Published in final edited form as:
J Learn Disabil. 2014 ; 47(1): . doi:10.1177/0022219413509969.

Putting Words to Work: Effects of Morphological Instruction on Children's Writing

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Abstract

This study examined effects of a 12-week, teacher-delivered morphologically focused intervention on writing outcomes for 5th grade U.S. students. The intervention called students' attention to the morphological structure of words drawn from the district's science curriculum, taught morphologically related forms of those words, and provided opportunities for students to use morphologically related forms in reading and writing. Multilevel model results of posttests showed that, compared to control students (*n*=75), intervention students (*n*=95) included more morphologically complex words in their responses to a sentence-combining task, and more morphologically complex words (targeted in the intervention) in their extended written responses. In addition, students with lower pretest scores on the sentence-combining measure showed greater intervention effects on the sentence-combining measure than higher-performing peers. Taken together, these results support the use of morphological instruction in the classroom, especially for lower performing children.

Much research has examined relationships between children's reading and their morphological awareness (i.e., children's understanding of how linguistic units of meaning such as stems and affixes signal specific changes in word meanings and grammatical roles). Relationships have been documented between morphological awareness and children's word reading in English (Carlisle & Stone, 2005; Deacon & Kirby 2004; Fowler & Liberman, 1995; McCutchen, Green & Abbott, 2008; Singson, Mahoney & Mann, 2000), in French (Casalis & Louis-Alexandre, 2000) and in Chinese (Ku & Anderson, 2003), among other languages. Children's morphological awareness has also been found to relate to reading comprehension (Carlisle, 2000; Foorman, Petscher, & Bishop, 2012; Kieffer & Lesaux, 2012; Mahoney, Singson, & Mann, 2000; Nagy, Berninger, & Abbott, 2006). Moreover, intervention studies have shown that morphological instruction can improve word reading (Berninger et al., 2003; Lyster, 2002), comprehension (Carlo et al., 2004; Elbro & Arnbak, 1996) and vocabulary (Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Bauman et al., 2002; see Carlisle, 2010 for a review). Morphological instruction may be especially helpful for students with learning disabilities, because morphological skills may help compensate for the phonological processing difficulties that characterize reading disability (Carlisle, 2010; Elbro & Arnbak, 1996).

Interest is also growing in relationships between children's morphological awareness and their writing. There has been considerable discussion of how morphological awareness might contribute to spelling skill, as well as emerging discussion of contributions to other composing skills. In their seminal model of writing, Hayes and Flower (1980) identified three major component processes: p*lanning* what to say, *translating* those plans into text, and *reviewing* the text for revision. Hayes and Flower (1980) were modeling skilled adult

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writers and consequently gave little attention to the challenges of translating conceptual plans into grammatical sentences and correctly spelled words. Given their interest in young writers, Berninger and Swanson (1994) partitioned the translating process into two components: *transcription* processes, such as spelling and handwriting, which are unique to written text production, and *text generation* processes, such as word retrieval and sentence construction, which occur in both oral and written language. Research suggests that morphological knowledge may play roles in both transcription and text generation for young writers, including students with disabilities.

Morphology and spelling

For languages such as English, in which spelling does not map transparently onto phonology, spelling skills are related to children's growing awareness of how orthography reflects morphology as well as phonology (Ehri, 1992; Carlisle, 1988). Nunes and Bryant (2006) argued that morphological insights can demystify many peculiarities in English spelling (see also Moats, 2000; Nagy & Scott, 2000), explaining why, for example, the same sounds are spelled differently across words with different morphological structures (*box*, *socks*). Evidence from English (Treiman, 1993), as well as Greek, French and Hebrew (Bryant, Nunes & Aidinis, 1999; Pacton & Fayol, 2003; Sénéchal & Kearnan, 2007; Share & Levin, 1999), suggests that children awareness of morphological aspects of orthography relates to more advanced spelling skills, and a similar developmental trend is evident among children with disabilities (Bourassa & Treiman, 2008). Moreover, morphological instruction has been found to improve spelling (Henry, 1989; Nunes & Bryant, 2006), including among students with diagnosed dyslexia (Berninger et al., 2008) for whom spelling is often a challenge (Moats, 2000).

Spontaneous use of English morphological forms in written narratives replicates patterns observed in oral English (Berko, 1958; Menyuk, 1988). Children's written control over inflectional morphology (e.g., tense and plural markers) appears earlier than control of all but the most common derivational morphemes, which change grammatical categories, as in *run* and *runner*. Carlisle (1996) found that by third grade, even children with disabilities used and spelled inflections appropriately and began to use derivational forms. Green et al. (2003) observed a similar trend among students in third and fourth grade, with almost all third and fourth graders using and spelling inflections correctly; however, only about one third of third graders and half of fourth graders produced accurately spelled derivational forms.

