

Invented words after writing intervention: Elementary student production of  
morphological inventions in two writing contexts

Emma Huey

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Deborah McCutchen, Chair

Elizabeth Sanders

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Emma Huey

University of Washington

**Abstract**

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Emma Huey

Chair of the Supervisory Committee:  
Deborah McCutchen  
Department of Education

Morphological inventions are an area of language development that has received limited attention. The present study examines pretest-posttest data from a 2-cohort randomized study of a 12-week writing-focused morphology instruction intervention for fourth and fifth graders compared to a business-as-usual control condition. Specifically, two writing tasks, sentence combining and text generation, were used to assess morphological derivations and inventions. Results of aptitude-by-treatment interaction ANOVA models showed that, while the intervention had no main effect on morphological inventions in the less constrained task (sentence combining), there was a treatment by grade interaction on inventions for instructed words. Students used more morphological derivations, both in correct and invented words, on transfer word items in the more constrained task (morphological production). Results of this study show

that instruction in morphological knowledge increases student use of invented words on constrained tasks, and transparency of derived words relates to invention usage.

Invented words after writing intervention: Elementary student production of morphological inventions in two writing contexts

Word learning has a reciprocal role in literacy development; it is both shaped by children's reading and a factor in shaping children's reading. To truly know a word, one must of course know the meaning, but also know how it relates to other words and ideas, when and where to use the word, and how its behavior changes in different contexts (Harmon, Hedrick, Soares, & Gress, 2007). The processes through which children acquire word knowledge are multifaceted due to the complexity of the English language, which makes vocabulary instruction by means of rote definitions inadequate for children (Nagy & Scott, 2000); instead, word learning must involve an active process through which metalinguistic awareness is achieved. The effectiveness of a child's metalinguistic ability may influence the difficulty he or she faces when learning new vocabulary (Nagy & Scott, 2000).

Metalinguistic ability encompasses the processes children use to recognize and manipulate the language that they hear and read, including phonologically and morphologically. Phonology is the knowledge of phonemes, the sound units of language, and a significant portion of literacy research has centered on how phonological awareness relates to and improves reading and spelling success (e.g., Blachman, 2000). Morphology refers to the understanding of morphemes, the smallest units of language that carry meaning. Morphemes either stand alone, as in *help*, or combine with others to build morphologically complex words, such as *unhelpful*. Morphological awareness is a growing topic in metalinguistic literature, as well as in vocabulary and literacy research. Metalinguistic knowledge of both of these language units allows readers to decode, process, and pull meaning from text.

Writing research is a valuable field for looking at child language and literacy development as it provides examples of productive language. However, there is little research on morphological knowledge in writing beyond spelling.

### **Defining Morphology**

The English written language is considered *morphophonological*, meaning that English orthography represents language both at the level of units of meaning and the level of units of sound (Chomsky & Halle, 1968). Phonemic knowledge aids in word decoding and encoding by connecting units of sounds to their corresponding letters; however, while many English words can be read through decoding strategies, others follow irregular orthographic patterns, such as *heard*, so reading strategies beyond decoding are required. Morphological strategies, employed both consciously and implicitly, can help readers work with written language.

In their review of morphological research, Bowers, Kirby, and Deacon (2010) distinguish between *morphological awareness*, which they call the active knowledge and manipulation of word structures, and *morphological processing*, the unconscious or implicit processing of morphological information. Goodwin, Petscher, Carlisle, and Mitchell (2017) also discuss these two aspects of morphology, which they call tacit and strategic. In the former, children build morphological awareness through repeated exposure, while the latter stems from deliberate analysis and manipulation of word parts that only occurs in settings that encourage this type of metalinguistic processing. To discuss the broad, encompassing area of morphology, including both processing and awareness, Bowers et al. (2010) suggest the term *morphological knowledge*, and I will use language throughout this paper.

Multiple authors have investigated the numerous and complex aspects of morphological knowledge. Goodwin et al. (2017) suggest that morphology is best viewed from a

multidimensional perspective, where general morphological knowledge is reflected through different constructs of processing and analysis. Goodwin et al. (2017) administered seven distinct measures of morphological skill, including analysis of real and nonsense words, recognizing relationships between word pairs, and processing spelling, meaning, and pronunciation of unfamiliar words. Their analysis of these measures led them to conclude that these tasks could not be reduced to fewer dimensions, and that each tapped a different aspect of morphological knowledge. Similarly, Tyler and Nagy (1989) distinguished three types of morphological knowledge: relational knowledge (words can share a common morpheme), syntactic knowledge (derivational suffixes indicate grammatical category), and distributional knowledge (rules of appropriate stems and suffixes). Each of these constitute of level of a child's development in vocabulary and literacy.

### **Morphology's Role in Literacy**

Carlisle and Stone (2005) suggest multiple ways children may or may not incorporate morphological awareness in reading. At one end, children who are developing reading fluency may process morphological units as common orthographic patterns without regard for the semantic and syntactic implications of the unit. For example, when reading the word *action*, a child may see the suffix *-tion* as an orthographic chunk without applying meaning to the suffix or recognizing *act* as a root being altered. This type of reading allows for proper pronunciation but does not incorporate metalinguistic thinking at the word level. At the other end, morphemes may be represented in memory separate from the words they form, and verbal memory for the morpheme may be distinct from the visual memory (Taft, 2003, as cited in Carlisle & Stone, 2005, p. 431). In this instance, the suffix *-tion* has a distinct place in the child's lexicon, where it has its own meaning, in addition to lexical entries for the derived forms of a given stem. These

morphologically indexed lexical entries influence reading fluency because the number of words in a word family (e.g. *act, acting, active*, etc.) affects recognition speed (Nagy, Anderson, Schommer, Scott, & Stallman, 1989). So with increased interactions with a morphological unit (root or affix), a reader will recognize an unfamiliar word with that unit and read it with greater speed. Morphological knowledge has been shown to predict variance in pseudo-word reading, reading speed, reading accuracy, spelling, and vocabulary knowledge (Bowers et al., 2010). Among these, morphology is most closely correlated to vocabulary.

Morphological knowledge develops as children age and build their lexicon, with noticeable growth between the third and fourth grades (Anglin, 1993), around the same time children begin reading more complex texts and building fluency. When encountering a new word, a child's two primary clues to meaning are context and morphology (Nagy & Scott, 2000). Kearns, Steacy, and Compton (2016) suggest that the skills children employ to read monosyllabic words are different from those needed to read polysyllabic words. When reading complex or polysyllabic words, such as compound words like *daycare*, or inflectional and derivational forms of words, like *caring* or *careless*, morphology provides valuable clues in regards to pronunciation, root word, tense, and meaning. Carlisle and Stone (2005) showed that both younger and older elementary school student read morphologically transparent derived words, such as *helper*, with greater speed than mono-morphological, "pseudo-derived" words, like *amber*. A major aspect of reading polysyllabic words is morphological awareness, as longer words often have multiple morphemes (Kearns, 2015), and recognition of morphological units aids reading speed and accuracy.

