Derivational Suffix Knowledge: What do Students Know and How to Best Support Their Learning

by

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Abstract

Despite the considerable attention given to morphology instruction in recent years, there remains an essential need to understand how and when it should be taught, as well as whether it is better suited for students with specific characteristics. Thus, the objective of this dissertation was twofold: first, to assess students' knowledge of the form and meaning of highly frequent derivational suffixes across different grade levels, and second, to examine whether explicit instruction in novel derivational suffixes has additional benefits over implicit instruction across two grade levels (Grades 3 and 5) and two languages (English and Spanish). To meet these objectives, I conducted three studies.

The first study examined the knowledge in form and meaning of highly frequent derivational suffixes in a group of Grade 3, Grade 5, and Grade 8 English-speaking Canadian students. We assessed 309 children on word reading and receptive vocabulary tests and two experimenter-designed tasks to assess the form (orthographic knowledge) and meaning (semantic knowledge) of 28 derivational suffixes (14 adjectives and 14 nominals). Overall, our findings showed a significant improvement in identifying and understanding derivational suffixes from Grade 3 to Grade 5 and a smaller, but still significant, improvement from Grade 5 to Grade 8. Our findings regarding suffix type were mixed. Although written forms of adjectives were identified more accurately than nominals across all grade levels, this advantage did not extend to the students' semantic knowledge of the suffixes. The variations in knowledge between adjectives and nominals correspond to the increasing occurrence of each suffix type in the readings of older children. These results highlight the importance of exposing students to multiple examples of suffixes in words, as this exposure appears to be crucial for consolidating suffix knowledge. Furthermore, the results highlight the distinction between recognizing suffixes and comprehending their meaning.

The second study compared the effects of implicit and explicit instruction on the learning of novel derivational suffixes across two grade levels (Grades 3 and 5). For three days, 83 Grade 3 and 86 Grade 5 English-speaking Canadian students were trained on target words containing experimenter-designed suffixes (i.e., pseudo-suffixes) consistent in form and meaning (e.g., the pseudo-suffix -nim in words such as “hillnim”: a small hill or “desknim”: a small desk). Implicit and explicit instruction differed in the attention paid to the co-occurrence of the suffixes in the target words. Participants were tested on the novel suffixes form and meaning at two different time points: immediately after training (i.e., immediate post-test) and one week later (i.e., delayed post-test). This testing included a suffix identification task (SIT-N) to assess for suffix form, and a word definition and multiple-choice tasks that assessed the meaning of both trained and transfer words (i.e., words not included in the training but whose meaning could be inferred if knowing the meaning of the trained suffixes). Results of mixed-effects models showed that participants at both grade levels scored similarly on the SIT-N across the two training conditions. Regarding meaning the results were mixed. For Grade 3, the added benefits of explicit instruction over implicit were evident in the two meaning tasks. For transfer words, this benefit was particularly evident during the delayed post-test where results showed that when receiving explicit instruction the knowledge was sustained. Nevertheless, the scores from those receiving implicit instruction significantly declined after a week of training. For Grade 5 the differences across conditions were only detected in the word definition task. Although no significant differences in scores emerged from the word type comparison (trained vs. transferred), the results showed that explicit instruction consistently led to higher scores for both types of words. The findings suggest that although younger readers benefit more from explicit instruction in morphological analysis, more advanced readers with presumably more reading experience, continue to benefit from

explicit teaching, particularly when it comes to acquiring a deeper understanding of the suffixes.

The third study compared the effects of implicit and explicit morphological analysis instruction in Spanish, a language characterized by high morphological complexity and relatively consistent letter-sound correspondences. Following the same methodology as in Study 2, 94 Grade 3 Spanish-speaking Mexican students underwent training for three days. Participants received either explicit or implicit training on target words containing experimenter-designed suffixes consistent in form and meaning (e.g., the suffix -isba refers to a factory, in words such as "bot<u>isba</u>": a boot factory, "caj<u>isba</u>": a box factory). Immediately after training concluded and a week after, participants were tested on the form and meaning of the novel suffixes in both trained and transfer words. Results of mixed-effects models showed that explicit instruction led to better outcomes in learning the form of the suffixes. Regarding meaning, across-condition differences were only detected in the word definition task; explicit instruction produced better results for both trained and transfer words. The findings suggest that in Spanish, explicit instruction continues to offer additional benefits for teaching the form and meaning of novel suffixes compared to when using an implicit approach.

Overall, this dissertation offers valuable insight into the current practices in morphology instruction, contributing to a growing body of intervention research that aims to provide guidance on the most effective strategies to enhance word reading, expand vocabulary, and improve reading comprehension through the lens of morphology. Furthermore, we provided evidence of the significant benefits of explicit morphology instruction in Spanish. This is particularly important given the limited body of studies examining the effects of morphology instruction in alphabetic languages other than English.

Preface

This thesis is an original work by Dalia Martinez under the supervision of Dr. George Georgiou at the University of Alberta. Research project 1 received ethics approval from the University of Alberta Research Ethics Board, Project Name "Morphological knowledge across grade levels", No. Pro00119949, approved April 29, 2022. Research project 2 received ethics approval from the University of Alberta Research Ethics Board, Project Name "Examining the effects of explicit versus implicit training on learning written morphemes", No. Pro00119324, approved April 13, 2022, supported by the Support for Advancement of Scholarship (SAS) given by the Scholarships and Research Awards Committee of the University of Alberta. Research project 3 received ethics approval from the University of Alberta Research Ethics Board, Project Name "Do children in an orthographically consistent language benefit from explicit morphological instruction", No. Pro00130051, approved June 6, 2023. Chapter 2 of this thesis has been accepted for publication in the Applied Psycholinguistics journal as Martinez, D., Colenbrander, D., Inoue, T., & Georgiou, G. (2024). How well do schoolchildren and adolescents know the form and meaning of different derivational suffixes? Evidence from a cross-sectional study. Chapters 3 and 4 have been submitted for publication to Scientific Studies of Reading and Journal of Experimental Child Psychology, respectively. Dalia Martinez was responsible for developing the novel tasks in Study 1, and the intervention conditions and tasks for Studies 2 and 3, coordinating and training interventionists, data collection, management, and interpretation, and writing the dissertation. Dr. George Georgiou was the dissertation supervisor and assisted with the concept formation, data interpretation, revision, and editing. Dr. Danielle Colenbrander assisted with the concept formation, task and training design, data interpretation, revision, and editing. Dr. Inoue Tomohiro assisted with data analysis and interpretation, and with the

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Chapter 1: General Introduction

As students progress through school, the vocabulary they encounter in their readings becomes more complex. An example of this complexity is the increasing number of morphemes within words. Words with multiple morphemes are known as morphologically complex, and among these, derived words (formed by adding a derivational morpheme to a base word, e.g., play + ful = "playful") are of particular interest. Nippold (2018) reported a significant number of derived words in children's textbooks across various subjects such as science, mathematics, and language arts. In addition, a recent analysis of the children's Language Arts textbooks in the U.S. revealed that by Grade 3 the occurrence of derived words in texts was twice as that of Grade 1 (Kearns & Hiebert, 2022).

Despite the increasing number of derived words in print across grade levels and the documented importance of morphological knowledge in text comprehension (e.g., Deacon & Kirby, 2004; Kirby et al., 2009; Nagy et al., 2006), only a few studies have explored students' knowledge, ability to use, and the learning process of derivational morphemes. Thus, the overall goal of this dissertation was 1) to assess derivational suffix knowledge in form and meaning across grade levels and suffix type, and 2) to examine the potential added benefits of explicit over implicit morphological analysis instruction in two grade levels and two languages. The first chapter of this dissertation provides an overview of the development of morphology in the oral and written modalities, the different approaches to morphology instruction, and discusses their respective limitations. In Chapter 2, I present the results of Study 1, in which we assessed the knowledge in form and meaning of highly frequent adjectival and nominal derivational suffixes in Grade 3, Grade 5, and Grade 8 English-speaking students. In Chapter 3, I present the results of Study 2 in which we compared the effectiveness of implicit and explicit instruction in morphological analysis in intermediate (Grade 3) and advanced (Grade 5) readers of English. In Chapter 4 (Study 3), I present the results of a study that examined the effectiveness of explicit and implicit morphology instruction in Spanish, a language characterized by high morphological complexity and high grapheme-phoneme consistency. The final chapter (Chapter 5) provides a general discussion of the key findings and their potential implications.

Development of Morphological Knowledge

A morpheme is the smallest unit of language that carries meaning. Base morphemes, also referred to as free or stand-alone, carry the main meaning of a word (e.g., "build"). On the contrary, bound morphemes cannot stand alone and must be attached or affixed, hence their designation as affixes, to the front of base morphemes (i.e., prefixes, e.g., re- in "rebuild") or to the end (i.e., suffixes, e.g., -er in "builder"). Morphologically complex words (i.e., words containing more than one morpheme) can be compounds when made from combining two stand-alone morphemes (e.g., "bookshelf"; "bookworm"); inflected when combining a base with an inflectional suffix that causes grammatical changes in number or tense (e.g., books, booking); and derived, which contain derivational prefixes and/or suffixes that can change the word's grammatical category or modify its meaning (e.g., "rebook", "bookish"). The ability to reflect on and manipulate the morphemic structure of words has been referred to as morphological awareness (Carlisle, 1995). However, accessing this information might not always be done at the conscious level (Deacon et al., 2008) and the term morphological knowledge has been used to refer to the initial stages of acquisition where knowledge seems to be rather implicit (Kirby et al., 2018). Nevertheless, researchers have not always been consistent in distinguishing between implicit and explicit knowledge, using the term interchangeably. For this dissertation, and since it was not always clear whether participants in the studies were conscious of their knowledge, I will use the term morphological knowledge.

Research suggests that the acquisition of oral morphology follows a developmental progression, with compound words being understood and used at an early age (see Clark, 1993, for evidence of compounding in free speech at the age of 18 months), the majority of inflections being mastered by Grade 1 (Berko, 1958; see also Maynard et al., 2018, for a recent compilation of studies on inflectional morphology), and the learning of derivations continues to present difficulty, even in upper grades (e.g., Ford et al., 2010; Gaustad et al., 2002; Nippold & Sun, 2008; Nunes & Bryant, 2006). The acquisition of derivational morphology seems to be a protracted process (e.g., Dawson et al., 2021; Gaustad et al., 2002; Nippold & Sun, 2008). For example, when assessing Grade 1 students, Duncan et al. (2009) reported an accuracy rate of only 20% of the items included in a sentence completion task that required children to produce derived forms. By Grade 5, Nunes and Bryant (2006), reported accuracy rates on a derivation analogy task of 40% suggesting a growth in derivational morphology knowledge with considerable room for improvement. Further studies have also reported a significant increase in derived word knowledge by grade level, with scores still not reaching ceiling levels, even among middle school and college students (Gaustad et al., 2002; Nippold & Sun, 2008).

The principles of semantic transparency and simplicity of form determine the ease with which morphological knowledge is acquired (Clark, 1993). The semantic transparency principle states that morphemes with less variation are easier to understand and thus, are acquired earlier (e.g., seven-seventh in contrast to five-fifth). The simplicity of form principle holds that highly frequent suffixes are acquired earlier as they are fundamental for communication. These two principles might explain why inflections are acquired earlier than derivations (Fejzo et al., 2018; Torkildsen et al., 2022) and why the morphological complexity of a language appears to influence the rate at which morphological knowledge can be acquired (see Duncan, 2018). For example, Duncan et al. (2009) found that Grade 3 French-speaking children performed significantly better than their English-speaking counterparts (80% accuracy rate in French compared to 39% accuracy rate in English) in a derived word production task. Differences in performance have been attributed to language characteristics in terms of affix frequency. Indeed, in French, 80% of the words are derived (Rey-Debove, 1984), in contrast to English for which compounds are more common (Bauer, 2019). Moreover, in a comparison between English and Chinese, where Chinese exhibits a higher frequency of compounding compared to English, the acquisition of compounds was found to be accelerated in Chinese relative to English (Ku & Anderson, 2003; Zhang et al., 2012).

Although morphological development in free speech has been well documented (see Maynard et al., 2018, for a review), its development in the written modality has been less explored. The development of written morphological skills has additional challenges. As pointed out by Nippold and Sun (2008), certain cognitive prerequisites need to be in place to support successful written morphological acquisition. These prerequisites include knowledge of word structure, metalinguistic competence, and reading fluency. Research has shown that morphological skills that are mastered orally can still produce errors when presented in writing. For example, the use of <-ed> to signal past tense undergoes a developmental shift from a writing based on phonological cues (pikt rather than picked) to an overgeneralization (i.e., the use of <-ed> for irregular verbs) to its final correct use (Nunes & Bryant, 2006; see also Apel et al., 2013, for differences in performance when using oral and written measures of morphological knowledge).