Morphology and text generation

There are also compelling theoretical arguments implicating morphological skill in writing that extend beyond spelling to include aspects of text generation. For example, evidence suggests that children can use morphological knowledge to infer meanings for unfamiliar words and thereby bootstrap vocabulary growth during reading (Baumann et al., 2002, 2003; McCutchen & Logan, 2011; Wysocki & Jenkins, 1987). With richer vocabulary, writers should be able to retrieve more precise lexical representations for their semantic intent (Nagy et al., 2006). In addition, knowledge of morphological transformations (changing, for example, *colony* into *colonist*) could assist writers as they try to construct the more complex syntax and disciplinary vocabulary that is characteristic of the academic register (Scott & Nagy, 2003) and do so with sufficient fluency to maintain attention to other aspects of the writing process (Saddler & Graham, 2005). For example, knowing how to transform the phrase "the people who lived in the colonies in America" to "the American colonists" can make for smoother syntax, more concise sentence constructions, and more nuanced meanings.

Control over morphological forms (e.g., fluently turning *colony* into *colonist*) can assist writers as they work to generate the conceptually dense and, sometimes, syntactically complex language that characterizes the academic register. An extensive literature documents general age-related development of syntactic complexity among typically developing writers (Berninger, Nagy, & Beers, 2011; Hunt, 1970; Loban, 1976), although such developmental differences are less marked among students with learning disabilities (Houck & Billinsgley, 1989). Myhill's (2008) analysis of adolescents' writing suggested that *varied* syntactic patterns, not simply longer syntactic patterns, characterize higher quality texts. Thus, morphological instruction may enable the more precise vocabulary and varied syntax that is characteristic of academic writing (Myhill, 2008; Scott & Nagy, 2003), and such instruction may be especially helpful for students with disabilities (Houck & Billingsley, 1989).

Empirical evidence for contributions of morphological knowledge to text generation (as opposed to spelling) comes from Berninger et al. (2011), who reported that measures of children's morphological awareness predicted their ability to combine ideas across sentences (see also Rubin, Patterson and Kantor, 1991). Research involving students with writing disabilities has documented that these students face challenges with both transcription (Graham, 1990; Graham & Harris, 2000) and text generation (i.e., word choice, Wong, Wong & Blenkensop, 1989). Instruction for students with learning disabilities has frequently emphasized planning and revising (Bui, Schumaker, & Deshler, 2005; De la Paz & Graham, 1997; Englert, Raphael, Anderson, Anthony, & Stevens, 1991; Graham, MacArthur, & Schwartz, 1995), but as yet, little research has examined effects of morphological instruction on translating processes beyond spelling. One exception is a study by Saddler and Graham (2005), which reports that instruction in sentence combining (which can entail morphological manipulations) increased the syntactic complexity of written sentences, including among students with learning disabilities.

The present study

In the present study we examined effects of a morphologically based instruction on children's writing, both transcription skill (i.e., spelling) and text generation skill (i.e., word choice). We focused specifically on students in U.S. grade five (ages 10–11) because by grade five, children are increasingly expected to learn from reading content-area textbooks and document that learning in writing. The content area on which we focused was science, which affords encounters with many morphologically complex words. The specific research questions guiding the study were:

1. Can morphological instruction improve children's ability to generate and spell morphologically complex words?
2. Is morphological instruction more effective for children who perform poorly on writing measures, compared to their higher-performing peers?

METHOD

Participants

Participants were 170 5th grade students, 48% female, from eight classrooms drawn from five public schools in an urban area in the U.S. Pacific Northwest. The racial composition of the sample was 45% European American, 32% Asian American, 9% African American, 2% Pacific Islander, 8% multiracial, and 3% not reported. Teachers reported that 7.4% of the students were receiving special education services and 8.0% were receiving or had recently exited support for English language learning (ELL)

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Teachers were recruited for participation in pairs from four schools (eight teachers). Within schools, teachers were assigned to intervention or control conditions. However, because one control teacher withdrew prior to pretesting, an additional teacher was recruited from a fifth school to serve as a control (assuring balanced group sizes). Thus, experimental conditions were not fully randomized. After student consents were received, there were n=95 intervention students within four classrooms, and n=75 control students within four classrooms. Teachers in the intervention condition supplemented their science instruction with morphological lessons during the course of one science unit. Teachers in the control condition completed the same science unit, but without the morphological intervention. Control teachers were provided with the morphological materials after data collection.

Intervention

In all classrooms, teachers and students used a district-provided science curriculum including an experiential kit developed by the National Science Resources Center (NSRC). The science unit involved students with hands-on explorations of the water cycle and effects of water on land forms (*Land and Water*, n.d.).