Although morphology has primarily been viewed through the lens of vocabulary and word recognition, there is also considerable discussion about its place in reading comprehension.

Morphology has been found to have a small, yet significant, role in comprehension, even when considering phonology and vocabulary knowledge (Deacon & Kirby, 2004). In a discussion of Perfetti's (2007) lexical quality hypothesis, which states that the quality and flexibility of word representations impact reading comprehension, Bowers et al. (2010) posit that morphology may influence comprehension through increased lexical quality.

**Phonological and orthographic transparency.** One factor that may influence the relationship between morphological knowledge and written language is the transparency or opacity of a word. This includes both phonological transparency, such as how *heal* maintains its pronunciation in *healer*, but shifts in *health*; and orthographic transparency, as in *decide* maintaining spelling in *undecided* but changing in *decision*. In transparent derivations, the written form of the word maps more clearly onto the spoken form, and this may enhance a child's ability to recognize morphological relationships and thereby enhance lexical quality. In non-transparent, or opaque, derivations, however, the phonological and orthographic shifts may mask the morphological relationship, making it more difficult for children to identify morphological units. Unsurprisingly, morphological knowledge is related to success reading and spelling polymorphemic words, even controlling for root word recognition and frequency (Kearns et al., 2016).

**Morphology in writing research.** Writing experience aids morphological knowledge development, as children learn to recognize morphemic boundaries and orthographic patterns through written text (Carlisle, 1996). Carlisle (1996) uses a student example to explain the learning of morphemic boundaries: the phrase *of course* in oral language can be interpreted as one word, *ofcourse*. It is only through the practice of reading and writing that a child recognizes and corrects word boundaries. Additionally, writing experience also helps children distinguish

between similar words, such as *cats* and *cat's*, by incorporating punctuation to delineate different morphological units (Carlisle, 1996). Nagy and Scott (2000) suggest that in order to have a complete understanding of a word, one must be knowledgeable of both its written and spoken form, and how it behaves syntactically. These are aspects of words that can be best understood through morphological units.

The connection between morphology and writing has only recently begun to be explored. Because writing incorporates the production of morphological forms, it provides a view of morphology distinct from receptive reading skills. The morphophonemic aspects of English require that children have accurate connections between orthographic patterns and both phonemes and morphemes to correctly spell words. McCutchen and Stull (2015) hypothesized that morphological knowledge may aid in young students' retrieval and construction of words as they write, and it may also contribute to flexibility in the syntactic aspects of writing, such as constructing and reconstructing sentences (Northey, McCutchen, & Sanders, 2016).

Inflectional changes are typically the first sign of developing morphological knowledge. Carlisle (1988) found that children begin incorporating inflectional changes into their writing early in elementary school with the addition of suffixes such as *-s* and *-ed*. These inflections may not appear correctly at first, especially as inflectional endings may not align with phonemes. For example, *-ed* appears as the phonemes /t/ or /d/ in multiple words, such as *hoped* written as *hopt*. But increased awareness of the morphological unit leads to correct spelling of verb forms.

By the fourth grade, children demonstrate understanding and manipulation of word forms, especially if they are transparent, and at this age, derivations begin to appear in writing (Carlisle, 1988). This development aligns with the growing appearance of polymorphemic words in text at this age. According to Nagy et al. (1989), 60% of unfamiliar words students in the 4<sup>th</sup>

grade and after encounter include multiple morphemes. Thus, students must be able to apply morphological awareness and strategies to read, understand, and spell derived words.

### **Morphological Interventions in Literacy**

Several studies have incorporated morphology into reading instruction and have seen positive results in varied aspects of literacy. Comparisons of phonics-only and combined phonics and morphology instruction show significant advantages in reading and writing to the latter group (Henry, 1988). Likewise, in their analysis of morphological interventions, Bowers et al. (2010) found that integrated instruction leads to greater results than isolated morphological instruction. Applying morphological strategies to word learning and spelling is an especially useful tool for students in the fourth and fifth grades (Nagy, Berninger & Abbott, 2006), likely because this is the age where there is an increasing number of polysyllabic and polymorphemic words in print.

Specific instruction in word structure has been shown to improve decoding skills (Vadasy, Sanders, & Peyton, 2006), and by improving word identification efficiency and providing readers with clues to meaning, Goodwin and Ahn (2013) showed that morphology instruction can improve reading comprehension. Additionally, for students with language impairments, instruction in morphology has been shown to improve morphological awareness, word-level reading ability, spelling, and vocabulary (Good, Lance, & Rainey, 2015; McLeod & Apel, 2015). In regards to higher level writing skills, structured morphology lessons help students improve their use of complex language and syntax in sentence writing (McCutchen, Stull, Logan Herrera, Lotas, & Evans, 2014).

**Assessing morphological knowledge in writing tasks.** Writing is a productive task, and although written assessments do not completely capture the mental processes involved in

planning and transcribing ideas into text, writing samples do offer a concrete look at an individual's productive language abilities, including phonological and morphological knowledge. Successful academic writing incorporates morphologically complex vocabulary to allow for varied and conceptually dense syntax, transition between concepts, and generation of precise vocabulary. To achieve this type of writing, a child must be able to generate, organize, and transcribe text accurately (Berninger & Amtmann, 2003).

Children's writing holds clues to a child's working morphological knowledge, and different writing tasks can provide opportunities to witness student errors and experimentation with derivations (Flinspach, Scott, & Vevea, 2010). Of writing assessments, spelling tests are the most common approach for examining morphological knowledge, though other tasks still provide opportunities for this experimentation. While spelling tests assess transcription abilities, word choice tasks show a child's control over morphological forms through text generation. Berninger, Nagy, and Beers (2011) reported that this type of measure predicts student ability to combine ideas across larger texts. However, word generation tasks are highly constrained, so sentence combining tasks are a more open setting for students to create syntactically complex sentences (Saddler & Graham, 2005). Sentence combining tasks require students to demonstrate ability in all three areas of Berninger and Amtmann's (2003) model, as well as provide opportunities for morphological derivations.

### **Invented Words**

There is a growing interest in how young children use invented words in spelling, writing, and speech. Inventions stem from misuse of phonological and morphological rules, and their appearance signals developing knowledge of these rules. Much of the work on invented spelling has focused on phonological development in early childhood, where children are

learning the rules of applying the phonetic code into writing (e.g., Gentry, 1982; Clarke, 1988; Ouellette & Senechal, 2008). Children's ability to create a written form of a word can show their understanding of phonological units and letter knowledge. Research in early childhood writing development shows that these invented words begin first as random series of characters with no phonological or orthographic connection to correct word forms, then become correct initial letters or salient phonemes, such as "P" or "A" to represent the word *play*. Next, written words begin representing correct phonological order and resembling complete words (e.g., "PLA" for *play*), and then finally using conventional spelling (Ouellette & Senechal, 2016; Gentry & Gillet, 1993). Research in this field shows that there is a bidirectional relationship between invented spelling and phonological awareness, where quality of invented spelling depends upon phonological awareness, and likewise phonological awareness is improved through practice with invented spelling. Both phonological awareness and usage of invented spelling are shown to predict literacy outcomes in kindergarten and the first grade (Ouellette & Senechal, 2016).