The presence of spelling errors in writing morphologically complex words indicates a strong dependence of written morphological skills on orthographic representation (Egan & Pring, 2004). Indeed, morphemes in writing can be seen as orthographic units that are generalizable across words (Deacon et al., 2008). Furthermore, as morphemes are units of meaning, the semantic information they convey is also recurrent in the words they create (e.g., adding the suffix -ness changes adjectives into nouns, happy-happiness, lonely-loneliness). Thus, to process morphologically complex written words, a reader must have the skills needed to spot co-occurring orthographic and semantic representations among words.

To what extent can students spot these co-occurrences? Can they be learned implicitly? The amount of evidence on students' uninstructed suffix knowledge is scarce (Gaustad et al., 2002; Mitchell & Brady, 2014; Nippold & Sun, 2008). For example, Gaustad et al. (2002) tested middle school (ages 11 to 12 years old) and college (ages 19 to 34 years old) students on their semantic knowledge of bound morphemes using a multiple-choice task (e.g., what is the meaning of re- as in "rewrite": a) important, **b) again**, c) moving, d) after). College students scored an average of 94% correct, and middle school students scored an average of 79% correct, indicating that knowledge of derived words is still developing in middle school. In another study, Nippold and Sun (2008) tested knowledge of morphologically complex words in 10-year-old children and 13-year-old adolescents and divided items into adjectives (e.g., "acceptable", "blissful") and nominals (e.g., "citizenship", "hostility"). According to the authors, expecting differences in suffix type is justified by the syntactic cues provided to adjectives in contrast to nominals. Adjectives consistently occur before nouns, while nouns can be surrounded by a broader range of word types, making their identification, and understanding more challenging. Their results showed higher knowledge of adjectives (76.9% correct for children and 89.7% correct for adolescents) compared to nominals (63.2% correct for children and 79.4% correct for adolescents), which suggests that learning words that contain adjectival suffixes might be less challenging compared to those with nominal suffixes.

Importantly, the studies conducted by Gaustad et al. (2002) and Nippold and Sun (2008) used tasks with derived words as part of their task items. Therefore, their results must be viewed with some caution, as they do not distinguish suffix knowledge from lexical vocabulary knowledge. In this regard, Mitchell and Brady (2014) compared the knowledge of real words (e.g., interoffice) and nonwords (e.g., interlanosts) sharing the same affix in Grade 3 and Grade 5 students. While their results did not show a significant difference in overall performance between words and nonwords, patterns of knowledge were different across the two measures at the item level (e.g., some students knew the meaning of the word "closure" but could not define nonwords that included the suffix -ure). These results suggest that knowledge of a derived word does not always equate to knowledge of the suffix within the word. Moreover, the results showed that not all suffixes are mastered equally, a question also raised by Nippold and Sun (2008). Whether the developmental trajectories of derivational suffixes differ by suffix type is still an open question.

Morphological Knowledge and Reading

There is consensus that morphological knowledge is important for reading and writing (e.g., Liu et al., 2024; Mann & Singson, 2003; Morris, 2019; Ruan et al., 2018). Indeed, several studies have shown that a unique contribution to reading, beyond the effects of other key predictors of reading such as phonological awareness (e.g., Carlisle, 1987; Nagy et al., 2003), rapid automatized naming (e.g., Apel et al., 2012; Layes et al., 2017; Metsala, 2023), and orthographic knowledge (e.g., Foorman et al., 2012; Kalindi & Chung, 2018). For example, in a study with Grade 3, 6, 9, and 12 children, Abu-Rabia et al. (2003) found that morphological skills (morpheme identification and morpheme production) in Arabic were the best predictors of reading accuracy and comprehension across all grades. Similar results have been reported in non-alphabetic languages such as Chinese (e.g., Shu et al., 2006; Tong et al., 2009) and Japanese (e.g., Muroya et al., 2017). Furthermore, there is evidence indicating clear differences between individuals with dyslexia and chronological-age controls on measures of morphological knowledge (see Abu-Rabia, 2007; Casalis et al., 2004; Deacon et al., 2006). A recent meta-analysis examining the size of deficits in morphological knowledge in individuals with dyslexia (Georgiou et al., 2023) yielded a large effect size (d= -1.13, individuals with dyslexia performing below chronological-age controls). Finally, intervention studies on morphology have produced significant effects on different reading outcomes of typically developed children (see Bowers et al., 2010; Goodwin & Ahn, 2013; Reed, 2008, for meta-analyses) and children with learning difficulties (Bowers et al., 2010; Goodwin & Ahn, 2010). Interestingly, the effects appear to be comparable to those of intervention studies focusing on phonemic awareness (see e.g., Erbeli, 2024; Rehfeld et al., 2022, for meta-analyses).

Although the body of empirical studies that highlight the impact of morphological knowledge on literacy outcomes is noteworthy, the role of morphology in theories of reading acquisition is somewhat implicit. This is perhaps due to a greater emphasis put on the initial reading stages, which focus on the decoding of monomorphemic words (see Rastle, 2019, for a full discussion). For example, the dual-route model (see Coltheart et al., 2001) suggests that more advanced readers shift from a sound-base code (phonologically based) to a spelling-to-meaning route (also known as the lexical route) where whole words can be accessed. Nevertheless, the role of morphology in the consolidation of this route is not explained. Other examples are the lexical quality hypothesis (Perfetti et al., 2002) and the distributed connectionist models (see Seidenberg, 2005) which suggest that skilled reading systems have built strong semantic, orthographic, and phonological representations of the words to support reading comprehension without explicitly mentioning the role of morphology. According to Kirby and Bowers (2017), the role of morphology is somehow present in these conceptualizations as a binding agent that facilitates spelling-to-meaning integration. On a similar explanation, morphology is seen as the hidden layer that appears when the overlapping of different types of information occurs (Plaut & Gonnermann, 2000), yet the specific role of morphology has not been fully integrated.

The prominent phase theory of reading development (Ehri, 1995, 2014) in its consolidated alphabetic phase explicitly addresses the use of morphemes to support accurate, efficient reading as readers progress in their development. Nevertheless, this theory presents morphemes largely as orthographic units and the different contributions of morphology to the different aspects of word reading (e.g., decoding and comprehension) are not clearly distinguished. This limitation has been addressed in recent years by refining our definition of morphological knowledge and deepening our understanding of its impact on different literacy outcomes. In 2014, Apel presented a comprehensive definition of morphological knowledge, encompassing knowledge of both oral and written morphemes, the knowledge of morphemes beyond lexical vocabulary knowledge (e.g., knowing the meaning of prefixes and suffixes), and an understanding of the modifications that affixes can convey into the grammatical class (e.g., going from the adjective “happy” to the noun “happiness”), and the spelling (e.g., happy → happ**i**ness) of base morphemes. Finally, it also addressed knowledge of morphological families (e.g., book: “booking”, “booked” “bookworm”, “bookshelf”, “rebook”) as an important aspect of morphological knowledge.

Embracing a multidimensional definition of morphological knowledge, Levesque et al. (2021) in their Morphological Pathway Framework made a clear distinction between morphological decoding and morphological analysis. Morphological decoding operates at the word form level, aiding in the breakdown of morphologically complex words and improving word reading accuracy and fluency. On the other hand, morphological analysis operates at the word meaning level, addressing the syntactical function of morphemes as well as their definition and usage in understanding and creating new words. Goodwin et al. (2021) have also provided support for the argument that morphological knowledge impacts various literacy outcomes in distinct ways. The authors tested over 1,000 fifth through eighth graders on a range of morphological tasks and their results showed that morphological knowledge is rather multidimensional and consists of four skills: Morphological Awareness, the ability to reflect upon and manipulate morphemes within a word; Morphological Syntactic Knowledge, knowledge of how morphemes can change words' grammatical categories; Morphological-Semantic Knowledge; the ability to use the infer a word's meaning through an analysis of its constituent morphemes (also known as *morphological analysis* or *morphological problem solving*); and Morphological Orthographic/Phonological Knowledge, knowledge of how morphemes influence words' spellings and pronunciations. Additionally, Apel et al. (2022) observed differences in first to sixth-grade students' profiles when assessing different aspects of morphological knowledge, revealing both strengths and weaknesses across the distinct dimensions. All authors (see Apel, 2014; Apel et al., 2022; Goodwin et al., 2021; Levesque et al., 2021) agree that the influence of morphological knowledge on literacy outcomes can differ depending on what dimension is being addressed by the assessment used, emphasizing that proficiency in one dimension does not necessarily indicate strength in another.

Instruction in Morphological Analysis

Interventions in morphology have shown significant positive effects on a variety of literacy outcomes (see Bowers et al., 2010; Goodwin & Ahn, 2010, 2013; Reed, 2008, for meta-analyses). For example, the most recent meta-analysis reported a moderate effect size on morphological knowledge (d = 0.44), phonological awareness (d = 0.48), vocabulary (d = 0.34), decoding (d = 0.59), and spelling (d = 0.30) (see Goodwin & Ahn, 2013).

Aligned with the notion of morphological knowledge being multidimensional, instruction in morphology employs diverse approaches to support its distinct dimensions. Carlisle (2010) analyzed 16 morphology intervention studies and identified four basic instructional approaches aiming to 1) improve awareness of the morphological structure of words, 2) increase knowledge of the meaning of affixes and base words, 3) support morphological problem-solving, and 4) develop hypotheses about the meanings of unfamiliar words. It is not uncommon for programs to use a combination of these approaches. For example, Baumann and colleagues (Baumann et al., 2002; 2003) incorporated elements of each approach by raising students' awareness of the words' constituent morphemes (e.g., the prefix mono- in the word "monorail"), teaching the prefixes meanings (e.g., mono- meaning one), and combining this knowledge to infer the meaning of unfamiliar words (e.g., "monotone": one tone).

Regardless of the instructional approach adopted, instruction can be explicit, where objectives and rules are clearly outlined; or implicit, where learning occurs unintentionally through exposure to multiple examples without any reference to the rules (Burton et al., 2021). Interventions in morphology, particularly following an explicit approach, are of growing interest given their positive effects on morphological knowledge, word reading, and vocabulary (e.g., Carlo et al., 2004; Davidson & O'Connor, 2019; Murphy & Diehm, 2020; Zhang, 2016). For example, Murphy and Diehm (2020) carried out an intervention with children in first to fourth grade with an emphasis on morphological families and explicit teaching on how morphology is interrelated with phonology and etymology in English orthography. Their results showed significant gains in word reading and spelling, with larger gains observed in spelling affixes within morphologically complex words.

Even when not explicitly taught, evidence suggests that children develop morphological knowledge as they gain more language experience. This implicit knowledge can further support reading (see Carlisle, 2000). For example, Carlisle and Stone (2005) showed that children read multimorphemic words (e.g., "hilly") more quickly than matched monomorphemic words (e.g., "silly"). Similar results have been found in other languages such as Spanish (e.g., D'Alessio et al., 2018, Suárez-Coalla & Cuetos, 2013; Suárez-Coalla et al., 2017) and Italian (e.g., Angelelli et al., 2014; Burani et al., 2018; Marcolini et al., 2011). These findings suggest that readers develop morphological knowledge at some point during their reading development even in the absence of explicit instruction. Certainly, intervention studies on morphology show that the effect of instruction weakens as children progress to higher grade levels (see Goodwin & Ahn, 2013). This raises questions about whether explicit instruction is always necessary, as it may not consistently offer additional benefits, particularly for older students.

Only a handful of studies have explored the potential additional benefits of receiving explicit over implicit morphology instruction (Bryant et al., 2006; Burton et al., 2021; Kemper et al., 2012). For example, Bryant et al. (2006) compared implicit versus explicit teaching of the spelling differences between the suffixes -ian and -ion to 9-year-old students. The explicit group was provided with the morphological rule of the person/non-person principle for the use of -ian and -ion. The implicit group was left to discover this rule independently based on the implicit morphological cues of the words (e.g., “magician”, “vegetarian”, vs. “education”, “institution”). The findings revealed that those who received explicit instruction performed better at a spelling task, especially when it came to words requiring knowledge transfer. The benefits of explicit over implicit morphology instruction in English have been reported to persist even up to two weeks after receiving instruction (Burton et al., 2021). However, these studies have solely examined the improvement in spelling in intermediate readers (ages corresponding to Grade 3).

Besides spelling, vocabulary development appears to be significantly impacted by morphology instruction (see Goodwin & Ahn, 2013). An approach taken to support its growth is morphological analysis, defined as the strategic use of the word’s morphological structure to infer the word’s meaning (Anglin, 1993). Morphological analysis provides students with a powerful generative tool to learn numerous words beyond those explicitly taught to them (see Kirby & Bowers, 2018). There is some evidence showing that students develop morphological analysis implicitly. For example, Larsen and Nippold (2007) observed that by Grade 5 some children exhibit the ability to engage in morphological analysis to infer the meaning of unfamiliar words. In their study, the authors used a dynamic assessment with varying scaffolds to test 15 low-frequency derived words (e.g., “dramatize”, “fearsome”). Their results showed a wide range of skill levels from some children readily engaging in morphological analysis to others requiring great amounts of adult scaffolding (e.g., breaking down words into their morphemes “fear” and “some”, examples of words within the same morphological family). Although these results suggest that instruction will most definitely benefit older students (Grade 5), they cannot elucidate whether this instruction necessarily needs to be explicit or if implicit instruction might be enough for these older students with more reading experience. To our knowledge, no previous study has compared implicit and explicit training on morphological analysis in a sample of Grade 5 students.