Teachers in the control condition led students through the science unit as described in the NSRC Land and Water kit. Teachers in the intervention condition supplemented the science unit with morphology lessons that focused on multi-morpheme words drawn from the science init (e.g., *erosion*, *conservation*). (Although NSRC makes available supplemental language arts materials, the participating school district was not using them.) The morphological intervention contained scripted lessons calling students' attention to the structure of morphologically complex words and providing definitions of words and morphemes. Students then completed activities including identifying stems, matching morphologically related words to definitions, using related words to complete sentences appropriately (i.e., identifying the appropriate grammatical form), and writing sentences using the instructed words. The intervention, modeled after various published sources (e.g., Archer, Gleason, & Vachon, 2005) included 14 lessons, with each containing two to four activities that required approximately ten minutes. Lessons were distributed across 12 to 14 weeks, at the discretion of the teacher. A sample lesson script is provided in Table 1, and a list of the instructed words is provided in Table 2, together with examples of morphological relatives that were incorporated into activities. As Table 2 illustrates, we did not teach isolated morphemes; instead, we drew words drawn directly from the science unit, defined the word and any morphemes that were relevant to the science content, and discussed relevant morphologically related words. (The one exception was the lesson on the prefix *un-* where we defined the prefix and provided examples of words relevant to the science content, e.g., *unpredictable*.)

Teachers were provided with instructional packets for each student, plus a teacher guide containing answer keys and activities (e.g., cards for students to match words with definitions). Because the instruction was so scripted, materials were reviewed with teachers, but no formal training was provided.

To monitor teacher implementation fidelity, members of the research team observed intervention teachers three times (once within the first five lessons, once by lesson ten, and once in the last four lessons). Control teachers were not observed. Observers rated teachers on a five-point scale (1=poor, 5=exceptional) in each of five categories: 1) Overall compliance with instructions, 2) Appropriate introduction/explanation, 3) Appropriate time allowed, 4) Components appropriately administered, and 5) Evidence of extension to science lessons. For each teacher, two research team members independently rated one observation. Raters showed exact agreement on 75% of ratings, and were within 1 point of each other on 95% of ratings.

For each timepoint, we calculated each teacher's means across categories, yielding grand means of 4.35, 4.30 and 4.40 at each time point, respectively. A repeated-measures ANOVA indicated no change in fidelity across time ($p > .05$). One-sample t-tests indicated that mean fidelity at each time point was significantly better than an adequate rating of "3" (midpoint of scale) (all ps<.05).

Student Assessments

All students completed standardized measures of word reading and oral vocabulary before the intervention began. Students also completed two writing tasks: a sentence-combining activity (O'Hare, 1973; Saddler & Graham, 2005) at pretest and posttest, and extended response writing activities that occurred multiple times across the science unit.

Word reading—Assessments included the *Woodcock Reading Mastery Tests-Revised* (WRMT-R) Word Identification subtest as a measure of word reading (Woodcock, 1987). This untimed measure of children's accuracy reading isolated words was administered individually. The test manual reports split-half reliability of .87 for fifth graders.

Oral vocabulary—Children completed the individually administered picture vocabulary subtest from the *Woodcock Johnson III Tests of Achievement* (Woodcock, McGrew, & Mather, 2001). The test manual reports test-retest reliability of .89.

Sentence combining—Because derivational morphological forms can be infrequent in children's spontaneous writing (Green et al., 2003), at pretest and posttest we asked students to complete a sentence combining measure that invited morphological manipulations. The sentence combining measure included eight items, each requiring students to read several short, simple sentences ("kernel" sentences) and rewrite them as one longer sentence. Although the instructions did not restrict students to any specific strategy, we encouraged children to combine phrases without using the word *and*, and we provided examples of morphological manipulations that changed the grammatical category of words to create more a conceptually dense sentence. For example, the kernel sentences for one of the test items included the following:

> The police investigated the crime.
>
> The investigation was careful.
>
> The crime was a mystery.

Morphological changes potentially created from this example include "the police carefully investigated," "mysterious crime," or "criminal mystery." The task assessed students' ability to generate morphologically complex words, and the open-ended format allowed for a variety of sentence constructions and morphological forms. For that reason, an exact total of possible morphological changes constructed from the 29 short sentences is difficult to determine, although 21 was calculated to be a realistic maximum. The sentence-combining task was completed twice by students in both groups, once early in the science unit, prior to the onset of morphological instruction for the intervention classrooms, and again at the conclusion of the science unit.

Responses were scored two ways. One score reflected the number of correct derivational changes made, allowing for misspellings that still clearly signaled the intended word (e.g., *terifyed* for *terrified*). The second score reflected the number of correctly spelled changes. The sample internal consistency (Cronbach's alpha) was calculated at .90 with misspellings allowed, and .87 with correct spelling required. Inter-rater reliability among the two research team members who scored the responses was .98 and .99 (Pearson's *r*) for each score type, respectively (a 30% random sample of responses were double-scored).