While most research in invented spelling focuses on phonological knowledge, Ouellette and Senechal (2008) suggest that morphological awareness also has a moderate correlation to invented spelling, but further research in this area is limited, as most morphological studies look at older elementary and middle school students (Bowers et al., 2010). Morphological knowledge is also considered an aspect of transitional spelling, where children begin to spell words using known syllable and letter patterns; however, most research focuses more on misspellings rather than completely invented words.

**Morphological inventions.** Morphological inventions are distinct from phonological inventions and misspellings in that they violate distributional knowledge rules (McCutchen & Stull, 2015). That is, inventions improperly match word stems with affixes (e.g., *non-safe* or

*help-y*). Tyler and Nagy (1989) posit that these inventions come from student internalization or overgeneralization of morphological rules, and children use their morphological skills to generate words when they cannot access an appropriate word in their lexicon. This theory of overgeneralization is supported by research in early childhood writing. Carlisle (1996) analyzed second and third graders' written stories and found that morphological inventions result from errors of commission, where children apply incorrect affixes to verbs (e.g., *She runned*).

Mirroring morphological knowledge development, written inventions appear first as inflectional forms and then as derivations. Derivational errors begin to appear towards late elementary, peaking in 5<sup>th</sup> grade (Tyler & Nagy, 1989) before mostly disappearing with increased vocabulary and writing competency. McCutchen and Stull (2015) showed that morphological inventions likely stem from incomplete productive morphological knowledge rather than issues of word identification or vocabulary, so children that demonstrate skills in processing and analyzing morphological units are less likely to resort to invented words.

### **The Current Study**

Building on the work of McCutchen and Stull (2015), which investigated the frequency of morphological inventions related to morphological awareness as well as effects of a morphology intervention on invention usage, the current study looks at fourth and fifth graders' morphological inventions on two writing tasks following a writing-focused morphological intervention. The two writing assessments, one a sentence combining task and the other a morphological production task, were analyzed to look at whether instruction in morphology influences the occurrence of invented words. The two assessment measures had different levels of constriction, with sentence combining allowing more open responses, so that inventions can be analyzed for the contexts in which they occur. Additionally, items were evaluated for their

phonological and orthographic transparency to examine links between word transparency and students' morphological inventions. The specific research questions were as follows.

1. Does instruction in morphology (treatment) influence morphological inventions in two writing tasks?
2. Are there developmental differences in morphological inventions between fourth and fifth graders? In other words, do fourth and fifth graders differ?
3. Is there a relationship between morphological inventions and transparency of the word forms?

## **Methods**

### **Participants**

This study used extant data from a 2-cohort randomized study of a fourth- and fifth-grade morphological instruction intervention. Cohort 1 included 12 classrooms (4 fourth grade, 7 fifth grade, 1 split grade) from 7 schools, and cohort 2 included 10 classrooms (6 fourth grade, 4 fifth grade) from 4 schools, for a total of 521 students participating in the study. Of these, 22 students were removed from data analysis because they did not participate in at least one assessment measure from either pre- or post-testing, so the final number of participants was  $N = 499$ .

For each cohort, classrooms were randomly assigned to either treatment or business-as-usual control conditions; across cohorts, 10 classrooms were in the intervention condition and 12 were in the control condition. All classrooms come from schools in a large metropolitan area in the Pacific Northwest. See Table 1 for demographic information about the participants.

### **Intervention**

The intervention consisted of a twelve-week curriculum implemented by classroom teachers for 20-30-minute sessions, four days a week. Teachers were trained in morphology and

its role in reading and writing, and they were given lesson plans for instruction. Lessons followed a weekly format, where teachers introduced 4-5 new word families each week and taught their students different morphological forms of each words (for example: *direct*—director, direction, directive, indirect). Over the course of each week, students read passages using instructed words, practiced analyzing and synthesizing word parts, answered questions about the words in context, and wrote sentences and passages using different forms of the words. Weeks 4, 8, and 12 were used as review weeks. Teachers were asked to question students about word forms and roots, provide feedback, and reinforce student use of instructed words during responses.

Researchers observed three fidelity lessons in each intervention classroom to ensure teachers were implementing the lessons according to the curriculum. Teachers were rated independently on a 1-5 scale on the following aspects of instruction: compliance to instructions, support for morphological insights, explanation of the task, quality of feedback, pacing, and student responsiveness. Control teachers did not implement the morphological intervention, and they were asked to provide information about their typical vocabulary and writing instruction.

## **Measures**

All students were pretested and posttested on measures of reading, writing, and vocabulary abilities to document baseline literacy levels. Morphological knowledge has an established relationship with vocabulary and word reading, so it was important that these areas were addressed in testing. Testing involved two hours of group administration split over two days for each class, followed by fifteen minutes of individual testing. For the purpose of the present study, I will focus on the comprehension and morphology measures. Students were given Passage Comprehension from the Woodcock Johnson III Tests of Academic Achievement

(McGrew, Schrank, & Woodcock, 2007). In this measure, students read increasingly complex passages to themselves and then provided a missing word. The measure was administered individually and required students to say their answer aloud. This measure is nationally normed for the participants' ages and has been used regularly in school assessments.

The outcome measures, which afforded morphological inventions, are researcher-developed tests of sentence combining and morphological production. In sentence combining, adapted from McCutchen et al. (2014), participants were provided three kernel sentences and asked to combine them into one sentence that maintains meaning (e.g. *The girl had lots of energy. The girl talked. Her talking was constant.*). This is considered a less constrained writing measure because it invites, but does not demand, morphological changes. Each item included 2 target words intended as an opportunity for participants to alter and derive words (e.g. *The energetic girl talked constantly.*), which could lead to morphological inventions. There were 8 items total; 4 items from this measure included instructed stem words, and 4 included non-instructed stem words to measure skill transfer. Student responses were scored in two ways: one based on the quality of sentences (determined by retention of critical information, and grammatical and semantic correctness), and the other on the number of derivational changes to given words. In addition to this composite sentence quality score, the measure also produced a count of morphological derivations and inventions. Estimated internal consistency for this task was .79 for number of derivations and .87 for quality.

In morphological production, participants were given a target word and an incomplete sentence and asked to complete the sentence using a derivation of the target word (e.g. *Farm. My father raises cows and is a \_\_\_\_\_*). This task is considered a more constrained measure of morphological control than the sentence combining measure because it required students to make

alterations to given words. Students were graded on their application of correct derivational forms. The measure included 40 items (20 instructed, 20 non-instructed). Estimated internal consistency is .92. On both sentence combining and morphological production, responses did not need to be spelled correctly to be considered a correct derivation; that is, recognizable phonological approximations of morphologically complex forms were allowed. For example, “The *nutrishus* soup” was considered a correct derivation. These two measures were provided at both pretest and posttest to control for invention usage in both groups prior to the intervention.