Finally, language characteristics may affect the effectiveness of explicit instruction in morphology. First, we consider the oral morphological complexity of the languages. Certainly, the morphological characteristics of a language have been shown to influence its speakers' morphological development. For example, the high occurrence and productivity of affixation in French align with the faster acquisition of morphological knowledge among French speakers compared to English speakers (Duncan et al., 2009; see also Ku & Anderson, 2003; Zhang et al., 2012 for cross-linguistic differences on the acquisition of compounds in English and Chinese).

Second, we must consider the orthographic depth of a given language. The letter-to-sound correspondences in the spelling of a language can be seen as a continuum that ranges from high consistency, considered to have shallow orthographies, to low consistency or deep orthographies (Seymour et al., 2003). The different levels of orthographic transparency impact both the size of processing units for young readers and the type of reading instruction they receive (see psycholinguistic grain size theory; Ziegler & Goswami, 2005). Generally, in languages with deep orthographies, individuals strategically look for larger units such as rimes, syllables, or morphemes to deal with the ambiguity in the mappings between individual letters and sounds (Ziegler & Goswami, 2005). English, for example, has been described as a morphophonemic language (Venezky, 1967), indicating that its orthography reflects both phonological and morphological considerations, in which morphology provides readers with "islands of regularity" (Rastle et al., 2000, p. 527) to the spelling and understanding of words. Nevertheless, in languages with a shallow orthography, learning the grapheme-to-phoneme correspondence rules is sufficient in reading almost all words, thus, readers are not forced to use units larger than a single grapheme to read a word. This high orthographic consistency influences educational practices that are mostly guided by methods that follow a letter-by-letter reading strategy (Pérez et al., 2014).

All existing meta-analyses on morphological instruction, except for Bowers et al. (2010), have considered studies with interventions carried out in English. English is characterized by having a deep orthography with a low grapheme-to-phoneme correspondence (Seymour et al., 2003) and is situated at the lower end of the morphological complexity spectrum when compared to languages such as Finnish, Hungarian, German, French, and Spanish (Borleffs et al., 2017). Although Bowers et al. (2010) did include studies on morphological intervention where instruction was given in languages other than English such as Norwegian, Danish, and Dutch, the studies identified were too few to compare their effects statistically. Furthermore, although the three languages identified are considered to have a more complex morphological structure, they still share a similar orthographic consistency to English, leaning towards the deep side of the continuum. To our knowledge, the only study that compared implicit and explicit morphology instruction in a language different from English examined the effects of these two approaches on the teaching of morphological spelling rules in Dutch (Kemper et al., 2012). Although their results continue to support the use of explicit over implicit instruction, Dutch is a language that still shares orthographic characteristics with English and their study focused on spelling outcomes. To our knowledge, no study has examined the benefits of providing explicit morphological analysis instruction (measuring orthographic and semantic learning) in a language that differs from English in both orthographic transparency and morphological complexity.

The Current Dissertation

Despite the rising interest in the role of morphology in literacy and its instruction (see Henbest & Apel, 2017), our understanding of its development in written language and the most effective methods to support its growth across various languages and grade levels is still in its early stages. The current dissertation aims to contribute to this regard.

Concerning suffix knowledge, the existing studies have three important limitations. First, most of the studies that reported scores on derivational suffix knowledge have used derived words in their tasks (e.g., "blissful"; Gaustad et al., 2002; Nippold & Sun, 2008) posing a challenge in isolating suffix knowledge from lexical vocabulary knowledge (e.g., knowing the meaning of the word "teacher" vs. knowing the meaning of the suffix -er). To address this limitation my first study employed nonwords created by attaching real suffixes to made-up bases (e.g., "spoochful"). Furthermore, previous studies centred on measuring semantic knowledge of the suffixes. Given that morphemes convey information at different levels (i.e., orthographic, semantic, syntactic), we decided to include two tests of suffix knowledge, one for meaning and one for form. Finally, since different suffixes may possess additional challenges given their grammatical function (see Nippold & Sun, 2008), I decided to expand the very limited literature that examines differences in developmental trajectories by suffix types and analyzed the knowledge of 14 nominal and 14 adjectival derivational suffixes.

For Studies 2 and 3, I delved into morphology instruction. Although there is consensus supporting an explicit over an implicit approach in teaching morphology, evidence is scarce and it comes mostly from the instruction of morphological spelling rules in intermediate readers of English. I decided to explore the effects of explicit instruction in learning both the spelling and meaning of novel suffixes also in a higher grade level (i.e., Grade 5) and in a language other than English (i.e., Spanish). Considering that older students have accumulated more experience in engaging in morphological analysis with previously encountered words (Larsen & Nippold, 2007), it remains unclear whether they will have additional benefits from explicit instruction. Results from a meta-analysis of morphological interventions in samples of typically developing children (Goodwin & Ahn, 2013) showed that the effects of morphological instruction on vocabulary for middle school were substantially smaller (d = 0.29) than those reported for early elementary grades (d = 0.68). This may imply that the benefits of instruction may decline as children naturally develop the ability to use morphology to derive word meanings.

Finally, we decided to explore whether the benefits of receiving explicit over implicit instruction reported in other languages such as English and Dutch will be replicated in Spanish, a language with rich morphology and high orthographic consistency. Given that Spanish speakers are immersed in a language environment that is morphologically richer than English (Borleffs et al., 2017), students may develop the necessary skills to engage in morphological analysis independently. This could result in less pronounced benefits obtained from explicit instruction. However, due to the high letter-to-sound consistency of Spanish spelling, reading instruction typically overlooks the use of morphemes (Jaichenco, 2013). Instead, it relies on decoding by individual letters, as this is sufficient for accurate word reading (Kalman, 2017; Reese et al., 2012). Thus, despite Spanish's morphological richness, children's ability to recognize and acquire novel morphemes in writing may be obscured by the orthographic characteristics of Spanish and instructional reading methods, underscoring the necessity for explicit instruction.

Overall, this dissertation aimed to provide evidence on derivational suffix knowledge and learning across grades (Grade 3, Grade 5, and Grade 8) and languages (English and Spanish) with contrasting morphological and orthographic features. Study 1 contributed to previous research on derivational suffix knowledge by isolating suffix knowledge from lexical knowledge. Additionally, the study measured suffix knowledge in form and meaning across three grade levels. Finally, it expanded on previous literature by analyzing a large set of derivational suffixes, categorized by suffix type. Results were mixed with suffix form knowledge being higher for adjectives, but meaning knowledge being higher for nominals. These results suggest that although students may be more familiar with the written form of certain adjectives and, therefore, more likely to recognize them, this does not necessarily imply a better understanding of their meaning.

Study 2, contributed to previous research on morphology instruction in English by measuring the effect of implicit and explicit morphology instruction on measures of both the form and meaning of the novel suffixes presented. Furthermore, we included participants in Grades 3 and 5 to examine if the effect of instruction weakens for older students who presumably had more experience working with morphologically complex words. The results showed large additional benefits of explicit over implicit instruction in morphological analysis for Grade 3 students and smaller, albeit significant, benefits for Grade 5 students. Nevertheless, the effect differed by task with no differences across conditions (implicit vs explicit) when assessing form and larger differences across conditions detected by a word definition task compared to multiple-choice. The results suggest that although younger readers benefit more from explicit instruction in morphological analysis, more advanced readers continue to benefit from explicit teaching, particularly when it comes to acquiring a deeper understanding of the suffixes. Finally, Study 3 contributed by conducting a short intervention in morphology instruction in Spanish comparing the benefits of explicit and implicit instruction. The results showed that, in Spanish, explicit instruction in morphological analysis yielded better outcomes compared to an implicit approach and that these benefits were significant to learning both the form and meaning of the novel suffixes.

Taken together, these studies highlight 1) the variations in knowledge of derivational suffixes that seem to be determined by suffix frequency and task characteristics, and 2) the benefits of receiving explicit instruction in morphological analysis. Importantly, our evidence in support of explicit instruction comes from children at two grade levels (Grades 3 and 5) and two languages that differed in morphological complexity and orthographic consistency (English and Spanish) building towards a more universal understanding of the positive effects of receiving explicit morphology instruction.

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Chapter 2: How Well do Schoolchildren and Adolescents Know the Form and Meaning of Different Derivational Suffixes? Evidence from a Cross-Sectional Study

Introduction

Reading materials for children in upper elementary school grades display a notable increase in the incidence of polymorphemic words (i.e., those containing more than one morpheme; see Dawson et al., 2023; Grainger & Ziegler, 2011; Kearns & Hiebert, 2022; Nippold, 2018; Rastle, 2019). Of particular interest are derived words, which are formed by adding a derivational morpheme, or affix, before (e.g., re-) or after (e.g., -ful) a base word (e.g., "replay" from "play" by adding re-, or "playful" by adding -ful). The English orthographic system is described as morphophonemic as it represents morphological information in addition to phonological information in words' reading and spelling (Venezky, 1967). For example, morphemic boundaries can influence how words are parsed into graphemes – the letters <p> and <h> usually form a digraph <ph>, which corresponds to the sound /f/ as in "phone" or "sphere," yet this is not the case for words like "uphill" or "shepherd", where the letters cross a morphemic boundary.

Knowledge of the morphemic structure of words has been shown to be associated with children's word spelling and reading accuracy and fluency (Apel & Henbest, 2016; Burani et al., 2018; Deacon et al., 2013; Levesque et al., 2017, 2021) as well as with vocabulary development (Carlisle, 2007; McBride-Chang et al., 2008; Pacheco & Goodwin, 2013; Ramirez et al., 2014), and morphology has been said to provide "islands of regularity" (Rastle et al., 2000, p. 527) within the English spelling system. Thus, children's ability to process the written form and meaning of derivational morphemes, either implicitly or explicitly, may be important for word reading and reading comprehension, even in the older grades of schooling where many content-specific vocabulary words are derived words (e.g., "measurement", "astrology" or "germination"; Nippold, 2018). Despite this, only a handful of studies have examined students' knowledge and understanding of derivational morphemes (Apel & Henbest, 2016; Gaustad et al., 2002; Mitchell & Brady, 2014; Nippold & Sun, 2008) and they have some important limitations (see below). Thus, in this study we aimed to examine students' knowledge of derivational morphology and whether this knowledge varies across grade levels and types of derivational suffixes (adjectives and nominals).

Development of Morphological Knowledge

A morpheme is the smallest unit of language that carries meaning. Base morphemes carry the main meaning in a word and can be free (stand-alone, e.g., "sun", "flower") or bound (e.g., -dict- in the word "prediction"). Prefixes are bound morphemes that we attach to the front of words or bases (e.g., un- in "unfair"), and suffixes are bound morphemes that we attach to the end of words or bases (e.g., -ate in "dictate"). There are three types of polymorphemic words: 1) Compounds, created by combining two free base morphemes, 2) inflected words, or words with inflectional suffixes that change the grammatical characteristics of the word, such as tense or number; and 3) derived words, which contain derivational prefixes and/or suffixes, that can change the word's grammatical category or alter its meaning. For example, the base "pack" has compounds (e.g., "backpack"), inflected forms (e.g., "packing"), and prefixed and suffixed derivations (e.g., "unpack", "packer").

Research suggests that the acquisition of oral morphology follows a developmental progression. Compound words are understood and used at early ages (Clark, 1993), the majority of inflections are mastered by Grade 1 (Berko, 1958; see also Maynard et al., 2018, for a recent compilation of studies on inflectional morphology), and derivations continue to present difficulty even in upper grades (e.g., Ford et al., 2010; Gaustad et al., 2002; Nippold

& Sun, 2008; Nunes & Bryant, 2006)[1]. The greater difficulty in learning derivations is arguably because, compared to inflections, they lack systematicity, morphological family sizes are smaller, and they are more likely to cause phonological and orthographic shifts to the base (Carlisle et al., 2006; Ford et al., 2010; Quémart et al., 2014).

A recent analysis of children's Language Arts textbooks in the U.S. showed that by third grade, the number of derived words found in texts is double that of Grade 1 (Kearns & Hiebert, 2022). These results resonate with those of Dawson et al. (2023) which also showed a significant increase in the number of derived words by grade level (see also Nippold, 2018, for a recent corpora analysis of derived words in children's textbooks by school subject). Thus, children who struggle to comprehend derived words may struggle to understand the content and key concepts presented in age-appropriate texts. This is especially true in non-fiction content areas where specialized vocabulary is often used (Dawson et al., 2023; Nippold, 2018).