Extended response writing tasks—We also asked students to generate more authentic writing in the context of prompts that built on the science unit. Students in both conditions were provided writing prompts at five similar time points across the science unit. For the students in intervention classrooms, the prompts occurred in morphological lessons 5, 6, 8, 10, and 14, and at corresponding time points in the science unit for students in control classrooms. The writing assignments referenced activities within the science unit and thus allowed both control and intervention students access to science content on which to base their writing.

Several scores were derived from students' extended written responses. We calculated average percent of words that were correctly spelled derivational forms of instructed words, average length (in words), and average number of any other derivational morphological forms, beyond those that were the focus of instruction. Inter-rater reliability (double-scoring a random sample of responses) for each of the score types ranged from .89 to .94.

Results

Data Analysis Strategy

We adopted multilevel modeling as our primary analytic tool in order to account for dependencies among student scores due to classroom nesting; and since data collection began three months into the school year, we had reason to believe that classroom effects should be considered even at pretest. We tested group differences on pretests using 2-level models (students within classrooms), with Group dummy coded (1 = treatment, 0 = control). Two-level models were also used to test predictor effects on sentence-combining posttests and the extended writing measures. In these latter analyses of outcomes, Group was effect coded (1= treatment, −1= control) and all pretest variables were standardized (z-scores) for ease of interpretation. For all multilevel (hierarchical) analyses, *HLM 7* was used (Raudenbush, Bryk, & Congdon, 2010).

Pretests

Children's observed pretest performance is presented in Table 3. Correlations among the measures are presented in Table 4. Results from the pretest models (i.e., multilevel models with Group as the Level2 predictor) revealed no significant differences between conditions (all *p*s>.31). Although we did not screen for learning disabilities, the sample did include students with a range of abilities. An examination of the observed standard scores indicated that 4.6% of the students performed more than one standard deviation below the standardized mean in word reading, and 12.6% scored at or below one standard deviation in vocabulary. Although group differences in word reading and vocabulary were not statistically significant, the observed differences in group means prompted us to include both as predictors in subsequent posttest models (as control variables).

Intervention effects: Sentence combining

To answer our first set of research questions, we tested the effect of intervention on each measure of sentence combining (with and without correct spelling required). Each of these two models also included the respective sentence combining pretest measure, a group X pretest interaction term, and the two other pretests (word reading and vocabulary) to control for potential pre-existing group differences). We were particularly interested in the interaction between group and sentence-combining pretest because we hypothesized that morphological instruction may be most useful for lower-performing students. In both analyses, we tested the following model:

$$\text{PostSentComb}_{ij}=\gamma_{00}+\gamma_{01}*\text{Group}_j+\gamma_{10}*\text{ZPreSentComb}_{ij}+\gamma_{11}*\text{Group}_j*\text{ZPreSentComb}_{ij}+\gamma_{20}*\text{ZPreWordRead}_{ij}+\gamma_{30}*\text{ZPreVocab}_{ij}+\text{U}_{0j}+\text{r}_{ij}$$

Table 5 presents model results for the two sentence combining posttests (with and without misspellings allowed).

As shown in Table 5, results revealed significant positive effects of the intervention regardless of the sentence combining scoring. Holding other variables constant, students in intervention classrooms were, on average, 3.28 points higher than students in control classrooms with misspellings allowed (recall Group was effect coded so the coefficient is doubled). Corresponding sentence combining pretest was also a significant positive predictor of posttests, as was the interaction between pretest and Group. The interaction is illustrated using model-implied values in Figure 1, which shows that the treatment effects were larger (difference between intervention and control condition) for students scoring one standard deviation below the pretest mean, compared with students scoring at average or one standard deviation above.

For posttest sentence combining in which correct spelling was required, the pattern of results was highly similar. Students in intervention classrooms were estimated at an average of 3.44 points higher than controls. Corresponding sentence combining pretest was also a significant positive predictor of posttest. And, although the interaction between pretest and group was not significant when correct spelling was required (p=.053), the strong trend clearly shows the same pattern as in Figure 1: treatment effects tended to be larger for lower-performing students, as illustrated in Figure 2.

As an example of the qualitative effect of the intervention, consider the responses of one intervention student who struggled at pretest. Table 6 presents the kernel sentences of two items, as well as her responses at pre- and posttest (presented without correction). At pretest, the student's responses were largely repetitions of the syntactic structure of the prompts, with occasional synonym substitutions. Her posttest responses were more concise and included multiple syntactic changes that were afforded by morphological changes. Although her misspellings did not receive credit in our most strict scoring, the sentence structure and word choice of her posttest responses clearly reflect a better approximation of the conceptually dense language that typifies the academic register.