Inventions were tallied for each item in sentence combining and morphological production. For both measures, inventions were defined as words that involved incorrect derivational alterations to fit the syntactic role of the word. One example from the sentence combining measure is: *The courageous boy saved the terrified bird*. In this example, the student applied the morphological unit *-ful* incorrectly to the base word *courage*, but because the *-ful* suffix is an adjectival marker, the invented word fits syntactically into the sentence. Each item in sentence combining included two target words, so there two opportunities for inventions per item. There were 8 items in the measure, for a possible 16 inventions. Overall, the majority of students (69%,  $n=344$  out of 499) made no inventions at all in the sentence combining pretest.

In the morphological production task, students provided one word answers. Because there were 40 questions, there was a total possibility of 40 invented words. As with sentence combining, inventions needed to correctly fit the grammatical meaning (e.g., *Suspect*. The open door seemed *suspectively*). Students were more likely to invent words in this task, and only 27% of students ( $n=134$  out of 499 total) made no inventions at all in the morphological production pretest.

## Data Analysis Plan

To check for non-independence due to classroom, one-way analyses of variance (ANOVAs) on the pretest measures and morphological tasks were conducted using classroom as a random factor. Although model results showed significant differences among classrooms on both morphology measures ( $F$ -test  $p$ -values  $< 0.05$ ), classroom was not in subsequent analyses due to modeling limitations.

To test research questions 1 and 2, two-way aptitude-by-treatment (ATI) ANOVAs were used to test for group and grade, controlling for pretest effects as well as all 2- and 3-way interactions, on each of the morphological tasks. For each of the tasks, instructed (taught) and non-instructed (transfer) words were examined separately, for a total of four models.

To test research question 3, I looked closer at the inventions students were using by evaluating target words based on transparency. For this analysis, I selected only the morphological production measure because each item had only one correct answer, and since this analysis was meant to examine the appearance of inventions regardless of instruction, only the pretest measure was analyzed. Each item's target word was coded as either fully transparent (e.g., *agreement* from *agree*) or non-transparent (*productive* from *produce*). Within the task's 40 items, transparency was equally distributed, with 20 transparent words and 20 opaque words. The number of inventions used on each word was tallied, with a total of 939 inventions used across the measure (note that there was a large range of inventions, with items featuring as few as 0 and as many as 103 inventions). To test the association between transparency level (transparent vs. non-transparent) and students' morphological production, a simple one-way fixed factor ANOVA was employed.

## Results

### Pretest

To test for potential group and grade-level differences at pretest, two-way Group (treatment vs. control) by Grade (fourth vs. fifth) analyses of variance (ANOVAs) were used to analyze student comprehension, as well as performance on sentence combining and morphological production. As anticipated, results showed that there were no significant group differences on pretest performance ( $ps > 0.05$ ; see Table 2 for descriptive statistics). Additionally, there were no grade effects on the pretest measures ( $ps > 0.05$ ).

### Sentence Combining

A difference score was determined to find the change in number of inventions from pretest to posttest for each student on each measure. A positive score indicates that a student created more inventions in posttest compared to pretest, and negative indicates fewer.

Results of the 2-way ATI ANOVA on change in number of invented words on sentence combining showed that there was no main effect of treatment on either taught or transfer words ( $ps > 0.05$ ). However, among taught words, there was a significant interaction between group and grade (see Table 3,  $p = 0.01$ ). Simple effects  $t$ -tests among the two groups within grade levels ( $p$ -values adjusted using Dunn-Sidak procedure) showed that the treatment group differed from the control at the fifth grade level ( $t$ -test adjusted  $p < 0.01$ ), with the treatment group being less likely to invent words on posttest than control, but not at the fourth grade level ( $t$ -test adjusted  $p > 0.05$ ). As shown in Figure 1, in the fifth grade, students in the treatment group made significantly fewer inventions on taught words,  $M = 0.01$ ,  $SD = 0.60$ , compared to the control group,  $M = 0.08$ ,  $SD = 0.60$ .

Additionally, for taught words, there was also a significant interaction between group and pretest ( $p < 0.05$ ). I plotted the model-implied group means for three levels of pretest (one standard deviation below average, average, and one standard deviation above average) in Figure 2. As shown, the interaction was ordinal, indicating that the treatment effect was larger for students who had more inventions at pretest. Among taught words, students in the treatment group who used a larger number of inventions during pretest were more likely to use fewer in posttest than their peers in the control group who had a similar number of pretest inventions. No differences between treatment and control groups or fourth and fifth grades were evident for transfer words on sentence combining ( $ps > 0.05$ ).

Finally, for both taught and transfer words, pretest was a significant predictor ( $ps < 0.001$ ), showing that students who used more inventions at pretest were more likely to have a negative difference score, implying fewer inventions at posttest compared to pretest. This makes sense in that students who used no inventions in pretest could not have made fewer inventions at posttest.

### **Morphological Production**

The influence of treatment becomes more clear when examining morphological production. Results of the 2-way ATI ANOVA on change in number of inventions for taught words showed that both treatment and grade main effects were significant (see Table 4,  $F$ -test  $ps < 0.05$ ). Specifically, after adjusting for pretest number of inventions on the same task, students in the intervention group ( $Adj M = -0.32$ ) used significantly fewer inventions in the posttest than the pretest compared to the control group ( $Adj M = 0.167$ ); and students in the fifth grade ( $Adj M = -0.20$ ) produced significantly fewer inventions in posttest compared to fourth grade students

(*Adj M* = .04). Follow-up pairwise comparisons (adjusted using Dunn-Sidak procedure) showed that group differences were present at both the fourth and fifth grade levels (adjusted *ps* < 0.01).

Additionally, the results for taught words also showed a significant interaction of treatment group and pretest inventions (*p* < 0.05). As shown in Figure 3, students in the treatment group with higher than average pretest inventions demonstrated a larger reduction in posttest inventions compared to students in the control group.

Results of the ATI ANOVA for transfer words also showed a significant main effect for treatment (see Table 5, *F*-test *p* < 0.01). As shown in Figure 4, after adjusting for pretest inventions in the morphological production task, students in the intervention group (*Adj M* = 0.40) used significantly more inventions for transfer words in the posttest task than their peers in the control group (*Adj M* = 0.13).

Similar to the sentence combining task, pretest morphological production task inventions had a significant effect (*p* < 0.001) on both taught and transfer words: students who used more inventions in pretest were more likely to use fewer inventions at posttest.