The increase in exposure to written morphology that occurs from the later elementary grades onwards has the potential to highlight form-meaning links that are not always noticeable in spoken language (Rastle, 2019). Therefore, as children are exposed to more examples of complex words that contain derivational morphemes, we might expect an improvement in both their ability to identify the written forms and their understanding of the meaning of these morphemes. In the literature on word recognition, there is evidence for increasingly automatic identification of suffix forms across development, with students as young as 7 years of age showing some ability to implicitly process written suffixes (e.g., Dawson et al., 2018). However, to our knowledge, only a handful of studies have examined

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[1] While this study focuses on development in English, it is important to note that languages differ in their morphological structure, and the developmental progression may differ across languages. See Duncan, 2018 for a cross-linguistic review on morphology. See also Diamanti et al., 2018 for evidence of the later development of derivational morphology in Greek, an orthographically transparent language, Ben-Zvi & Levie, 2016 for evidence in Hebrew, a morphologically rich language, and Ku & Anderson, 2003 for evidence in Chinese, a non-alphabetic language.

children's knowledge of derived word meanings using written tasks[2]. In a study by Gaustad et al. (2002), college (ages 19 to 34 years old) and middle school (ages 11 to 12 years old) students were asked to complete a multiple-choice task that tested their semantic knowledge of bound morphemes, including inflections and derivations (e.g., what is the meaning of re- as in "rewrite": a) important, **b) again**, c) moving, d) after). College students scored an average of 94%, and middle school students scored an average of 79%, indicating that knowledge of derived words is still developing in middle school. Performance dropped to 89% for college students and 70% for middle schoolers when the items contained embedded bound morphemes that were less familiar (e.g., what is the meaning of therm- as in "thermal"), suggesting that performance on this task was also influenced by lexical vocabulary knowledge.

In another study, Nippold and Sun (2008) tested knowledge of morphologically complex words in 10-year-old children and 13-year-old adolescents and divided items into adjectives (e.g., "acceptable", "blissful") and nominals (e.g., "citizenship", "hostility"). Their results showed higher knowledge of adjectives (76.9% for children and 89.7% for adolescents) compared to nominals (63.2% for children and 79.4% for adolescents), which suggests that learning words that contain adjectival suffixes might be less challenging compared to those with nominal suffixes. According to Nippold and Sun, these differences could be driven by contextual cues provided by adjacent words, where adjectives are typically followed by a noun, whereas nouns can be followed by a wider variety of words such as prepositions, verbs, or adverbs. However, these results should be interpreted with some caution. Nippold and Sun used a cloze task with four choices (e.g., When Ali Baba's wife saw the gold coins, she was: a) speechified, b) specialized, c) speechmaker, **d)**

[2] Although previous studies have examined the understanding of derived words using an oral task (e.g., Carlisle, 2000), we are primarily interested in studies using written tasks. Further, we acknowledge that the study by James et al. (2021) used a written derivational morphology task. However, their task assessed morphological awareness rather than morphological semantic and/or orthographic knowledge.

speechless), but it was not clear how the difficulty of foils was balanced across adjective and nominal conditions. Therefore, answers for certain questions across conditions might have been more salient given the differences in the frequency of the foils (e.g., Question 26 tested the knowledge of the adjective “molecular”. The four possible answers were: a) molecularity, b) mollescent, **c) molecular**, d) mollified). Likewise, the criteria used to control sentence context informativeness across conditions was unclear. Nippold and Sun further acknowledged that they did not control for the number of derivational suffixes attached to words. For instance, the five most difficult words for students were “concealment”, “consolable”, “dictatorship”, “tactfulness”, and “strenuousness”. Notably, four of these words are nominal, and most contain more than one derivational affix. Thus, the difficulty of some words might have reflected not solely the derivational affix’s difficulty but also the morphological complexity of the whole word and the number of orthographic and semantic shifts it underwent.

Nippold and Sun’s study highlights the complexities associated with assessing derivational suffix knowledge using real-world stimuli. In addition to knowledge of derived words, it is interesting to know whether students can identify and understand their constituent parts, because this may help us tease apart the development of lexical knowledge from the development of morphological knowledge. The use of nonwords with either real affixes or real bases can be useful in this respect. In 2014, Mitchell and Brady compared the knowledge of real words (e.g., interoffice) and nonwords (e.g., interlanosts) with the same affix in Grade 3 and Grade 5 students. While their results did not show a significant difference in overall performance between words and nonwords, patterns of knowledge were different across the two measures at the item level (e.g., some students knew the word “closure” but not the suffix -ure). These results suggest that knowledge of a derived word does not always equate to knowledge of the suffix within the word. Moreover, the results also showed that not all suffixes are mastered equally, a question also raised by Nippold and Sun (2008).

Only a limited number of studies have explored whether the knowledge of derived words differs depending on their part of speech, and these studies have found mixed results. As above, Nippold and Sun (2008) found evidence that the meanings of derived adjectives were better known than the meanings of nominals, whereas a study by Marinellie and Kneile (2011) demonstrated no significant differences between the two. It is of interest to know whether different types of suffixes have different developmental trajectories, because such insights have important practical implications, such as when and how different types of suffixes are better taught. They may also shed light on the factors that contribute to the relative ease or difficulty of suffix acquisition.

Furthermore, knowledge of the meaning of a suffix does not imply knowledge of the orthographic form, or vice versa (e.g., Apel et al., 2013; Goodwin et al., 2017; Kristensen et al., 2023), and these two aspects of knowledge, while interconnected, may have different developmental trajectories. Masked priming studies have shown that for adolescents and adult skilled readers, the parsing of morphologically complex words can be driven by orthographic characteristics without an influence from meaning (e.g., parsing the written word corner into corn+er, e.g., Beyersmann et al., 2016; Dawson et al., 2021). With this in mind, we aimed to explore the potential differences in knowledge of the derivational suffixes at two levels: form and meaning. Such knowledge may have implications for the instruction or remediation of children with reading, spelling and/or language difficulties. However, to our knowledge, no previous study has examined the derivational suffix knowledge at these two levels and distinguished this knowledge by suffix type.

The Present Study

The purpose of this study was twofold: (a) First, to explore whether there were any differences in form (orthographic) and meaning (semantic) knowledge of written suffixes in Grades 3, 5, and 8, and (b) to examine whether the pattern of knowledge differed by suffix type and compared performance for adjectival and nominal suffixes. We measured and controlled for word reading and vocabulary because both skills are closely associated with morphological knowledge (e.g., Adams, 1990; Deacon et al., 2014; Haase & Steinbrink, 2022; Inoue et al., 2023; Kuo & Anderson, 2006; Mitchell & Brady, 2014; Nagy et al., 2003). Controlling for word reading was particularly important as our tasks were written tasks completed individually and in silence.

In sum, we aimed to answer the following research questions:

Q1. How well do students know the written form and meaning of nominal and adjectival derivational suffixes in different grade levels?

Q2. Does the development of derivational suffixes vary as a function of suffix type (nominals vs. adjectives)?

Because there is very little data comparing both form and meaning knowledge of the same suffixes across development, we did not have a directional hypothesis. Regarding suffix type, we expected that children would perform better on tasks of adjectival suffix knowledge than on tasks of nominal suffix knowledge. Importantly, in this study, we expanded on Nippold and Sun's (2008) work by comparing the knowledge of different suffix types using nonword stimuli. We also carefully controlled foil characteristics, reduced the potential influence of sentence context and used a larger range of suffixes. In addition, we extended Mitchell and Brady's (2014) work by using two different measures to assess suffix knowledge, one measuring form knowledge (i.e., orthographic knowledge) and the other measuring meaning or semantic knowledge (see also Apel et al., 2022 and Goodwin et al., 2017, for discussions of why multiple measures of morphological knowledge are useful).

Method

Participants

To select our participants, we first sent letters describing our study to the parents of 118 Grade 3, 148 Grade 5, and 114 Grade 8 students attending 11 public schools in Edmonton, Canada. The schools were located in different parts of the city to increase the representation of different demographics in our study as much as possible. We received parental consent from 108 Grade 3, 125 Grade 5, and 90 Grade 8 students that were subsequently invited to participate in the testing. All students had English as their first language and did not experience any intellectual, behavioral, or sensory difficulties (based on their teachers' reports). Ethics approval from the University of Alberta (Pro00119949) was also obtained prior to testing. From our original sample, 4 participants (2 in Grade 5, and 2 in Grade 8) were removed due to very low reading scores (standard scores in word reading accuracy below 70) and 10 participants (5 in Grade 3, 3 in Grade 5, and 2 in Grade 8) were removed for not following instructions (selecting more than one option in the multiple choice task or failing to respond the last page of the task) or answering randomly (circling the last two letters for all items in the Suffix Identification Task-Nonwords). This left a total sample of 103 Grade 3 (51 females, M_{age} = 8.9 years; SD = .53), 120 Grade 5 (58 females, M_{age} = 10.9 years; SD = .49), and 86 Grade 8 (38 females, M_{age} = 13.9 years; SD = .48) students.

Materials

Word Reading Accuracy

To assess word reading accuracy, we administered the Word Reading task from the Wide Range Achievement Test-5 (WRAT-5 blue form; Wilkinson & Robertson, 2017). Children were asked to read aloud 15 letters and 55 words of increasing difficulty. The task was discontinued after five consecutive errors, and a participant's score was the total number correct (max = 70). The raw score was subsequently converted to a standard score following the instructions in the manual. Cronbach's alpha reliability has been reported to be .91 in Grade 3, .95 in Grade 5, and .93 in Grade 8 (Wilkinson & Robertson, 2017).

Vocabulary Knowledge

Vocabulary knowledge was assessed with the Listening Comprehension subtest from the Wechsler Individual Achievement Test-2 (WIAT-2; Wechsler, 2005). Children were first asked to listen to a word provided orally by the examiner and then select one of four pictures that best depicted the word's meaning. The task was discontinued after four consecutive errors, and a participant's score was the total number of correct responses (max = 19). The raw score was subsequently converted to a standard score following the instructions in the manual. Cronbach's alpha reliability has been reported to be .85 in Grade 3, .83 in Grade 5, and .85 in Grade 8 (Wechsler, 2005).

Derivational Suffix Knowledge

Two measures of derivational suffix knowledge were administered: The Suffix Identification Task-Nonwords (SIT-N) and the Suffix Meaning Task-Nonwords (SMT-N). Both tasks were designed for the present study to measure students' knowledge of derivational suffixes separately from the influences of base word or whole word knowledge by using nonwords as the base of the novel-created derived items (e.g., "plemette" meaning a small "plem"). Because evidence has shown that suffix frequency, family size, and length can influence how words are processed and understood (Carlisle et al., 2006; Ford et al., 2010; Sánchez-Gutiérrez et al., 2018), all the suffixes attached to the nonword bases were matched on frequency, length, and family size. The complete tasks are available at https://osf.io/wx2q9/?view_only=e27f169880c640d6929b96dc28555687

Suffix Identification Task - Nonwords (SIT-N). The SIT-N was adapted from Apel et al. (2013). The SIT-N assessed children's ability to identify real derivational suffixes in the context of nonwords. This task contained nonword bases (e.g., *drex*) with real suffixes attached (e.g., -ness to create the derived word “drexness”; more examples are given in Appendix 1A). All nonwords for the bases were selected from the English Lexicon Project database (Balota et al., 2007) with the characteristics of being monosyllabic, three-to-five letters long (*M* = 4.4) and having an orthographic neighborhood density no higher than 25 (*M* = 5.81). The suffixes used in the SIT-N were 14 derivational adjectives (e.g., -ic, -ish, -able) and 14 derivational nominals (e.g., -ity, -er, -itis) taken from the MorphoLex database (Sánchez-Gutiérrez et al., 2018). Derivational noun suffixes were matched to derivational adjective suffixes on summed token frequency[3], length, and family size. All target suffixes, grouped by type, and their characteristics are listed in Appendix 1B. Each suffix was joined to two nonword bases for a total of 56 target items. Additionally, four items in the task contained a pseudosuffix (e.g., -mut to create the word “feemut”). These items were distractors and were distributed amongst the other items to discourage students from simply circling the last 2-3 letters of each word. The examiner provided the following directions: “*This activity has lots of silly words you have never seen before. These words have real suffixes or add-ons at the end of the word. You use and have seen many of these suffixes (add-ons) before. Your job is to find and circle them.*” Then the examiner would show the word “cars”, circle the -s at the end of the word and say, “*The word cars has the suffix -s that means more than one. Now we are going to try to find the suffixes in these silly words.”* Next, the examiner would show the participant two nonwords (e.g., “pleemed”) in written form and ask the participant to circle the suffix in each example. The examiner answered all questions and confirmed the correct response for all practice trials. In cases where the participant provided an incorrect response, the examiner would present the correct response and provide an explanation using real words to emphasize why it was the correct answer. For instance, in

[3] Summed frequency of all members in the morphological family of a morpheme. For example, the frequency of the suffix -ance would be the sum of the frequency of the words that contain this suffix (e.g., attendance, pleasance, appearance). The frequency count used for this calculation was the HAL frequency provided in the English Lexicon Project.

the word “pleemed”, the examiner would highlight that we needed to circle -ed because it is the add-on that we find at the end of the word to indicate that something happened in the past, similar to words like “jumped”. The participant was then asked to circle the suffixes in all the test items printed on paper. The task was done in silence without a discontinuation rule. Only the real suffixes were scored (i.e., responses on the four distractor items were not scored). Thus, the maximum possible score was 56. Cronbach’s alpha reliability was .95 in Grade 3, .92 in Grade 5, and .90 in Grade 8, indicating high levels of internal consistency.