Intervention effects: Extended responses

To examine whether intervention effects generalized to a less constrained writing task, we examined the extended responses that both intervention and control students completed in conjunction with the science unit. Not all students completed all five writing assignments, and only students completing three or more (n=129) were included in the analyses that follow. Because the nature of the writing prompts contributed as much variability as did their sequence in the science unit, mean scores were calculated across all of a student's extended responses. To analyze these data, a 2-level (students within classrooms) was employed for each of the three types of written response scores. The model is nearly identical to the sentence combining posttest model, but does not include corresponding pretest or interaction term since it was not measured at pretest). The model is as follows.:

$$\text{Outcome}_{ij}=\gamma_{00}+\gamma_{01}*\text{Group}_j+\gamma_{10}*\text{ZPreWordRead}_{ij}+\gamma_{20}*\text{ZPreVocab}_{ij}+\text{U}_{0j}+\text{r}_{ij}$$

The model results of all three outcomes are provided in Table 7. (Note that analyses that did not take spelling into account showed a similar pattern.) The focal outcome of interest (of the three types of written response scores) was the percent of words written that were derivational forms of the instructed words. The model results for this outcome showed a significant effect of Group, with model-implied estimates of the percent of correctly spelled derivational morphological forms at 9.2% for students in intervention classrooms, compared to 6.8% for controls.

The results of the latter two written response measures (middle and right columns of Table 7) were analyzed in order to evaluate potential pre-existing group differences in extended writing skills (i.e., we had no pretest measures for these skills). Recall that average text length serves as a proxy for overall writing fluency, and percent of non-instructed derivational forms serves as a proxy for general written vocabulary. In other words, we did not expect differences between conditions on these skills. Neither of the results showed a significant effect of condition, suggesting little evidence of systematic differences across groups in general vocabulary or writing fluency.

As another example of the qualitative effect of the intervention, consider the responses of several intervention students provided in Table 8 (again responses are presented without correction). As the first prompt indicates, we were as explicit as possible to ensure that students from control classrooms understood the expectations and could engage with the writing prompts. As illustrated in Table 8, students from intervention classrooms were able to vary the morphological forms of the instructed words in their written responses, although not always with accurate spellings.

Discussion

This study documented positive effects of morphological instruction on children's writing, and although the study did not focus exclusively on students with disabilities, intervention effects were observed among the lower-performing students in general education classrooms. We documented improvements in fifth graders' spelling and word use in a sentence-combining task and saw transfer to a more authentic extended writing task. Moreover, in the sentence-combining task for which we had a valid pretest measure, we saw an intervention-by-group interaction such that students who were lower at pretest made greater gains, although when correct spelling was required, the interaction failed to reach significance (p=.053). Such results suggest that for upper elementary students (particularly those who struggle), instruction to support morphological insights may be beneficial in helping master the complex word structures that characterize academic language.

Prior research has documented relations between morphological awareness and spelling and effects of morphological instruction on spelling outcomes (Berninger et al., 2008; Henry, 1989; Nunes & Bryant, 2006); however, translating ideas into written text requires more than spelling knowledge alone. Students with disabilities face considerable challenges with both transcription (Graham, 1990; Graham & Harris, 2000) and text generation (Wong, Wong & Blenkensop, 1989). Although immature writers with and without disabilities typically do little polishing of language as they move from the retrieval of ideas to the generation of written text, one hallmark of skilled writing is manipulating written expression to conform to authorial intent (Bereiter and Scardamalia, 1987; Hayes & Flower, 1980; McCutchen, 1988). The present study provided evidence that morphological instruction can help young writers with such manipulations of words and sentence structures. After morphological instruction, students showed improved ability to manipulate derivation morphological forms during sentence combining, spell them correctly, and coordinate multiple ideas with grammatical integrity within a single sentence. The extended written responses also revealed intervention students using a greater variety of morphological forms in more authentic writing contexts. In both writing tasks, students from intervention classrooms generated language that better approximated the conceptual density and morphological variety typical of the academic register.

Limitations

It should be acknowledged that the effects of the intervention did not generalize broadly to students' overall vocabularies; that is, in their extended responses, intervention students included more morphological variety among words on which they received instruction, but not among other words. Although we interpreted the lack of difference as evidence that the intervention and control students did not differ systematically in their general vocabulary, such a result might also be considered evidence of limited transfer. However, the intervention and the writing prompts were relatively brief and tied closely, by design, to the vocabulary of the science unit; thus evidence of broad-scale transfer may have been surprising.