#### **Ancillary Analysis: Correct Derivations**

One of the possible reasons that students created fewer inventions at posttest is that they may have been making correct derivational changes. To check whether this was the case, I looked at students' correct derivations for both morphological tasks. Correct derivational changes were tallied, and a difference score was again created to show the change in number of derivations from pretest to posttest (as with inventions, a positive score implies more correct derivations in the posttest compared to the pretest). Two-way ATI ANOVAs with pretest derivations as covariate were conducted on taught words, transfer words, and total (all) words.

Overall, students in both the treatment and control condition used more correct derivations at posttest than at pretest (see Table 5 for descriptive statistics). In all analyses, both in sentence combining and morphological production, group was found to have a significant effect on the change in scores (see Table 6,  $ps < 0.001$ ). Specifically, for total words (including both taught and transfer) on sentence combining, after adjusting for pretest differences, students in the treatment group wrote significantly more correct derivations during posttest ( $Adj M = 5.00$ ) than their peers in control ( $Adj M = 2.45$ ). Similarly, for total words on morphological production, students in the treatment group wrote significantly more derivations on posttest ( $Adj M = 8.60$ ) than the control group ( $Adj M = 3.32$ ). These patterns held true for taught and transfer words for both tasks.

### **Word Transparency and Inventions**

To address the final research question regarding the situations in which inventions occur, I looked closer at the inventions students were using by evaluating target words based on transparency. Only the morphological production measure at pretest was used for this analysis because each item had only one correct answer and because this analysis was meant to examine the appearance of inventions regardless of instruction. Results of a one-way, fixed factor ANOVA (i.e., transparent vs. opaque) on number of inventions showed a large, significant effect of transparency,  $F(1,38) = 5.729$ ,  $p = 0.022$ ,  $\omega^2 = 0.11$ . As shown in Figure 5, students used more inventions on non-transparent words ( $M = 33.90$ ,  $SD = 33.35$ ) than on fully transparent words ( $M = 13.05$ ,  $SD = 20.08$ ).

### **Discussion**

The pattern of results presented here suggests that multiple factors influence the likelihood that morphological inventions appear in writing tasks. In the less constrained writing

task, sentence combining, where students were invited, but not required, to make derivational changes to words, there was no significant difference between treatment and control groups in regards to number of inventions in transfer words. However, among taught words that the treatment group had been instructed in over the course of the intervention, fifth grade students in the treatment group (but not fourth) were less likely to invent words in the posttest compared to their peers in control. Because the treatment group used more correct derivations overall in the posttest, we might assume that this difference comes from the instructed group getting more correct answers, and that fifth grade students perhaps benefitted more from the intervention in this respect.

On morphological production, a more constrained task where students were required to derive words, there were noticeably more inventions present. As with the sentence combining task, following instruction, students in the treatment group used fewer inventions on taught words than control students did, and fifth graders in both groups invented less than the younger students. Again, because these were instructed words, we can assume the group differences arise from the treatment group using more correct word forms. Where this pattern flips, however, is in the task's transfer words. These were words not instructed during the intervention, and therefore provide a glimpse of how instruction transfers beyond the lessons. When encountering novel (i.e., non-instructed) words, students in the treatment group were more likely to invent words compared to their peers in control, regardless of grade. Additionally, students in the treatment group were also writing more correct derivational forms for both taught and transfer words than the control group, so we can infer that students who received instruction in morphology were more likely to attempt a word derivation, even for words that they were not instructed in, and

these derivations resulted in either correct word forms or invented forms that conformed to syntactic structure.

Although we cannot directly compare invention use across task type due to the different words used in each task, and the different number of opportunities to invent, we do see clues to how the type of task may influence a child's semantic decisions. In the sentence combining task, there were fewer inventions overall, though there was an increase in correct derivations. Students who knew correct derivational forms appeared to apply them to their writing, but did not necessarily force themselves to use words in new syntactic forms when they were not sure of the correct form. The likely reason for this is that students who did not know the correct derivation could circumvent unfamiliar words by playing with syntax. In one question from sentence combining, for example, students were asked to combine the following three sentences into one cohesive sentence: *The bird was saved by a boy. The boy had lots of courage. The bird felt terror.* While an optimal way to combine these sentences would be to transform words so they fit different syntactic roles (e.g., "The *courageous* boy saved the *terrified* bird"), many students avoided making these changes in favor of creating longer sentences without derived word forms, such as "The bird felt terror but then it was saved by a boy with courage". This response fits the requirements of the problem without making any derivational changes. Students who did not know the correct form of the word may have resorted to this type of sentence to avoid making a mistake, thus leading to fewer inventions overall.

In the more constrained task, however, students had pressure to create altered word forms, and this likely led to more inventions. In morphological production, students were required to provide a word, and they could not use circumlocution as in sentence combining, so overall there were more inventions present in this task. Interestingly, although the number of

inventions used by the treatment group on taught words went down from pretest to posttest (undoubtedly because they produced more correct derivations), the treatment group was more likely to use inventions on the transfer words than their peers. What this implies, then, is that when required to make a morphological change, students instructed in morphology may have increased morphological knowledge that enables them to make attempts using known affixes, leading to more invented words. For example, when asked to change the word *suspect* to fit the sentence “*The open door seemed \_\_\_\_\_*”, students in the treatment group were more likely to either write in the correct word form *suspicious*, or invent a word using an affix that fits the part of speech. Examples of student inventions were *suspectful*, *suspectable*, and *suspective*. While none of these responses correctly derive the word, *-ful*, *-able*, and *-tive* are all suffixes that denote adjectives, and so fit into the sentence. Students in the control group, on the other hand, were more likely to write errors, such as *suspected* or *suspushisly*. It seems, therefore, that students who participated in morphologically based instruction had a greater knowledge base for morphological forms and their syntactic role, and thus they could apply this knowledge in writing tasks.

Another factor that may influence the presence of invented words is the transparency of the word students are asked to build. When words were coded for transparency (whether the target word maintains the same written form and sound units as the given word), we observed that students were more likely to create an invented word when the target word was phonologically or morphologically opaque, meaning that the pronunciation or spelling of the root word changes when derived. It is possible that this shift inhibits the recognition or generation of the derived word form, so students may invent transparent forms (e.g., writing *produceful* instead of *productive*). This analysis of transparency was just a preliminary look at word form and does

not evaluate whether treatment interacts with these word types; further research in this area may be enlightening.

### **Implications**

The results of this study show that the creation of morphological inventions may be a discrete step in developing morphological knowledge, where students are able to apply burgeoning understanding of morphological units to shape and construct novel word forms to fit the needed context. Invented words, therefore, are a sign that students are beginning to internalize morphological rules, and they appear more frequently with students receiving instruction in these rules. Teachers instructing morphology should be aware of the contexts in which inventions occur and expect them in writing assignments as a marker of developing productive morphological knowledge.

