adding suffixes enables the word formation process, which in turn allows students to read and spell low frequency words they encounter from fourth grade and beyond that are morphologically complex. These words may also be complex in terms of sound-letter relations and internal structure (i.e., syllabic or morphemic structure) (Nagy and Anderson 1984). Students who earlier focused on alphabetic principle, word families (patterns larger than grapheme-phoneme correspondence), and syllable structure and their application to decoding face new challenges in linking precise phonological and orthographic representations (Ehri 1992) and encountering low frequency written words frequently enough to recognize specific words automatically (Ehri 1992; Snowling 1980). Prefixes may also contribute to knowledge of the word formation process but we did not study them because they affect shade of meaning for given words more than semantic relatedness across words or between words and syntax.

Students may need additional morphological strategies to deal with the complexity in English orthography in content-area text, which may have irregular spellings, complex word structures, or unfamiliar, low frequency words, beginning in the fourth grade and thereafter (White et al. 1989). Analysis of the number of distinct words in printed school English showed that students encountered over 88,000 "distinct" words in texts through ninth grade

(Nagy and Anderson 1984). For every word a student learns, there are between one and three related words that should be understandable to the student. Semantic transparency of words—whether the meaning of the base word is apparent in a longer word that contains that base word (i.e., *red* and *redness* have relative semantic transparency, whereas *apply* and *appliance* do not)—also affects complex word learning. The less aware a student is of word relations, the more distinct words need to be learned. About half the words in printed texts through ninth grade occur once in a billion words of text or less (examples of words that occur less than three times in a billion words are *inflate, extinguish, nettle*), and semantically transparent words are skewed toward the low end of the frequency distribution to a greater degree than morphologically basic words or semantically opaque words (Nagy and Anderson 1984). About 60% of the unfamiliar words encountered by students in the middle school years and beyond are sufficiently transparent, even though they are morphologically complex in structure and meaning, that a reader might be able to infer the meaning of the word from context (Nagy et al. 1989).

To summarize, as exposure to language expands from the high frequency words that serve as the foundation for learning phonological decoding and encoding of written words to exposure to lower frequency words that are longer and morphologically more complex, knowledge of word-formation processes becomes necessary for reading and spelling words (Nagy and Anderson 1984). To date, national attention in the United States has focused on evidence-based practices related to phonological decoding, but not to evidence-based practices related to word formation, which may be critical for fostering literacy achievement in fourth grade and beyond.

Is One Kind of Linguistic Awareness Sufficient for Learning to Read and Write?

Given the issues just discussed, is phonological awareness alone sufficient for learning to read and spell words? The National Reading Panel reviewed evidence on effective practices in learning to read (National Institute of Child Health and Human Development, NICHD 2000) and concluded that instruction aimed at developing phonological awareness was an evidence-based, essential component of effective instruction. However, the other kinds of linguistic awareness—orthographic and phonological—were not acknowledged or addressed. The current study showed that substantial growth occurs in phonological, orthographic, and morphological awareness in the first three grades. It follows that reading and writing instruction should, therefore, focus not only on phonological awareness but also orthographic and morphological awareness, especially given the research evidence discussed next for the importance of teaching children to coordinate all three kinds of linguistic awareness. At the same time some forms of morphological awareness (and their relationships to orthographic, phonological, and syntactic awareness) show their maximal growth beginning in fourth grade and thereafter. The current studies add to existing knowledge by documenting growth in three kinds of linguistic awareness early in schooling, when children are likely to benefit from explicit, grade-appropriate instruction in all three and their interrelationships.

Does Linguistic Awareness Develop in Stages or Conjointly?

On the one hand, stage theorists have proposed that written word learning proceeds in sequential stages from phonology to orthography to morphology (e.g., Templeton and Bear 1992). On the other hand, other theorists propose that phonology, orthography, and morphology contribute conjointly to literacy learning (Silliman et al. 2006; Apel and Masterson 2001). Conjoint theorists often make a distinction between lexical and sublexical processes within each of these three kinds of linguistic awareness (e.g., Seymour 1997). Evidence for the development of conjoint connections across two kinds of linguistic awareness, at the lexical or sublexical levels, include the following.