In addition, because intervention teachers were asked to commit to implementing the supplemental vocabulary intervention in conjunction with their science instruction, assignment of teachers to condition was not random, and thus assignment of students to condition was not random. It was therefore important to examine potential pretest differences between intervention and control students, as well as the nesting of students within classrooms. Although multilevel analyses revealed no significant pretest differences, all analyses of intervention effects took into account pretest scores, and in none was word identification or vocabulary a statistically significant predictor.

Instructional implications

As we observed classrooms in preparation for the study, we were surprised to see that students did relatively little reading and writing in the context of science activities. This was unexpected because STEM learning is a major theme in contemporary reform efforts; the importance of reading and writing within science has been stressed in both the Common Core State Standards (National Governors Association Center for Best Practices, 2010) and the recently released framework for the Next Generation Science Standards (National Research Council, 2012).

Content areas such as science and social studies provide a rich array of morphologically complex words that can be exploited to improve students' comprehension (Baumann et al., 2003) and composition. Word-level instruction that involves interesting content-area words (e.g., *erosive/erosion, colonial/colonization*) embedded in the reading and writing of the content areas holds potential for the kind of transfer that decontextualized instruction in vocabulary or grammar rarely shows (Lawrence, White, & Snow, 2010). To be clear, we are not advocating isolated lessons in roots and affixes. Rather, the morphological instruction in the present study was prompted by and embedded in the science vocabulary that students were encountering in their content-area instruction. Such integrated instruction that melds conceptual work with disciplinary language is necessary if students are to develop the literacy skills to advance their conceptual understandings of content and document their learning through writing. In the present study, our focus was at the level of words – how words work, how related word meanings are reflected in morphological structure, and how words can be manipulated during composing. Beyond the scope of our study but equally important to authentic disciplinary literacies will be attention to the structure and function of disciplinary texts – how whole texts are structured, how evidence is marshaled, and even what counts as evidence (Shanahan, Shanahan, & Misischia, 2011; Stevens, Wineburg, Herrenkohl, & Bell, 2005). Still, the present study documents the value of instruction in the morphological structure of words and how words work within texts and provides evidence that such instruction can be especially important for students who struggle or may be at-risk for disabilities.

Acknowledgments

The research reported here was supported by the Eunice Kennedy Shriver National Institute of Child Health & Human Development, Grant P50HD071764, and by the Institute of Education Sciences, U.S. Department of Education, Grant R305H060073. The opinions expressed are those of the authors and do not represent the views of the NICHD or the Department of Education.

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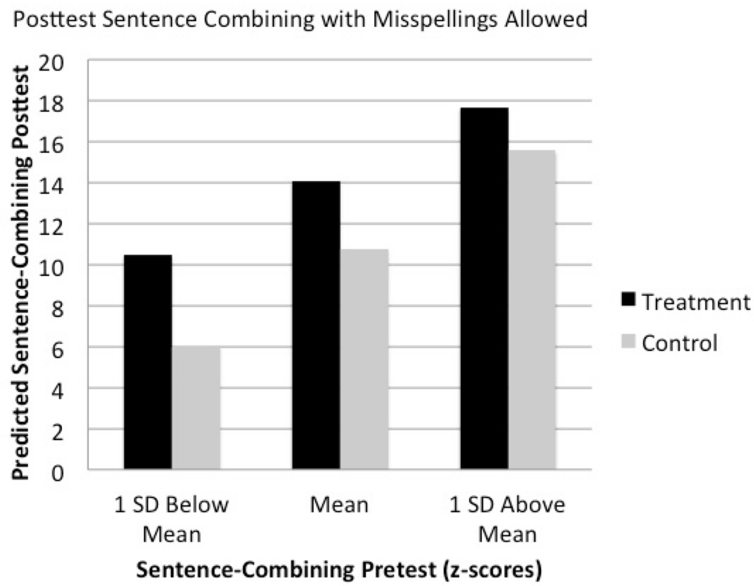

Figure 1.

Predicted posttest sentence combining (misspellings allowed) at three skill levels