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Table 1. Participant Characteristics

	Treatment <i>n</i> = 233	Control <i>n</i> = 266
	<i>N</i> (%)	<i>N</i> (%)
4th grade N(%)	123 (53%)	122 (46%)
Male N(%)	114 (49%)	131 (49%)
SPED (%)	29 (12%)	24 (9%)
ELL (%)	3 (1%)	4 (1%)

*Note* : SPED and ELL are reported by official school designation

Table 2.  
*Descriptive Statistics for Pretest Measures*

Measure	Treatment <i>n</i> = 233		Control <i>n</i> = 266	
	<i>M</i>	( <i>SD</i> )	<i>M</i>	( <i>SD</i> )
<i>Passage Comprehension</i>				
Grade 4	103.00	(9.61)	103.14	(9.43)
Grade 5	100.61	(9.57)	102.40	(11.22)
Total	101.88	(9.65)	102.74	(10.43)
<i>Sentence Combining</i>				
Grade 4	24.31	(12.57)	24.70	(12.98)
Grade 5	26.71	(12.60)	29.89	(13.96)
Total	25.43	(12.61)	27.51	(13.74)
<i>Morphological Production</i>				
Grade 4	21.52	(7.85)	21.72	(7.47)
Grade 5	24.99	(7.21)	25.67	(8.40)
Total	23.14	(7.74)	23.86	(8.21)

*Note:* *N* = 499 students from 22 classrooms and 11 schools (*n* = 123 and 110 grade 4 and 5 students in treatment and *n* = 122 and 144 grade 4 and 5 students in control). Passage Comprehension from the Woodcock Johnson III Tests of Achievement (WJ-3) uses standard scores (*M* = 100). Sentence Combining and Morphological Production are listed as raw scores (out of 48 and 40 points, respectively).

Table 3

*Analysis of Variance Results for Pretest-Posttest Change in Word Inventions by Task*

Measures	Group			Grade			Pretest			Grp*Grd			Grp*Pre			Grd*Pre			Grp*Grd*Pre			
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	
<i>Sent Comb</i>																						
Total	0.36	0.550	.00	0.13	0.716	.00	174.24	<0.001***	.26	1.59	0.209	.00	3.29	0.070	.01	0.78	0.379	.00	1.18	0.277	.00	
Taught	2.94	0.087	.01	0.13	0.722	.00	338.90	<0.001***	.41	6.77	0.010*	.01	4.30	0.039*	.01	0.61	0.436	.00	4.33	0.038*	.01	
Transfer	0.26	0.608	.00	0.19	0.661	.00	90.14	<0.001***	.16	0.00	0.958	.00	0.43	0.514	.00	0.02	0.877	.00	1.84	0.175	.00	
<i>Morph Prod</i>																						
Total	2.60	0.107	.01	7.83	0.005**	.02	309.82	<0.001***	.40	0.74	0.389	.00	3.59	0.059	.01	2.17	0.141	.00	0.26	0.611	.00	
Taught	25.89	<0.001***	.05	5.71	0.017*	.01	332.75	<0.001***	.40	0.26	0.612	.00	5.14	0.024*	.01	0.81	0.368	.00	0.27	0.607	.00	
Transfer	9.59	0.002**	.02	3.42	0.065	.01	257.80	<0.001***	.34	0.54	0.461	.00	3.29	0.070	.01	0.09	0.760	.00	0.82	0.365	.00	

*Note.*  $N=499$  students from 22 classrooms and 11 schools ( $n = 123$  and 110 grade 4 and 5 students in treatment and  $n = 122$  and 144 grade 4 and 5 students in control). All *F*-tests based on  $df = 1, 491$ .

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Table 4.  
*Descriptive Statistics for Word Inventions by Task*

Measure	Treatment <i>n</i> = 235		Control <i>n</i> = 271	
	<i>M</i>	( <i>SD</i> )	<i>M</i>	( <i>SD</i> )
<i>Sentence Combining</i>				
Total Words				
Grade 4	0.23	(1.03)	0.20	(1.01)
Grade 5	0.22	(0.96)	0.23	(0.96)
Combined	0.22	(0.99)	0.22	(0.98)
Taught Words				
Grade 4	-0.02	(0.70)	-0.01	(0.68)
Grade 5	0.01	(0.60)	0.08	(0.60)
Combined	0.00	(0.65)	0.04	(0.64)
Transfer Words				
Grade 4	0.25	(0.67)	0.21	(0.74)
Grade 5	0.21	(0.64)	0.15	(0.74)
Combined	0.23	(0.66)	0.18	(0.74)
<i>Morph Production</i>				
Total Words				
Grade 4	0.26	(2.30)	0.37	(2.09)
Grade 5	-0.22	(1.76)	0.27	(1.82)
Combined	0.03	(2.08)	0.32	(1.94)
Taught Words				
Grade 4	-0.19	(1.59)	0.24	(1.47)
Grade 5	-0.58	(1.29)	0.15	(1.30)
Combined	-0.37	(1.47)	0.19	(1.38)
Transfer Words				
Grade 4	0.44	(1.37)	0.13	(1.13)
Grade 5	0.36	(1.24)	0.12	(1.02)
Combined	0.40	(1.31)	0.12	(1.06)

*Note.* *N*=499 students from 22 classrooms and 11 schools (*n* = 123 and 110 grade 4 and 5 students in treatment and *n* = 122 and 144 grade 4 and 5 students in control).

Table 5  
*Descriptive Statistics for Word Derivations by Task*

Measure	Treatment <i>n</i> = 235		Control <i>n</i> = 271	
	<i>M</i>	( <i>SD</i> )	<i>M</i>	( <i>SD</i> )
<i>Sentence Combining</i>				
Total Words				
Grade 4	5.00	(3.46)	2.30	(2.86)
Grade 5	5.11	(3.35)	2.56	(2.73)
Combined	5.05	(3.41)	2.44	(2.79)
Taught Words				
Grade 4	2.41	(1.90)	0.98	(1.56)
Grade 5	2.55	(1.97)	1.22	(1.65)
Combined	2.48	(1.93)	1.11	(1.61)
Transfer Words				
Grade 4	2.59	(2.14)	1.32	(1.97)
Grade 5	2.56	(2.05)	1.35	(1.82)
Combined	2.58	(2.10)	1.33	(1.89)
<i>Morph Production</i>				
Total Words				
Grade 4	9.54	(5.07)	4.18	(5.23)
Grade 5	7.80	(5.05)	2.71	(4.04)
Combined	8.73	(5.12)	3.38	(4.67)
Taught Words				
Grade 4	6.28	(3.22)	2.33	(2.97)
Grade 5	5.14	(3.19)	1.43	(2.56)
Combined	5.75	(3.25)	1.84	(2.79)
Transfer Words				
Grade 4	3.27	(2.73)	1.85	(3.01)
Grade 5	2.66	(2.74)	1.28	(2.44)
Combined	2.98	(2.74)	1.54	(2.73)