Developing connections between the orthography and morphology may result in perceptual sensitivity to the roots or meaning-bearing fragments of polysyllabic words and nonwords (Adams 1990). Relationships between orthographic and morphological complexities may pose challenges for middle school and high school students (Windsor 2000). Connections between phonology and orthography are often more predictable at the level of rime units (word families) in high frequency words than at the level of alphabetic principle (e.g., ould in could and would) for English-speaking children. Links between phonological-morphological analysis of inflectional and derivational suffixes are very strong in first and second graders learning to read French (Casalis and Louis-Alexandre 2000). Phonological-morphological connections may also pose challenges for the phonological shifts that characterize morphological relations (e.g., *decide* and *decision*; *invade* and *invasion*) (Carlisle 2000). Phonological and morphological awareness affect word reading, both independently and interactively (Carlisle 2000; Fowler and Liberman 1995; Singson et al. 2000). Amalgamation theory (Ehri 1978, 1980) may be the first conjoint theory. It has stood the test of time based on research reviewed in this article that orthographic representations are interrelated with phonological representations at the lexical level (pronunciation of whole words) and sublexical phonemic level and with semantic representations at the word level and sublexical morphemes.

An example of a more recent conjoint theory is triple word form and cross-word form theory (Berninger et al. 2003), according to which learning to read and write words is a process of learning to become aware of and coordinate the three word forms and their parts. Multidisciplinary evidence for triple word form theory is accumulating. In typically developing third graders, phonological awareness, orthographic awareness, and morpheme awareness were correlated at $p < .01$ with real word single word reading accuracy and rate, pseudoword accuracy and rate, oral passage reading accuracy and rate, reading comprehension, spelling, and written expression; however, in typically developing fifth graders, although orthographic and morphological awareness were significantly correlated at $p < .01$ with each of the same reading and writing measures, the phonological factor was correlated with fewer literacy outcomes (only with real word reading and pseudoword reading accuracy and rate and written expression at $p < .05$ and spelling at $p < .01$). Subsequent SEM modeling evaluated which paths were significant and predicted unique variance over and beyond the shared covariance among the predictor factors. In third grade, the phonological factor predicted unique variance only to pseudoword reading, the orthographic factor predicted unique variance only to written expression, and the morphological factor predicted unique variance only to reading comprehension. In fifth grade, only the orthographic factor predicted unique variance—in real word and pseudoword reading accuracy and rate and spelling, suggesting that the autonomous orthographic lexicon (Perfetti 1992) was well established by then and that phonological awareness alone is not sufficient for literacy acquisition in the upper elementary grades.

However, these preliminary results for typically developing readers and writers were not reported because an SEM model based on the same predictor and outcome factors with a 2nd order factor underlying the separate phonological awareness, orthographic awareness factors fit better than one based on separate linguistic awareness factors. Of most importance, the 2nd order factor had a significant path to all the reading and writing outcomes for typically developing readers and writers and children with dyslexia (see Berninger et al. 2008b).

Coordination among separate word forms and their parts, which is the central tenet of Triple Word Form theory, has also been validated in a series of brain imaging studies.

Phonological (Richards et al. 2007), orthographic (Richards et al. 2006a, 2009), and morphological (Richards et al. 2002, 2006a) word forms are associated with unique as well as common brain activation, yielding a unique brain signature for each of the separate word forms and parts underlying the different kinds of linguistic awareness (Richards et al. 2006b). Combined treatment and brain imaging studies found evidence of cross-word form mapping for forging connections among the three kinds of linguistic awareness, two at a time to three at a time in children who had completed fourth, fifth, or sixth grade (Berninger et al. 2008a; Richards et al. 2005, 2006b).

Stage theory and conjoint theories of linguistic awareness may be reconcilable (Berninger et al. 2009). What some theorists may mean by the phonological stage is the developmental phase when children are learning grapheme-phoneme correspondences and phonological decoding. Those theorists should not lose sight that children are also learning to apply morphological knowledge at this time, as the results of the current study show, for example, to coordinate sound and spelling with inflectional suffixes for number and tense. This morphological awareness also contributes to efficiency of phonological decoding (Berninger et al. 2003; Richards et al. 2002). Also, phonological decoding draws on orthographic and phonological awareness of graphemes and phonemes in alphabetic principle (Berninger et al. 2000). What some theorists may mean by the orthographic stage is the developmental phase when children's orthographic lexicon achieves a degree of autonomy supporting automatic access to orthographic representations underlying word reading and spelling rather than the more effortful phonological-orthographic mapping. What some theorists may mean by the morphological stage is the developmental phase when children who have mastered basic decoding skills for high frequency words are learning to read less frequent, longer, morphologically more complex words by applying spelling rules for dropping and adding letters to the end of the base word and beginning of the suffixes (e.g., Dixon and Engelmann 2001). While names of stages capture key concepts being learned about coordinating phonology, orthography, and morphology, it should not be assumed that only one of these kinds of linguistic awareness is developing and contributing at a particular stage of literacy development.