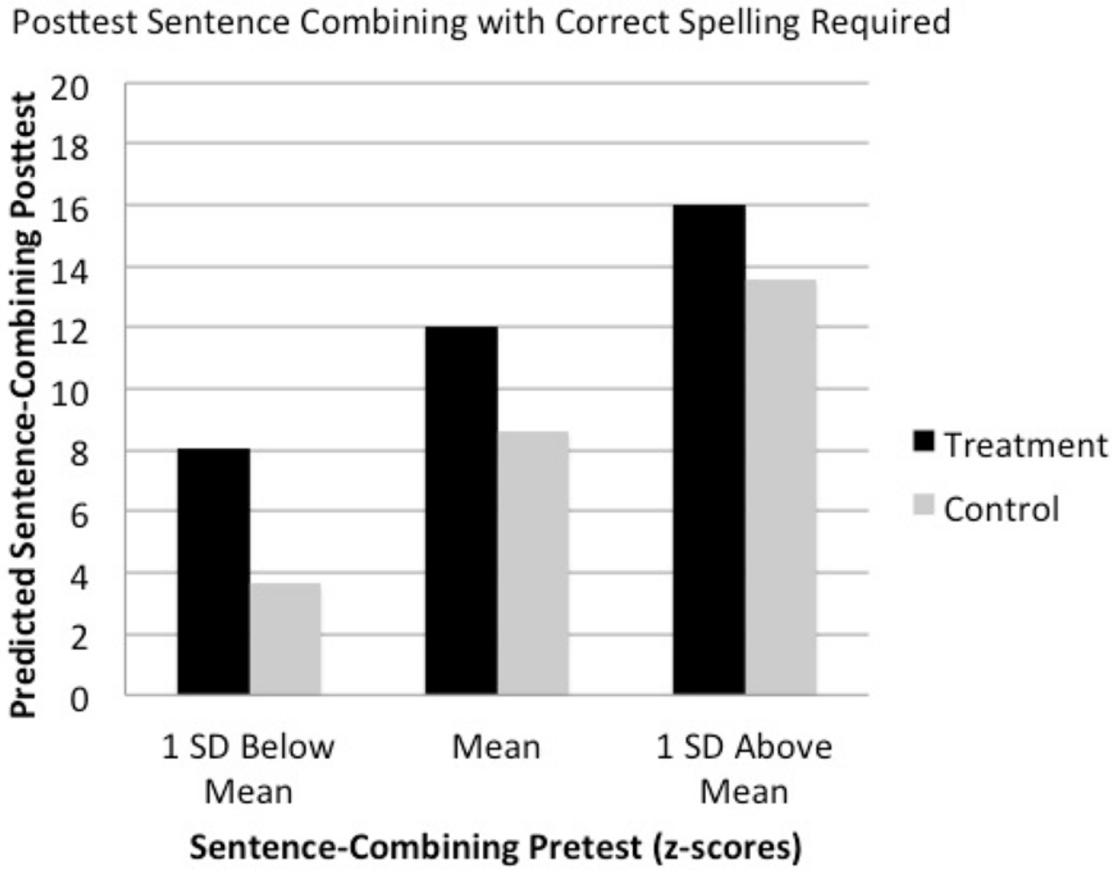

Figure 2.
Predicted posttest sentence combining (with correct spelling) at three skill levels

Table 1

Sample vocabulary lesson

"Aqua" is a morpheme meaning water, just like the *water* you are learning about in your science unit. Unlike "terr," it is a type of morpheme that can stand by itself as a word. You may know it better as the name of a blue-green color (like the color of water).

"Aqua" is found in many words that have something to do with *water*. You will probably come across some of them as you learn about land and *water*. Let's look at some examples:

"Aquatic" is an adjective (a describing word") meaning "living in, or having to do with, water".
"Whales, dolphins, and shrimp are all aquatic creatures."

"Aquarium" is a noun (a person, place, or thing") and is "a container (such as a glass tank) in which living water animals or plants are kept," or "a building or establishment where collections of living water animals and plants are kept.
"At the aquarium, I saw many kinds of fish and even some sharks!"

"Aquifer" is a noun and is "an underground laver of rock, sediment, or soil that contains ground water, often for use in wells."
'The well gets its water from an aquifer under the ground."

Choose the words (from above) to complete the sentences:

1. If you want to learn more about animals that live in the ocean, you could visit an____________________________.
2. Rain that is absorbed by land flows under the ground to areas called ____________________, which can be used to build wells.
3. Fish need to live in an ____________________ environment in order to survive.

Table 2

Summary of instructed words and morphological relatives

Instructed word/morpheme	Definition discussed	Examples of related forms discussed
terrain	land	terrain, territory, subterranean
aqua	water	aquatic, aquarium, aquifer
cycle	circle	cycle, recycle, cyclone, bicycle
vapor	suspended in air	evaporate, evaporation, vaporize
condense	make compact	condensation, condenses
observe	see. notice	observation, observatory, observedly
predict	before + say	prediction, predicted, predictable
un-	not	unhealthy, unpredictable, unknown
erosion	eat away	erode, eroded, erosion, eroding, erosive
magnify	great, big	magnification, magnified, magnifying
particle	part	part, partly, partition, parted, partake
explain	out of + clear	explanation, explaining/express, extend
energy	work	energize, energizing, energetic, energized
effect	do, make	effects, effective, ineffective, effectiveness
vary	change	varies, variable, variation
procedure	forward + to move	proceed, recede, exceed
mountain	clime, sum up	mountainous, mount, dismount, surmount
solve	loosen, untie	dissolve, solution, unsolved
gravity	heavy, weighty	gravitate, gravitation
conserve	serve, protect	conservation, conservationist, conservative