Suffix Meaning Task – Nonwords (SMT-N). The SMT-N was designed after the study by Berko (1958) and adapted from an original task designed by Colenbrander (2015). In the SMT-N task, participants were asked about the meaning of 24 derivational suffixes (12 adjectives and 12 nominals; target suffixes and their characteristics are listed in Appendix 1B) in a written, multiple-choice format. This task included the same adjectives and nominals used for the SIT-N, except for four suffixes that were removed (-ness, -ance, -ic, -ile) due to their abstract nature, which made it challenging to construct unambiguous definitions. These items were eliminated based on comments provided by ten university students who participated in a pilot testing of the SMT-N before data collection.

The 12 remaining derivational adjectives and 12 derivational nominals were taken from the MorphoLex database (Sánchez-Gutiérrez et al., 2018). The two groups of suffixes were matched on summed token frequency (adjectives: M = 888,870.83, SD = 1192138.95; nominals: M = 909,751.92, SD = 1311387.91), length (adjectives: M = 3.00, nominals: M = 3.00), and family size (adjectives: M = 518.58, SD = 694.38; nominals: M = 410.50, SD = 620.70). For each target suffix a question was constructed, for a total of 24 questions. Each question asked about the definition of a suffix in the context of a nonword (e.g., Trab. Which one means something like “without trab”? a) trabbish, b) trabbive, c) trabful, **d) trabless**; more examples are given in Appendix 1A). One point was given for each correct response, and all questions had only one correct response, for a total of 24 points. For each question, the three foils were matched to the target on suffix frequency, family size, and suffix type. The definitions were taken from Gaustad et al. (2002) and Colenbrander (2015). The definitions were designed to contain simple language and to be no more than three words in length (e.g., a person who…, full of…, the study of…, a bit like…, having lots of…).

One individual SMT-N booklet that contained all 24 questions was given to each student. The first page of the booklet had two practice items read aloud by the examiner. After reading practice item 1 (Wug. Which one means "more than one wug"? A) wuggy, B) wugging, C) wugs, D) wugged), the examiner asked the group to call out the best answer along with an explanation for their response. The examiner then confirmed the correct response and asked all participants to circle that choice in their booklets. The same procedure was repeated for practice item 2, and after both practice questions, the participants continued working individually, answering each question on their booklets in silence. The maximum possible score was 24. Internal consistency as measured by Cronbach's alpha in our sample was .60 in Grade 3, .72 in Grade 5, and .77 in Grade 8.

Procedure

Testing took place during the months of May and June (towards the end of the school year in Canada). All tasks were administered during school hours by trained assistants with experience in psychoeducational assessments. The SIT-N, WIAT-2, and WRAT-5 were assessed first in a quiet room in a one-on-one session that lasted approximately 15 minutes. Participants then returned to their regular activities for about an hour until the examiner was ready to deliver the second part of the assessment. The second part included only the SMT-N, which was administered as a large group activity in the children's classrooms with their teachers present at all times. While the participants completed their work, the examiner walked around the classroom to ensure all participants were on task. Once a participant had answered all questions, the examiner collected their booklet and had a quick look to ensure all questions were addressed. Participants were then asked to remain silent until the whole group had finished. All participants completed the task within 20 minutes. For schools with more than one group participating in the project, two examiners delivered the assessment to ensure that the data for Part 1 and Part 2 were collected on the same day.

Statistical Analysis

All statistical analyses were conducted using R Version 4.2.2 (R Core Team, 2022) through RStudio Version 2023.03.0+386 (RStudio Team, 2020). Separate logistic mixed effects models were fitted using the binomial dependent variable (coded as 0 for incorrect responses and 1 for correct responses) for the two suffix knowledge tasks (SIT-N and SMT-N) to account for the nested structure of our data: Items (Level 1) were nested within Participants (Level 2). For model construction procedures for each task (for details, see Appendices 1G and 1H), we started with a baseline model that included only random intercepts at the Item and Participant levels (Model 0). We then entered fixed and random effects into the models in a stepwise manner as follows: the fixed effects of word reading accuracy and vocabulary knowledge (both continuous variables) in Model 1; the fixed effects of grade (a three-level factor) and suffix type (a two-level factor) in Model 2; the fixed effect of the interaction between grade and suffix type in Model 3; the random effect of suffix type at the Participant level in Model 4; the random effect of grade at the Item level in Model 5; both of these random effects in Model 6. Word reading accuracy and vocabulary knowledge were centered before the analyses. Grade and suffix type was coded using the contr.sdif function in the MASS package Version 7.3-59 (Venables & Ripley, 2002). Grade was coded with repeated contrasts to compare two consecutive grades, namely Grade 3 vs. Grade 5 and Grade 5 vs. Grade 8; the three grades were coded as -2/3, 1/3, and 1/3 in the first contrast, while they were coded as -1/3, -1/3, and 2/3 in the second contrast. Suffix type was coded with a simple contrast; adjectives and nominals were coded as -0.5 and 0.5, respectively. The best-fitting models were selected based on the models' fit indices (AIC, BIC, and Log Likelihood values) and the results of likelihood ratio tests for model comparisons between nested models. In addition, the marginal and conditional R^2 values for the models were calculated using the MuMIn package Version 1.47.5 (Barton, 2019); marginal R^2 indicates the variance explained by fixed effects, and conditional R^2 indicates the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013; Orelien & Edwards, 2008).

All models were fit using the glmer function in the lmerTest package (Version 3.1-3; Kuznetsova et al., 2017). The data and analysis code for all models is available at https://osf.io/wx2q9/?view_only=e27f169880c640d6929b96dc28555687

Results

Descriptive statistics for all the variables are presented in Table 1.1. A closer examination of the Participant level variables (word reading, vocabulary knowledge, and the proportions of correct responses in Suffix Identification Task-Nonwords [SIT-N] and Suffix Meaning Task-Nonwords [SMT-N]) showed one univariate outlier on word reading in Grades 5 and 8, one outlier on the adjective items of the SIT-N in Grades 5 and 8, and one outlier on the nominal items on the SIT-N in Grade 8 (scores were 3 *SD* above/below the group mean). To avoid overemphasizing their effects on the results, we winsorized their scores by replacing them with a value equal to the next highest/lowest non-outlier-score plus 1 unit of measurement before further analyses (Tabachnick & Fidell, 2012). All assumptions of normality in our sample were met. Pearson's *r* and Spearman's ρ correlations between the variables are presented in Table 2.1. Both SIT-N and SMT-N were weakly to moderately correlated with word reading across grades (*r*s ranged from .32 to .39 for Grade 3, .17 to .51 for Grade 5, and .38 to .52 for Grade 8). Their correlations with vocabulary knowledge were relatively weaker than those with word reading, except for SMT-N in Grade 8 (*r*s ranged from .02 to .22 for Grade 3, .09 to .34 for Grade 5, and .17 to .48 for Grade 8).

Table 1.1

Descriptive Statistics for the Measures Used in the Study

	Grade 3 (N = 103)			Grade 5 (N = 120)			Grade 8 (N = 86)		
	Mean	*SD*	Range	Mean	*SD*	Range	Mean	*SD*	Range
Age	8.88	0.48	8.1 – 10.0	10.88	0.49	10.1 – 11.8	13.94	0.53	13.1 – 15.5
Word reading	109.28	15.31	76 – 145	106.49	16.39	55 – 145	105.30	15.57	55 – 139
Vocabulary	104.94	15.17	71 – 142	101.89	14.93	67 – 135	102.70	14.51	69 – 133
SIT-N_Adj	.56	.24	.07 – 1.00	.79	.17	.18 – 1.00	.83	.15	.32 – 1.00
SIT-N_Nom	.42	.28	.00 – 1.00	.69	.22	.07 – 1.00	.77	.18	.11 – 1.00
SMT-N_Adj	.40	.17	.08 – .83	.55	.17	.17 – 1.00	.53	.17	.17 – .92
SMT-N_Nom	.39	.19	.08 – .92	.51	.23	.00 – 1.00	.65	.24	.17 – 1.00

Note. SIT-N = Suffix Identification Task-Nonwords; SMT-N = Suffix Meaning Task-Nonwords; Adj = adjectives; Nom = nominals.

Table 2.1

Correlations Between the Variables for Each Grade

	1	2	3	4	5	6
Grade 3 (*N* = 103)						
1. Word reading		.29**	.37**	.37**	.36**	.32**
2. Vocabulary	.27*		.19	.14	.27*	.00
3. SIT-N_Adj	.39**	.18		.83**	.30**	.24*
4. SIT-N_Nom	.39**	.15	.83**		.25*	.27*
5. SMT-N_Adj	.37**	.22*	.35**	.29**		.29**
6. SMT-N_Nom	.32**	.02	.30**	.32**	.35**	
Grade 5 (*N* = 120)						
1. Word reading		.45**	.26**	.29**	.14	.50**
2. Vocabulary	.49**		.07	.10	.08	.39**
3. SIT-N_Adj	.22*	.11		.72**	.03	.35**
4. SIT-N_Nom	.30**	.11	.77**		.02	.37**
5. SMT-N_Adj	.17	.09	.01	.02		.25*
6. SMT-N_Nom	.51**	.34**	.35**	.39**	.25*	
Grade 8 (*N* = 86)						
1. Word reading		.35**	.32**	.49**	.49**	.49**
2. Vocabulary	.41**		.12	.15	.29*	.42**
3. SIT-N_Adj	.38**	.20		.61**	.34**	.27*
4. SIT-N_Nom	.52**	.17	.75**		.30**	.48**
5. SMT-N_Adj	.49**	.34**	.34**	.27*		.52**
6. SMT-N_Nom	.48**	.48**	.32**	.45**	.53**	

Note. Pearson's *r*s are shown below the diagonal, and Spearman's ρs are shown above the diagonal. SIT-N = Suffix Identification Task-Nonwords; SMT-N = Suffix Meaning Task-Nonwords; Adj = adjectives; Nom = nominals.
**p* < .05. ***p* < .01.

The results of the best-fitting models for each of the two suffix knowledge tasks are presented in Tables 3.1 and 4.1 (see Appendices 1E and 1F, for the results of model comparisons). For both SIT-N and SMT-N, the models that included the fixed effects of word reading accuracy, vocabulary knowledge, grade, suffix type, and the interaction between grade and suffix type, as well as the random effects of suffix type at the Participant level and grade at the Item level showed the best fit (see the footnotes of the tables for the model equations). For SIT-N (see Table 3.1), word reading had a significant fixed effect (estimate = 0.029, $p < .001$), while vocabulary knowledge did not (estimate = 0.000, $p = .986$). In addition, the fixed effects of the two grade contrasts (estimates = 1.554, $p < .001$ for the Grade 3 vs. Grade 5 contrast and 0.454, $p = .014$ for the Grade 5 vs. Grade 8 contrast) and suffix type (estimate = -0.672, $p = .020$) were significant. The former result indicates that the probability of correct responses increased with grade level, while the latter indicates that the probability of correct responses was relatively higher for adjectives than for nominals across grades (see Figure 1.1). The interaction between grade and suffix type was not significant (estimates = 0.206, $p = .489$ for the Grade 3 vs. Grade 5 contrast and 0.119, $p = .558$ for the Grade 5 vs. Grade 8 contrast).