Implications for Evidence-Based Literacy Instruction

This new evidence-based knowledge needs to be disseminated to teachers. Teachers who understand how to develop their students' phonological, orthographic, and morphological awareness and ability to coordinate the three kinds of linguistic awareness will optimize the reading achievement of their students. Research has validated effective instructional strategies for developing orthographic awareness (e.g., looking games for words, letters in words, and letter groups in words, see Berninger and Traweek 1991; Berninger et al. 1995, orthographic leprechaun and proofreaders' trick, Berninger et al. 2008c, Study 1), morphological awareness (e.g., Arnback and Elbro 2000; Berninger et al. 2003, 2008c Study 1; Casalis and Louis-Alexandre 2000; Henry 1989; Nunes and Bryant 2006) and interrelationships among phonological and orthographic awareness at different levels of language (e.g., Berninger et al. 2000), and phonological, orthographic, and morphological awareness (e.g., Berninger et al. 2000; Henry 1989; Nunes and Bryant 2006). Comprehensive reviews of this research literature are needed.

See Nunes and Bryant (2006) for an example of how research on morphological and orthographic awareness (spelling word units that are regular in their pronunciation at the morpheme level rather than at the alphabetic principle level) conducted initially in the laboratory can be transformed for teachers to implement in classroom practice. See Henry (2003) for teacher-friendly background knowledge on teaching phonological, orthographic, and morphological awareness and their interrelationships for English words of Anglo-Saxon, French and Latinate, or Greek origin.

Implications for Future Research

Developmental Trajectories Within and Across Kinds of Linguistic Awareness

Future research should identify typical and possibly alternative developmental patterns in developing each kind of linguistic awareness and its relationship with the other kinds of linguistic awareness. One example of a model that yields testable hypotheses in this regard was proposed by Bahr et al. (2009): (a) lexical processes are studied separately for spoken words (phonotactic knowledge) and for written words (orthotactic knowledge); and procedural mapping across spoken and written words for varying units of analyses ranging from lexical (names and letter sequences for whole words) to sublexical (rimes and multi-letter units in syllables or phoneme-grapheme correspondence) (e.g., Berninger et al. 2000). Much remains to be learned about how morphemes in word formation, which are coded in spoken and written language, may facilitate this mapping across spoken and written words.

Potential Advantages of Deep Orthographies

A widespread assumption is that transparent orthographies have an advantage over deep orthographies. That advantage, however, may be restricted to learning to pronounce words in the early grades, that is, beginning phonological decoding. Deep orthographies may have special advantages for accessing, expressing, and comprehending meaning (see Jaffré and Fayol 2006; Pacton and Fayol 2004; Venezky 1970, 1999). Comparing different deep orthographies (e.g., Pacton and Deacon 2009) holds promise for understanding how written spelling may access meaning. Although deep orthographies are not perfectly predictable in grapheme-phoneme correspondences, at a deeper level they may facilitate the representation and coordination of phonological, orthographic, and morphological information in words (e.g., Foulin and Chanquoy 2006; Pacton and Deacon 2009; Pacton et al. 2001, 2005; Plaza and Cohen 2004; Treiman and Cassar 1997; Walker and Hauerwas 2006). Orthography may be coded independently of phonology (Johnson 1978, 1986) and orthographic representations of words may be created and gain access to semantic representations even if the orthography does not have phonological correspondences (e.g., Fayol et al. 1995; Largy et al. 2007; Martinet et al. 2004). The morphological information, in particular, may build bridges between written or spoken words and the syntax levels that contribute to constructing or comprehending meaning in written texts (e.g., see Carlisle 1994). Future research should investigate the potential advantages of a deep morphology that, from a developmental perspective, grows throughout formal schooling in phonological, orthographic, and morphological awareness related to word formation (e.g., Nagy et al. 1989).

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