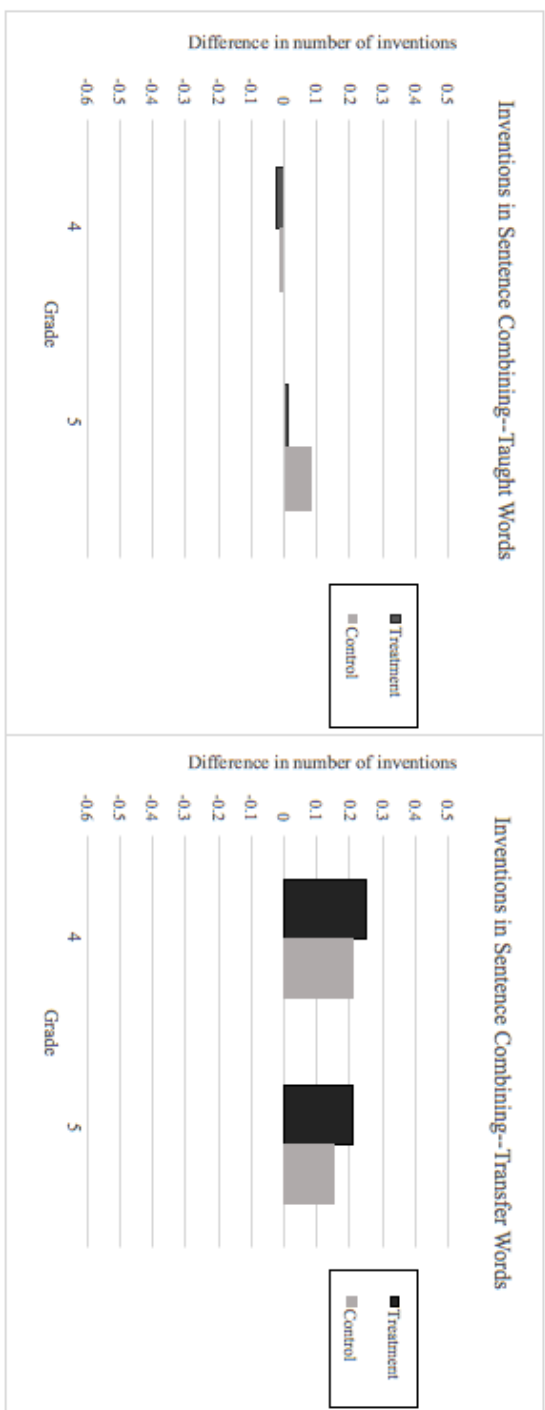
*Note.* *N*=499 students from 22 classrooms and 11 schools (*n* = 123 and 110 grade 4 and 5 students in treatment and *n* = 122 and 144 grade 4 and 5 students in control). Inventions are listed as raw scores for each task with a possibility of 24 and 40 inventions, respectively.

Table 6  
*Analysis of Variance Results for Pretest-Posttest Change in Correct Derivations by Task*

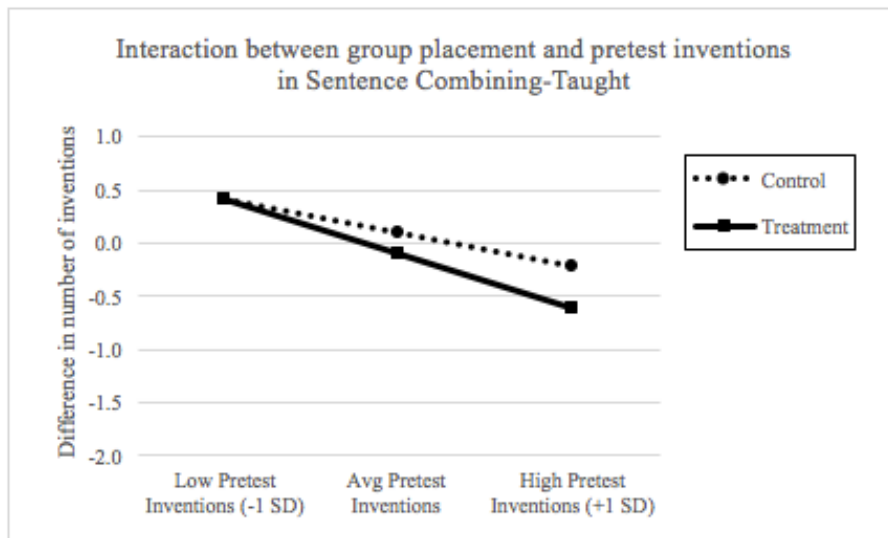
Measures	Group			Grade			Pretest			Grp*Grd			Grp*Pre			Grd*Pre			Grp*Grd*Pre			
	F	p	$\eta^2$	F	p	$\eta^2$	F	p	$\eta^2$	F	p	$\eta^2$	F	p	$\eta^2$	F	p	$\eta^2$	F	p	$\eta^2$	
<i>Sent Comb</i>																						
Total	84.78	<0.001***	.15	1.65	0.200	.00	21.76	<0.001***	.04	0.28	0.599	.00	0.27	0.602	.00	0.08	0.783	.00	0.01	0.919	.00	
Taught	76.81	<0.001***	.14	4.22	0.040*	.01	47.34	<0.001***	.09	0.63	0.429	.00	0.19	0.666	.00	0.89	0.345	.00	0.21	0.644	.00	
Transfer	45.66	<0.001***	.09	0.51	0.478	.00	46.60	<0.001***	.09	0.19	0.667	.00	2.73	0.099	.01	0.68	0.410	.00	1.41	0.235	.00	
<i>Morph Prod</i>																						
Total	217.56	<0.001***	.31	0.67	0.415	.00	263.26	<0.001***	.35	0.57	0.450	.00	33.92	<0.001***	.07	1.06	0.303	.00	6.65	0.010*	.01	
Taught	331.87	<0.001***	.40	0.39	0.534	.00	338.81	<0.001***	.41	0.74	0.391	.00	47.57	<0.001***	.09	0.01	0.933	.00	6.33	0.012*	.01	
Transfer	45.12	<0.001***	.08	0.00	0.957	.00	186.28	<0.001***	.28	0.16	0.691	.00	11.32	0.001**	.02	2.01	0.157	.00	3.50	0.062	.01	

Note. N=499 students from 22 classrooms and 11 schools ( $n = 123$  and 110 grade 4 and 5 students in treatment and  $n = 122$  and 144 grade 4 and 5 students in control). All  $F$ -tests based on  $df = 1, 491$ .