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Table 3

Means of Pre-Intervention Observed Scores and Summary of Two-Level Models

Measure	**Group** Intervention (n=95)	Control (n=75)	***t*-ratio (Group)**	***p*-value (HLM)**
WRMT-R Word ID	80.6 (10.9)	76.9 (11.2)	0.894	ns
WJ-III Vocabulary	27.2 (4.4)	24.7 (4.9)	1.098	ns
Sentence Combining (misspellings allowed)	12.3 (6.1)	8.3 (5.9)	1.357	ns
Sentence Combining (correct spellings only)	10.4 (5.8)	6.5 (5.2)	1.380	ns

Table 4

Correlations among Word Reading, Vocabulary, and Sentence Combining Pretests

Variable	1	2	3	4
1. WRMT-R Word ID	---	.700***	.654***	.689***
2. WJ-III Vocabulary		---	.635**	.615***
3. Sentence Combining Pretest (misspellings allowed)			---	.953***
4. Sentence Combining Pretest (correct spelling only)				---

*** $p \leq .001$

Table 5

Models of Sentence Combining Posttests With and Without Misspellings Allowed

	Misspellings Allowed			Correct Spelling Only		
Fixed effects	**Coeff**	**SE**	***t***	**Coeff**	**SE**	***t***
Intercept	12.413	(0.405)	30.616***	10.324	(0.267)	38.719***
Group	1.638	(0.453)	3.613*	1.723	(0.312)	5.523***
Pretest	4.184	(0.340)	12.304***	4.475	(0.324)	13.821***
Group x Pretest	−0.595	(0.294)	−2.026*	−.0504	(0.258)	−1.950
Word ID	0.694	(0.365)	1.901	.0489	(0.354)	1.383
Vocabulary	0.412	(0.372)	1.108	.0283	(0.330)	0.859
Random effects	**Variance**	**SD**	χ^2	**Variance**	**SD**	χ^2
Between-classrooms	0.793	0.891	15.764*	0.148	0.385	6.899
Residual	9.354	3.058			7.972	2.823

Note:

* p<.05,

*** p≤.001

Table 6

Examples of an intervention student's sentence-combining responses

Kernel sentences provided as prompt	**Pretest Response**
The police investigated the crime. The investigation was careful. The crime was a mystery.	The police were investigating a crime. They were very careful. I sure was a mystery.
	Posttest response
	The police investigated a mystirious crime carfuly.
Kernel sentences provided as prompt	**Pretest Response**
The seal swam toward the penguins. The penguins felt terror. The seal's path was direct. The seal had spots.	A seal went by some penguins then the penguins were scard, the seal was moving fast, he also had spots
	Posttest response
	A terrifing, yet spoted seal swam right towards the penguins.

Table 7

Models of Extended Written Responses

	Instructed Morphological Forms (%)			Number of Words			Any Complex Morphological Forms (%)		
Fixed effects	**Coeff**	**SE**	***t***	**Coeff**	**SE**	***t***	**Coeff**	**SE**	***t***
Intercept	0.080	(0.004)	17.748***	23.304	(3.402)	6.85***	0.023	(0.002)	14.892***
Group	0.012	(0.004)	2.681*	0.016	(3.414)	0.005	0.002	(0.002)	1.051
Word ID	− 0.002	(0.003)	−0.561	1 071	(1.068)	1.003	0.000	(0.002)	0.161
Vocab	− 0.001	(0.003)	−0.252	− 0.592	(1.107)	−0.535	0.002	(0.002)	0.814
Random effects	**Variance**	**SD**	**χ^2**	**Variance**	**SD**	**χ**	**Variance**	**SD**	**χ^2**
Between-classrooms	0.000	0.010	16.540**	74.190	8.613	82.516***	0.000	(0.000)	3.079
Residual	0.001	0.025		75.940	8.714		0.000	(0.017)	

Note:

* $p<.05$,

** $p<.01$,

*** $p\leq.001$

Table 8

Examples of two intervention students' extended responses

Prompt	Intervention student response
Write about using a magnifying glass in your experiment. Use different forms of the word "magnify" to describe what you did.	I magnified the water with the magniffying glass. I still couldnt see it even when the magnifier was (the purple) microscope.
Look at these headlines. Choose one. Then on the lines below, write a paragraph to tell what happened as if you were the news reporter. **A.** Off-Trail Hikers at Discovery Park Cause Erosion of Popular Park **B.** Broken City Buses Magnify the City's Traffic Problem **C.** Student Protestors Want to Partake in Next Presidential Election	Off Trail Hikers cause Erosion at a popular park! Because they are walkin on unstable soil, the parks territor is beggining to erode! The hikers had no idea until we magnified the problem