Table 3.1

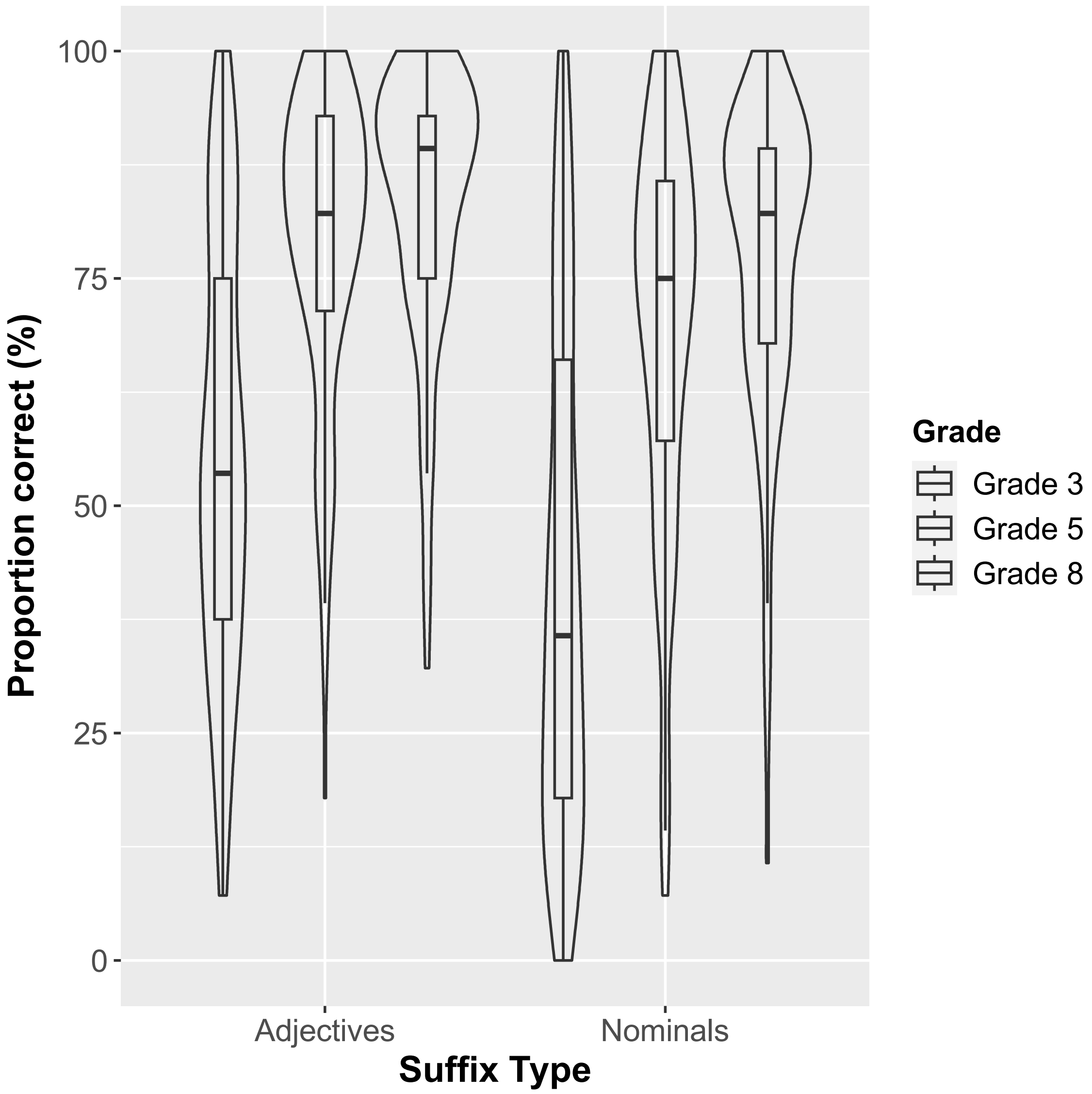
Results of the Best Fitting Model for SIT-N

		95% CI		
Fixed Effects	Estimate (*SE*)	UL	LL	*p*
(Intercept)	1.085 (0.157)***	0.776	1.393	< .001
Word reading	0.029 (0.005)***	0.020	0.038	< .001
Vocabulary	0.000 (0.005)	-0.009	0.010	.986
G3vsG5	1.553 (0.208)***	1.145	1.961	< .001
G5vsG8	0.454 (0.185)*	0.093	0.816	.014
Suffix_type	-0.672 (0.289)*	-1.239	-0.105	.020
G3vsG5:Suffix_type	0.206 (0.297)	-0.377	0.789	.489
G5vsG8:Suffix_type	0.119 (0.204)	-0.280	0.518	.558
Random Effects	Variance	*SD*	Correlation	
Participant (Intercept)	1.244	1.115		
Participant (Suffix_type)	0.358	0.598	.34	
Items (Intercept)	0.563	0.750		
Items (G3vsG5)	0.508	0.712	-.04	
Items (G5vsG8)	0.153	0.391	-.10	.64
Model fit	Marginal	Conditional		
R^2	.151	.480		

Note. CI = confidence interval; LL = lower limit; UL = upper limit. Number of observations = 17304; number of participants = 309; number of items = 56. Model equation: accuracy ~ word_reading + vocabulary_knowledge + grade + suffix_type + grade:suffix_type + (1 + suffix_type | participant) + (1 + grade | item).
**p* < .05. ***p* < .01. ****p* < .001.

Figure 1.1

Performance Levels of Each Grade on the SIT-N Task



Note. The plots are a combination of violin plots and box plots. Violin plots show the density distribution of the proportion correct, and box plots show the median, the interquartile range, and 1.5 times the interquartile range.

For SMT-N (see Table 4.1), both word reading and vocabulary knowledge had a significant fixed effect (estimates = 0.023, $p < .001$ for word reading and 0.010, $p < .001$ for vocabulary knowledge). The fixed effects of the two grade contrasts were also significant (estimates = 0.779, $p < .001$ for the Grade 3 vs. Grade 5 contrast and 0.325, $p = .008$ for the Grade 5 vs. Grade 8 contrast), indicating that the probability of correct responses increased with grade level. In contrast, the fixed effect of suffix type was not significant (estimate = 0.070, $p = .850$). The interaction between the Grade 5 vs. Grade 8 contrast and suffix type was significant (estimate = 0.759, $p < .001$), while that between the Grade 3 vs. Grade 5 contrast and suffix type was not (estimate = -0.185, $p = .303$). These results indicate that the probabilities of correct responses for the two suffix types were similar in Grades 3 and 5, while they differed between Grades 5 and 8, showing that Grade 8 children had a higher probability of correct responses to nominals than adjectives (see Figure 2.1).

Table 4.1

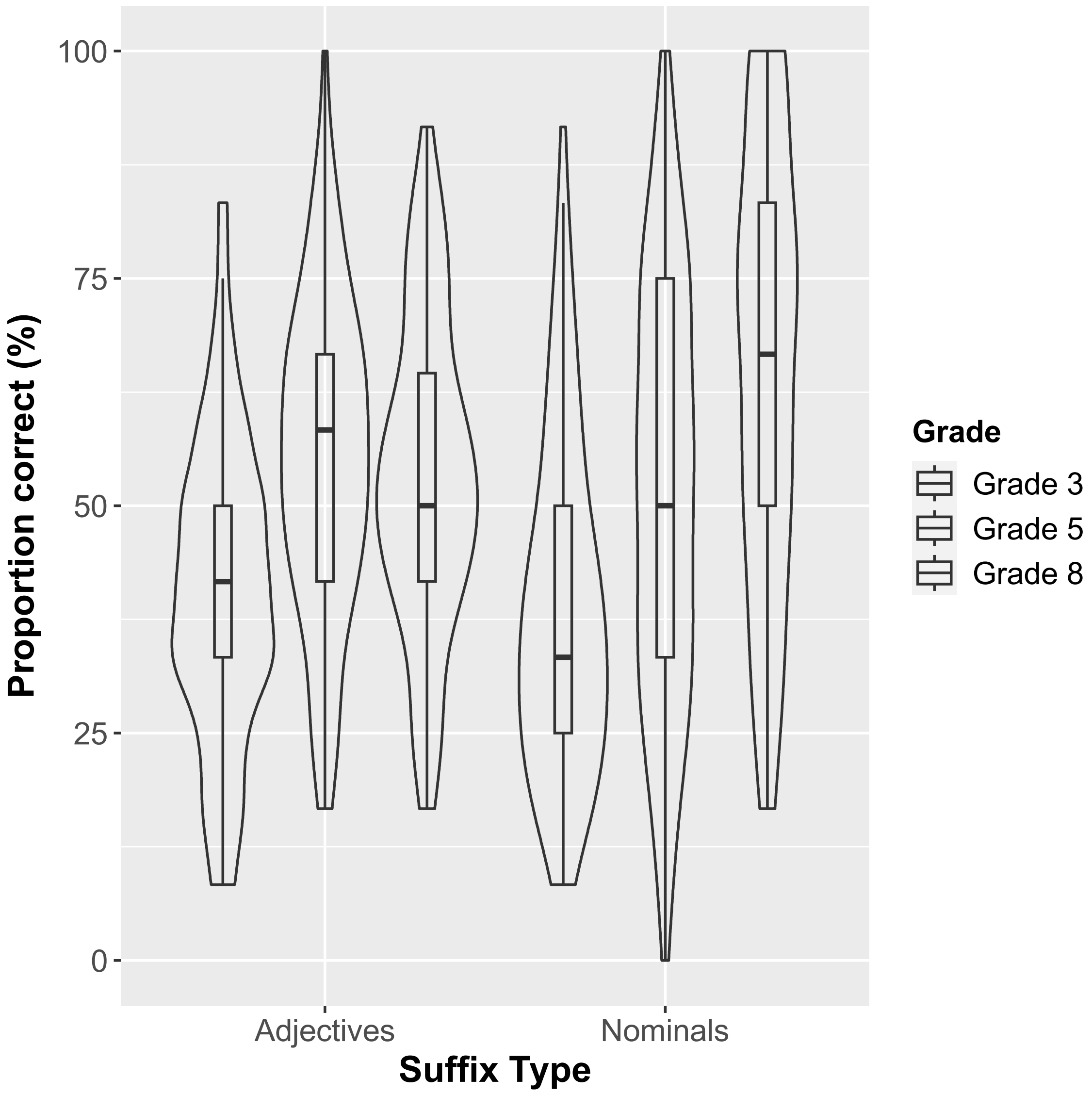
Results of *the Best-Fitting Model for SMT-N*

		95% CI		
Fixed Effects	Estimate (*SE*)	UL	LL	*p*
(Intercept)	0.068 (0.187)	-0.299	0.436	.715
Word reading	0.023 (0.003)***	0.017	0.028	< .001
Vocabulary	0.010 (0.003)***	0.004	0.016	< .001
G3vsG5	0.779 (0.111)***	0.560	0.997	< .001
G5vsG8	0.325 (0.122)**	0.087	0.563	.008
Suffix_type	0.070 (0.370)	-0.656	0.796	.850
G3vsG5*Suffix_type	-0.185 (0.179)	-0.536	0.167	.303
G5vsG8*Suffix_type	0.759 (0.200)***	0.367	1.152	< .001
Random Effects	Variance	*SD*	Correlation	
Participant (Intercept)	0.305	0.552		
Participant (Suffix_type)	0.284	0.532	.41	
Items (Intercept)	0.800	0.894		
Items (G3vsG5)	0.068	0.261	.61	
Items (G5vsG8)	0.095	0.308	.45	.36
Model fit	Marginal	Conditional		
R^2	.078	.325		

Note. CI = confidence interval; LL = lower limit; UL = upper limit. Number of observations = 7416; number of participants = 309; number of items = 24. Model equation: accuracy ~ word_reading + vocabulary_knowledge + grade + suffix_type + grade:suffix_type + (1 + suffix_type | participant) + (1 + grade | item).
**p* < .05, ***p* < .01, ****p* < .001.

Figure 2.1

Performance Levels of Each Grade on the SMT-N Task



Note. The plots are a combination of violin plots and box plots. Violin plots show the density distribution of the proportion correct, and box plots show the median, the interquartile range, and 1.5 times the interquartile range.

Discussion

The present study examined students' knowledge of the written form and meaning of derivational suffixes, assessed through two experimenter-designed tasks (SIT-N to assess form and SMT-N for meaning) in which real suffixes were paired with nonword bases (e.g., "spoochful"). Nonwords were used to ensure that we were measuring students' knowledge of suffixes independently of their lexical vocabulary knowledge. The study examined differences in knowledge across grade levels (third, fifth, and eighth grades) and different types of derivational suffixes (adjectives and nominals). The findings indicated substantially greater knowledge of the form and meaning of derivational suffixes in Grade 5 compared to Grade 3 and a smaller, albeit significant, growth in Grade 8 compared to Grade 5. These results are consistent with those of previous studies showing that the development of derivational morphology is a protracted process (e.g., Berninger et al., 2010; Dawson et al., 2018; Ford & Davies, 2010; Gaustad et al., 2002; Ku & Anderson, 2003; Nippold & Sun, 2008).

When it comes to growth patterns across suffix types, our findings diverged from the limited existing research comparing adjectives versus nominals. For the identification task (morphological orthographic knowledge), participants in all grades showed better performance for adjectival suffixes. In contrast, on the meaning task (morphological semantic knowledge), there was no difference between suffix types in Grades 3 and 5, but participants in Grade 8 scored higher on nominal suffixes. This result differs from the results of Nippold and Sun (2008), which showed higher performance on adjectives across grade levels in a task that simultaneously tapped both form and meaning knowledge of real morphologically complex words. In other words, once we controlled for lexical vocabulary knowledge (by using nonword bases) and foil characteristics (by balancing foils on frequency, family size, grammatical category, and length), the advantage for adjectival suffixes was only evident in the identification task.

This suggests that although students may be more familiar with the written form of certain adjectives and, therefore, more likely to recognize them, this does not necessarily imply a better understanding of their meaning. Previous studies on the dimensionality of morphological knowledge (Apel et al., 2013, 2022; Goodwin et al., 2017, 2021) have also shown that individuals can have varying degrees of proficiency across different dimensions of morphological knowledge. Studies that support the view of morphological knowledge as a multidimensional construct make a broad distinction between implicit morphological knowledge (or morphological processing), which refers to the knowledge at the orthographic level driven by the orthographic co-occurrences that morphemes represent, and more in-depth knowledge that emerges when students start to reflect on the structure of the word, the meaning, and the roles of the affixes (this type of knowledge is also known as morphological analysis, see Goodwin et al., 2014). However, work from the masked priming literature suggests that implicit morpho-orthographic processing initially relies on a degree of semantic knowledge, but later becomes semantically "blind" (Diependale et al., 2005; Rastle et al., 2004).