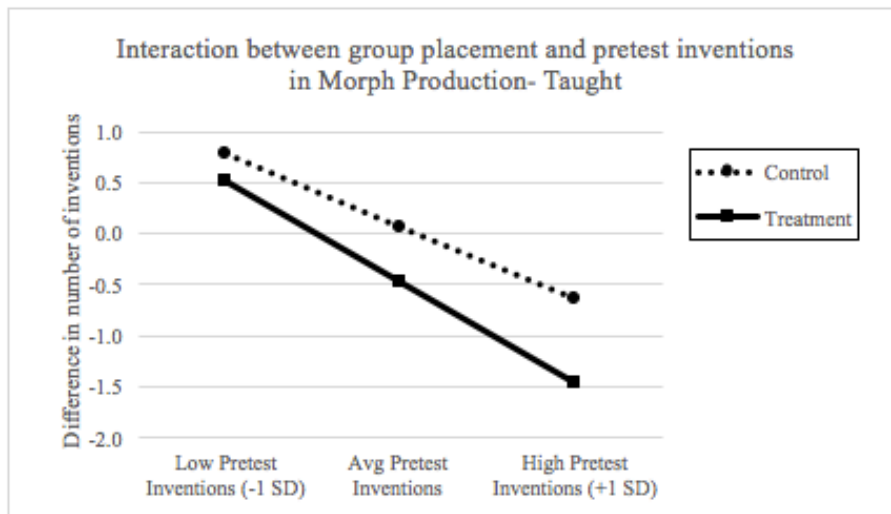
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .



*Figure 1.* Visualization of differences of inventions in the two word types of the sentence combining measure. N = 499 students from 22 classrooms and 11 schools (n = 123 and 110 grade 4 and 5 students in treatment and n = 122 and 144 grade 4 and 5 students in control). This figure uses difference scores, where positive scores show more inventions on posttest than pretest, with a possibility of 16 inventions total. In the taught words task, there was a significant group x grade interaction ( $p = 0.01$ ); in transfer words, there were no significant group or grade effects ( $p > 0.05$ ).



*Figure 2.* The interaction between group and pretest number of inventions for the taught items on sentence combining.  $N = 499$  students from 22 classrooms and 11 schools ( $n = 123$  and 110 grade 4 and 5 students in treatment and  $n = 122$  and 144 grade 4 and 5 students in control). This figure uses difference scores, where positive scores show more inventions on posttest than pretest, with a possibility of 16 inventions total.



*Figure 3.* The interaction between group and pretest number of inventions for the taught items on morphological production.  $N = 499$  students from 22 classrooms and 11 schools ( $n = 123$  and 110 grade 4 and 5 students in treatment and  $n = 122$  and 144 grade 4 and 5 students in control). This figure uses difference scores, where positive scores show more inventions on posttest than pretest, with a possibility of 40 inventions total.

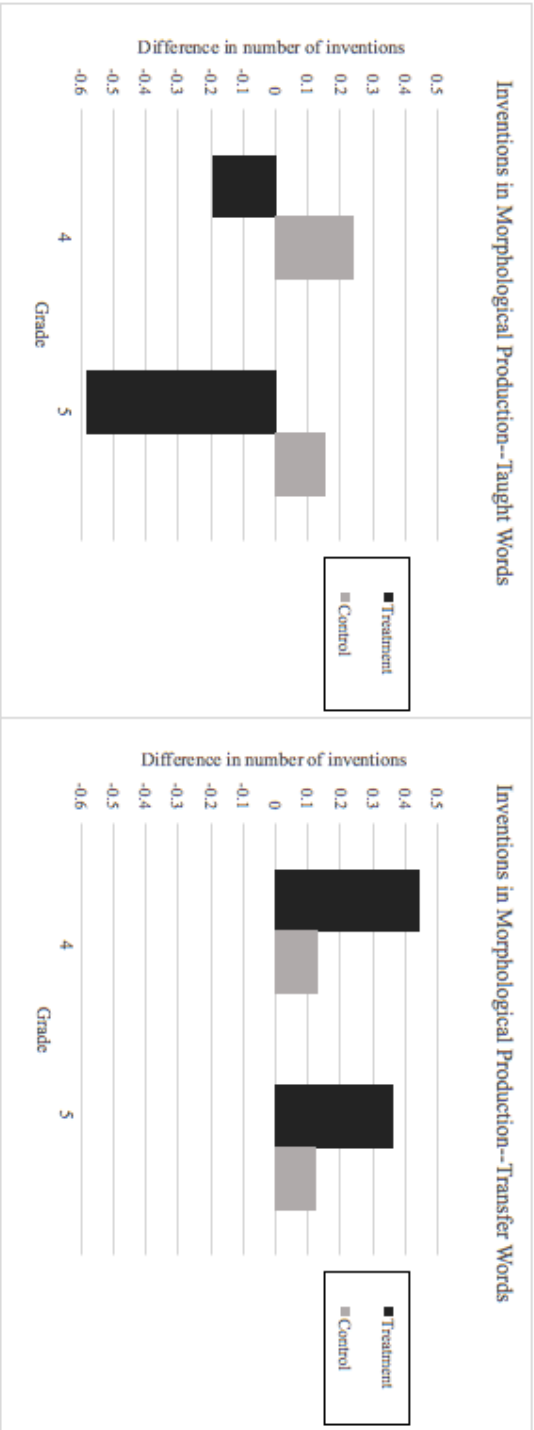
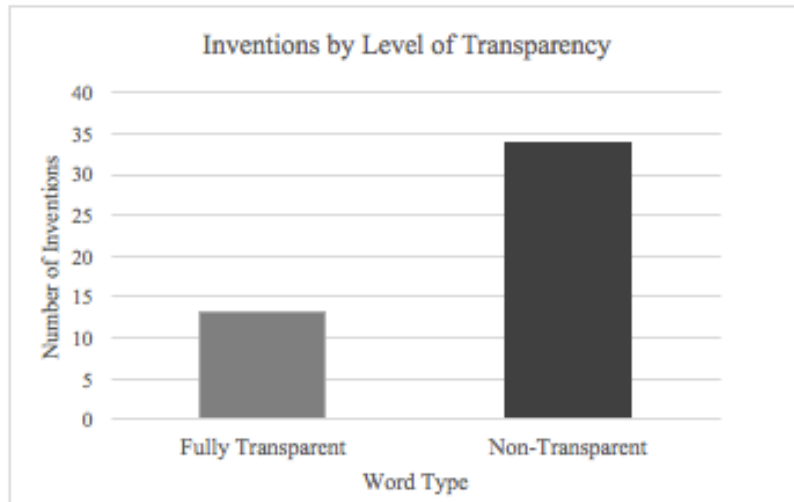


Figure 4. Visualization of differences of inventions in the two word types of the morphological production measure. N = 499 students from 22 classrooms and 11 schools (n = 123 and 110 grade 4 and 5 students in treatment and n = 122 and 144 grade 4 and 5 students in control). This figure uses difference scores, where positive scores show more inventions on posttest than pretest, with a possibility of 40 inventions total. In the taught words items, there were significant main effects of group and grade ( $p < 0.05$ ); in transfer words, there was a significant group effect ( $p < 0.01$ ).



*Figure 5.* The number of inventions per word based on transparency.  $N = 499$  students from 22 classrooms and 11 schools ( $n = 123$  and 110 grade 4 and 5 students in treatment and  $n = 122$  and 144 grade 4 and 5 students in control). This figure represents all inventions used in the pretest of morphological production (939 inventions). There was a significant effect of word type ( $p < 0.05$ ).