Our findings suggest the possibility that for more abstract, later-acquired suffixes, it may be the case that morpho-orthographic learning is semantically "blind" from the beginning. In other words, students may perceive the suffixes as orthographic "chunks" given their co-occurrence but have yet to assign meaning. This raises the question of whether these orthographic chunks are treated as real productive morphemes.

In other words, our findings support a distinction between morphological processing (at the orthographic level) and morphological analysis (at the semantic level). However, the different growth patterns for adjectives and nominals raise questions about the factors that help consolidate their learning. Empirical evidence shows that suffix frequency and family size influence how words are processed and understood (Ford et al., 2010; Sánchez-Gutiérrez et al., 2018), but our study controlled for these factors. Concreteness has also been proposed as a factor that may influence the acquisition of different suffix types (Nippold & Sun, 2008; Strik-Lievers et al., 2021). Recently, Strik-Lievers et al. (2021) calculated the level of concreteness of a variety of derivational suffixes. From their data, we were able to obtain concreteness scores for seven adjectives and five nominals. Contrary to what Nippold and Sun's (and to some extent, our own) data suggest, most of the adjectives (5 out of 7) showed low concreteness scores, while the nominals displayed high concreteness scores. Our findings show that low concreteness scores do not necessarily translate into low scores for suffix identification. Alternatively, it is conceivable that after the orthographic representation of the morpheme has been learned, concreteness assumes an important role in consolidating meaning, which might explain why semantic knowledge for nominals was higher only in Grade 8. Nevertheless, it is important to interpret this with care as we only possess concreteness scores for approximately half of the items featured in our task, and concreteness could potentially interact with other variables in the learning process.

Our findings are better explained by data on suffix frequency and the role of exposure to suffixes in children's reading materials. As mentioned before, the number of derived words in children's texts increases as they progress to higher grades, but the rate of increase is not consistent. Dawson et al. (2023) analyzed derivational suffix frequency in children's reading material at three stages (corresponding to education levels in England and Wales); Key Stage 1, which included reading material for students ages 5 to 7 (early elementary school), Key Stage 2, corresponding to reading material for students ages 7 to 11 (later elementary school), and Key Stage 3, reading material for students ages 11 to 14 (late elementary school and early secondary school). Their results showed that the increase in the number of derived words between Key Stages 1 and 2 (early to late elementary school) is more than double the increase reported between Key Stages 2 and 3 (late elementary school to early secondary, see Appendix 1G). In a broad sense, this could explain why Grade 5 students have significantly more knowledge of the form and meaning of derivational morphemes than Grade 3 students, but the difference is less pronounced between Grade 5 and Grade 8 students.

Using data from Dawson et al. (2023), we were able to explore results for adjectives and nominals more closely. Interestingly, in Stage 1, the frequency of adjectives is considerably higher than that of nominals, but the reading material of students at later key stages showed no increase, and even a decline, in the frequency of adjectives, while the occurrence of nominals continued to increase. For example, the suffix -ful had a frequency of 24,772 per million suffixed words in the reading material for students ages 7 to 11, but a frequency of 17,252 per million in texts for students ages 11 to 14. This trend is also visible for other adjectives such as -ar and -ous (for more examples, see Appendix 1G).

This drop in frequency might not have a significant impact on suffixes that have already reached a high level of mastery by Grade 5, such as -ful and -less. However, it appears to hinder further development of other suffixes that still require consolidation, especially in terms of understanding their meaning. For example, suffixes such as -ar and -ous that show a decrease in text frequency also show no increase in performance in our tasks between Grades 5 and 8, where they seem to plateau at scores around 80% accuracy for identification and 60% accuracy for meaning. Together, these results suggest that the knowledge of certain derivational adjectives begins to approach a plateau by Grade 5. The growth pattern in adjectival suffix knowledge appears closely related to the language children are exposed to via their reading experience.

An increase in performance for nominal derivational suffixes at each grade level could also be attributed to the type of written language children are exposed to. Research has shown that nominalizations are around four times more common in academic writing compared to fiction and speech (Biber et al., 1998). Many nominal derivational suffixes are frequently used in academic writing to nominalize verbs and adjectives, which can reflect a more formal and depersonalized style (see Dawson et al., 2023, for further discussion on nominalizations). Dawson et al.'s (2023) analysis shows that nominal derivational suffixes consistently increase in frequency as students move to upper grades. For example, the suffix -itis had a frequency of 0 with no appearances in the reading material for children aged 5 to 7, a frequency of 48 in the texts for children aged 7 to 11; and finally, a frequency of 320 in reading material for ages 11 to 14. Dawson et al. (2023) reported a substantial increase in frequency for all nominal suffixes in texts aimed at older children, with the only exception being the suffix -ism (see Appendix 1G, for more information on each suffix). Therefore, the consistent increase in knowledge of nominal derivational suffixes across grade levels could be linked to their increasing prevalence in more advanced and formal texts.

Limitations and Future Directions

Some limitations of the present study should be reported. First, the Suffix Meaning Task-Nonwords (SMT-N), created for this study to measure semantic knowledge of suffixes, showed relatively low internal consistency, particularly in Grade 3. This could be due to the constrained-choice aspect of the task, the small number of items, and the grade level. Previous studies have reported low-reliability scores for early grades in constrained-choice tasks (see Ursachi et al., 2015, for a review on further external factors that influence reliability scores). Future research should consider additional assessment formats, such as expressive questions and multiple testing sessions to increase the number of items per suffix and improve internal reliability. Second, the study was cross-sectional, which limits our ability to identify developmental changes within the same sample. To determine if there is genuinely limited growth in the knowledge of adjectival derivational suffixes between Grades

5 and 8, future longitudinal studies are necessary. Finally, our study focused on English, and it is important to note that our findings may not generalize to other languages. The importance we placed on children's reading materials as a potential factor influencing the growth in suffix knowledge suggests the need for further investigations in other languages where the types and frequency of polymorphemic words differ (see Borleffs et al., 2017, for a discussion on morphological complexity across languages in alphabetic orthographies). Exploring languages with different levels of morphological richness and orthographic consistency can help clarify language-specific differences and enrich our understanding of morphological development.

The different growth paths for adjectives and nominals found in our study highlight the importance of using multiple forms of assessment to evaluate morphological knowledge. Future research should consider an examination of derivational suffix knowledge using a wider range of tasks that carefully tackle the orthographic, semantic, and syntactic dimensions of morphological knowledge (see Goodwin et al., 2017, 2021). Studies have demonstrated that different aspects of morphological knowledge may contribute uniquely to different aspects of reading, with orthographic knowledge impacting speed and accuracy, and semantic knowledge influencing comprehension (see e.g., Goodwin et al., 2017). Consequently, future research on derivational affix knowledge should consider incorporating a range of reading measures to investigate how different aspects of suffix knowledge contribute to each measure of reading.

Furthermore, studies that look into the effect of the positional constraint of the morphemes (i.e., prefixes versus suffixes) and a wider variety of grammatical and syntactic functions (including verbs and adverbs in addition to adjectives and nominals) could advance our understanding of written morphological development and inform instruction tailored to the specific requirements of each affix type.

Conclusion

Our study showed that children's knowledge of written nominal and adjectival derivational suffixes progresses at each grade level (Grades 3, 5, and 8). When comparing the form and meaning knowledge of these two types of suffixes, we observed distinct growth patterns. While students of all grade levels demonstrated stronger identification skills for adjectival suffixes, this proficiency did not carry over to their understanding of suffix meaning. Notably, Grade 8 students showed superior semantic knowledge of nominals compared to adjectives. The notable differences between identification and meaning across suffixes highlight the significance of assessing suffix knowledge across multiple dimensions, such as orthographic and semantic knowledge, as proficiency in one does not guarantee mastery in the other. Moreover, our findings draw attention to the importance of reading experience, as the growth patterns in suffix knowledge for each suffix type align with data on children's exposure to new words in written materials. Engaging in reading can contribute to the development of morphological knowledge through exposure to polymorphemic words that contain morphemes consistent in form and meaning. Additionally, practice in reading can help strengthen metalinguistic competencies, previously proven to hold a positive correlation with morphological skills (see Larsen & Nippold, 2007).

There is consensus that knowledge of morphology is closely related to literacy development (see Levesque et al., 2021) with derivational morphology being particularly important at older grades (Nippold, 2018). Our work on the knowledge of typically developing children can help inform assessment tasks aimed at identifying children who may have difficulty reading, spelling, or comprehending polymorphemic words and thus need extra instruction. It can also help guide the content of intervention programs aimed at teaching morphology to children with reading or language difficulties. Our data can help inform the content of intervention programs by presenting accuracy rates for both form and meaning of a large number of suffixes across three grade levels; adding to the literature offering empirical evidence that recognizing a suffix does not always imply understanding its meaning, emphasizing the need for diverse tasks to monitor progress; and highlighting the importance of exposing students to numerous examples of polymorphemic words to support further morphological development.

Given the different growth patterns for adjectives and nominals, further empirical research on when and how different types of derivational affixes are learned is crucial for enhancing our understanding of derivational morphology and how to best support its acquisition and development.

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Chapter 3: Comparing Implicit and Explicit Morphological Analysis Instruction for Upper Elementary Readers

Introduction

Morphemes, the smallest units in words bearing meaning, can be seen as the building blocks that form words. A growing body of evidence suggests that children, at a young age, develop sensitivity to the morphological structure of words in print even in the absence of explicit instruction (e.g., Carlisle, 2000; Carlisle & Stone, 2005; Mann & Singson, 2003). Another body of evidence supports the view that morphological instruction has added benefits for reading and spelling, but there are ongoing debates about how much morphological instruction is appropriate and what form it should take (Bowers & Bowers, 2018; Goodwin & Ahn, 2013; Manyak et al., 2018; Ng et al., 2022). In light of this debate, this study aimed to determine whether children can identify and use the implicit morphological information provided in our target words to engage in morphological analysis (i.e., deciphering the meaning of a word through an analysis of its individual morphemes), or if explicit teaching provides additional benefits.

While there is evidence of the development of early sensitivity to the morphemic structure of words (Bourassa et al., 2006; Treiman & Cassar, 1996), the maturation of this skill appears to be a protracted process (Dawson et al., 2021; Gaustad et al., 2002; Nippold & Sun, 2008). Although much of this evidence comes from word recognition studies (Beyersmann et al., 2012; Casalis et al., 2015; Dawson et al., 2018), there is also some work showing protracted development of meaning knowledge. For example, Larsen and Nippold (2007) asked Grade 5 students to engage in morphological analysis to define 15 low-frequency derived words (e.g., “dramatize”, “fearsome”). Their results showed that 20% of their sample required explicit guidance for success, such as assistance in breaking down words into their constituent parts (e.g., "fear" and "some"). These results suggest that explicit instruction in morphological analysis may remain crucial even for upper elementary students.

However, results from a meta-analysis of morphological interventions in samples of typically developing children (Goodwin & Ahn, 2013) challenge this view. Their results showed that the effect of morphological instruction on vocabulary for middle school was substantially smaller (d = 0.29) than those reported for early elementary grades (d = 0.68). This may imply that the benefits of instruction decline as children naturally develop the ability to use morphology to decipher word meanings. Given this contrasting evidence, the purpose of this study was to examine whether students, at two different grade levels (Grade 3 and Grade 5) exhibit additional benefits from explicit instruction in morphology when learning the form and meaning of novel suffixes.

How Does Morphological Analysis Develop?

Morphological analysis is the strategic use of the word's morphological structure to infer the word's meaning. Interactive models of morphologically complex words[4] (Taft, 2003), along with the affix discovery principle (Schreuder & Baayen, 1995), concur that the effective use of this strategy relies heavily on word experience. Accordingly, morphologically complex words are first stored as whole lexical units (e.g., "redo"), which are later employed as analogies to understand new words sharing a similar structure (e.g., using "redo" to understand "reread"). Over time and with increasing exposure, the formation of individual nodes for each morpheme begins to emerge as well as their correct use and understanding in

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[4] Morphologically complex words have been described as those containing at least two morphological units (e.g., "dangerous"; see Deacon et al., 2011) that result in compound, inflected, or derived words. These types of words have also been called polymorphemic (Hyönä, 2015) or multimorphemic (Melvie et al., 2023).

novel contexts (e.g., an independent representation of the prefix re- which understanding can be used to infer the meaning of words such as “replay” and “rewrite”; see Beyersmann & Grainger, 2023). As a result, morphological analysis may not emerge until children have ample exposure to morphologically complex words, arguably after three to four years of formal schooling (Anglin, 1993; Gaustad et al., 2002; Nippold & Sun, 2008). The existing evidence on morphological analysis in elementary students supports this view. For example, Larsen and Nippold (2007) reported a notable improvement in the use of morphological analysis in Grade 3 students compared to first graders, with an even more substantial growth observed from the third to the fifth grade. Over time, adults’ morphological analysis allows for independent vocabulary development (Merkx et al., 2011; Tamminen et al., 2015). The point in children’s development at which their morphological analysis resembles that of adults remains unexplored.

Interventions to Support Morphological Analysis

There is evidence to suggest that morphological analysis can be taught (Baumann et al., 2002, 2003) and that interventions on morphology can be effective for improving the vocabulary of typically developing children (Bowers et al., 2010; Goodwin & Ahn, 2013; Reed, 2008). A meta-analysis (Goodwin & Ahn, 2013) on morphological interventions reported a moderate effect size ($d = 0.34$) on vocabulary with grade level and study design (experimental vs. quasi-experimental) emerging as the only significant moderating factors. However, the conclusions drawn come from only eight studies, indicating the need for further research into the ideal form and timing of instruction that best benefits students across various grade levels.

Instruction can be explicit, where objectives and rules are clearly outlined; or implicit, where learning occurs unintentionally through exposure to multiple examples without any reference to the rules (Burton et al., 2021). Many studies in the broader education literature have demonstrated advantages for explicit instruction over more implicit approaches (see e.g., Rastle et al., 2021). However, only a small number of studies have directly compared these two approaches to morphology instruction. In one intervention study, Bryant et al. (2006) compared implicit versus explicit teaching of the spelling differences between the suffixes -ian and -ion to 9-year-old students. Participants were divided into two groups exposed to the same target words. While the explicit group was provided with the morphological rule explaining the choice of one suffix over the other (specifically, the person/non-person principle for the use of -ian and -ion), the implicit group was left to discover this rule independently based on the implicit morphological cues of the words (e.g., “magician”, “vegetarian”, vs. “education”, "institution”). The findings revealed that those who received explicit instruction performed better at a spelling task, especially when it came to words requiring knowledge transfer (i.e., words not included in the training, but whose spelling could be inferred following the same morphological rule). Similar results that support the benefits of explicit over implicit instruction in morphological spelling rules were reported for students with spelling difficulties (Kemper et al., 2012), and with delayed post-testing happening 2 weeks after training (Burton et al., 2021).

These studies mainly focused on the spelling dimension of words and did not explore the role of morphology in enhancing meaning. However, empirical studies have shown that morphological knowledge is multidimensional. This complexity is evident in the results of various studies with morphological tasks, which do not converge on a single factor (Apel et al., 2013, 2022; Goodwin et al., 2017, 2021). The Morphological Pathways Framework

(Levesque et al., 2021) also supports this notion theoretically, suggesting that morphemes contain information in more than one dimension (e.g., phonology, orthography, semantics, syntax). Although these dimensions interact, they can be considered distinct processes having different weights in their contribution to literacy outcomes such as word decoding, spelling, or reading comprehension. With this in mind, there is no guarantee that knowing the form (spelling) of the learned affixes will translate into knowing their meaning. Knowledge of the meanings of morphologically complex words may be important for reading comprehension (see Nippold, 2018), and this may be particularly true for older elementary students who counter an increasing number of morphologically complex words as they move through schooling (Dawson et al., 2023; Kearns & Hiebert, 2022). However, considering that older students have accumulated more experience in engaging in morphological analysis with previously encountered words, it remains uncertain whether they will still derive additional benefits from explicit instruction. Therefore, a study comparing the effects of explicit and implicit teaching on both form and meaning outcomes is needed.

Finally, numerous factors can influence the learning outcomes of morphological instruction. The use of real words, while more ecologically valid, poses challenges in maintaining control over stimulus characteristics and the information available to learners. Students come to instruction with different levels of vocabulary and morphological knowledge, so the use of novel experimenter-designed words allows experimenters to ensure that all participants are learning truly novel words, and as suggested by Merkx et al. (2011), it can provide an avenue for precise experimental control. For example, it is important to separately consider the frequencies of a word's base and affixes, as they may affect target words' processing and acquisition (Carlisle & Katz, 2006; Ford et al., 2010; Taft, 2004).

Furthermore, it is important to consider how the affixes may induce orthographic, semantic, and/or phonological changes to the base (see Sénéchal & Kearnan, 2007).

The Present Study

Following Merkx et al. (2011) we created target words containing experimenter-designed suffixes. For three training days, children were presented with paragraphs containing the target words in which the meaning of the novel suffixes remained consistent (i.e., -urf meaning a factory, in target words such as “booturf”: a boot factory or “boxurf”: a box factory). Children undergoing explicit training received guidance on how to break down the words’ constituent elements (morphemes) to understand their meaning. Conversely, implicit training focused on using words surrounding the targets as hints to derive meaning, never guiding the children’s attention to the co-occurrence of the suffixes in the targets. The purpose of this study was to compare the effects of explicit and implicit instruction on the morphological analysis abilities of Grade 3 and Grade 5 students.

The ultimate goal of children engaging in morphological analysis is to equip them with a generative tool that enables independent vocabulary expansion (refer to Carlisle, 2010, for a more detailed discussion). To test whether children truly engage in morphological analysis that serves them to transfer their knowledge to new contexts we included transfer words into our post-training tasks (i.e., transfer words were not included in training but included a trained suffix; thus, their meaning can be obtained only through morphological analysis). Considering grade level (Grade 3 and Grade 5) as a moderating factor, we set out to address two research questions:

RQ1: Is explicit instruction more effective than implicit instruction for teaching the forms and meanings of novel suffixes? To answer this question, we examined whether the form and the meaning of the novel suffixes were learned one day (immediate post-test) and one week (delayed post-test) after training concluded. Previous studies comparing explicit to implicit approaches for teaching morphological spelling rules found an advantage for explicit instruction (e.g., Bryant et al., 2006; Burton et al., 2021; Kemper et al., 2012). The understanding of a word using a morphological analysis approach requires first an analysis at the level of word form (i.e., spelling) and further an analysis at the level of word meaning. With this in mind, we hypothesized that explicit instruction would be more effective for both form and meaning outcomes. Further, we hypothesized that the difference between explicit and implicit conditions would be greater for the Grade 3 students, who have had less exposure to morphologically complex words and therefore fewer opportunities to implicitly develop morphological analysis skills independently.

RQ2: To what extent can knowledge transfer occur following implicit and explicit instruction? To answer this question, we compared performance in trained and transfer words. In line with previous studies that found evidence of transfer only after explicit instruction (e.g., Kemper et al., 2012), we hypothesized that transfer in Grade 3 students would be evident in the explicit condition, but not the implicit condition. Whether Grade 5 students benefit more from explicit instruction and can demonstrate transfer skills solely under this condition remains to be tested.

Method

Participants

To select our participants, we first sent letters describing the study to the families of 118 Grade 3 and 113 Grade 5 students attending four public elementary schools in Edmonton, Canada. The schools were located in different parts of the city in order to include as much as possible diverse demographics in our study. We obtained parental consent from 97 Grade 3 and 96 Grade 5 students with English as their first language and no report of any intellectual, behavioral, or sensory difficulties (based on school records). All students were tested on word reading accuracy and efficiency as part of the pre-training battery. Based on these results, five students (three in Grade 3 and two in Grade 5) were further removed from the study due to very low reading scores (standard scores lower than 70 in WRAT-5 word reading and TOWRE-2 word reading efficiency) as they would not be able to complete the activities included in the training.

The remaining 94 Grade 3 and 94 Grade 5 students were randomly assigned to a training condition, either implicit or explicit, through the use of an online random group generator (https://www.randomlists.com/team-generator). Once the study concluded, the data from 11 Grade 3 students and 8 Grade 5 students was further removed due to recurrent absences during testing or training. This left us with a final sample of 83 Grade 3 students, 41 in the implicit condition group (18 females, M_{age} = 8.3 years; *SD* = 0.41) and 42 in the explicit condition group (20 females, M_{age} = 8.4 years; *SD* = 0.41). For Grade 5, our final sample was 86 students, 43 in the implicit condition group (24 females, M_{age} = 10.4 years; *SD* = 0.39) and 43 in the explicit condition group (17 females, M_{age} = 10.3 years; *SD* = 0.49).

Research Design

The study followed an experimental design, with the same pre- and post-tests administered to all participants with three training days in between. We created two types of training to teach novel derived words presented in the context of short narratives. The novel words were created by attaching made-up derivational suffixes to real word bases. Each training session started by reading a passage that contained the target words, followed by three activities to help consolidate the meaning of the targets. Once training was completed, the knowledge of the form and meaning of the suffixes was tested one day (i.e., immediate post-test) and one week after training (i.e., delayed post-test).

Materials

Pre-training Battery (Background Measures)

Word Reading Accuracy. We administered the Word Reading task from the Wide Range Achievement Test-5 (WRAT-5 blue form; Wilkinson & Robertson, 2017). Participants were asked to read aloud 15 letters and 55 words of increasing difficulty. The task was discontinued after five consecutive errors and a participant's score was the total number of correctly read letters and words (max = 70). The raw score was subsequently converted to a standard score. Cronbach's alpha reliability has been reported to be 0.91 for Grade 3 and 0.95 for Grade 5 (Wilkinson & Robertson, 2017). The results from this task were used as exclusion criteria for the study (see Participants' section).

Word Reading Efficiency. We administered the Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE) tasks from the Test of Word Reading Efficiency (TOWRE-2, Form B; Torgesen et al., 2012). Students were given 45 seconds to read as many items as possible from a card (list form) containing either real words to test for word efficiency or pseudowords for phonemic decoding. These two item types were assessed independently (two different cards) and 45 seconds were given to each task. A participant's score was the total number of words read correctly within the time limit. The raw score was subsequently converted to a standard score. Torgesen et al. (2012) reported a test-retest reliability of 0.90 for SWE and 0.89 for PDE for children ages 8 to 12. Reliability in our sample was estimated by correlating the scores for the two tasks, $r = 0.78$ in Grade 3 and 0.79

in Grade 5. A composite score calculated by averaging the two scores was used in the analysis.

Vocabulary Knowledge. We administered the Listening Comprehension subtest from the Wechsler Individual Achievement Test-3 (WIAT-3; Wechsler, 2005). Participants were first asked to listen to a word provided orally by the examiner and then select one of four pictures that best depicted the word's meaning. The task was discontinued after four consecutive errors and a participant's score was the total number of correct responses (max = 19). The raw score was subsequently converted to a standard score. Cronbach's alpha reliability has been reported to be 0.85 for Grade 3 and 0.83 for Grade 5 (Wechsler, 2005).

Morphological Knowledge. The morphological knowledge task was adapted from Carlisle's (2000) morphological structure test. The task was divided into two sections, section 1 for derivation (e.g., Farm. My uncle is a _____ [farmer]) and section 2 for decomposition (e.g., Driver. Children are too young to _____ [drive]), of 15 items each. The items were of increasing difficulty, with the first items in each section being transparent (e.g., help-helpful) and the final items having orthographic and phonological transformations (e.g., deep-depth, produce-production). Both sections included a practice item that allowed for feedback. The section 1 derivation task was discontinued after four consecutive errors. Once the discontinuation rule was reached, or after all items were attempted, the participant proceeded to section 2. The same instruction and discontinuation rule was applied to section 2. Each section was scored separately, and the participant's score was the total number of correct responses (max =15 per section). A composite score, calculated by averaging the two scores, was used in the analysis. The complete task is available at https://osf.io/tw86u/?view_only=56e0048daf8d4d3986a2a0cd8736e338

Suffix Identification Task - Nonwords (SIT-N). The SIT-N was adapted from Apel et al. (2013). The SIT-N assessed the participant's ability to identify the form of the trained novel suffixes in a new context. To test this ability, three types of nonwords were included in the task 1) nonword bases + real suffixes (e.g., "geedable"), 2) nonword bases + trained pseudo-suffixes (e.g., "mirlnim"), and 3) nonword bases + untrained pseudo-suffixes (e.g., "splomnaf"). All nonwords bases were selected from the English Lexicon Project database (Balota et al., 2007) with the characteristics of being monosyllabic, three-to-five letters long (M = 4.4) and having an orthographic neighborhood density no higher than 25 (M = 5.81). The real suffixes used were highly frequent inflectional and derivational suffixes (-ing, -ful, -ist, -able, -less, -er, -est) taken from the MorphoLex database (Sánchez-Gutiérrez et al., 2018). The two types of pseudo-suffixes included, the four used to create the target words (-urf, -nim, -tep, -isp; pseudo-suffixes taken from Behzadnia et al., 2023) and four untrained pseudo-suffixes (-lef, -naf, -orp, -elp) that matched the trained ones on length (3 letters) and orthographic neighborhood (M = 2.75; Balota et al., 2007).

Each suffix/pseudo-suffix appeared four times for a total of 28 items that included real suffixes, 16 items that included trained pseudo-suffixes, and 16 items that included untrained pseudo-suffixes, which added up to 60 items. The task was done in silence without a discontinuation rule. Instructions given to the participants are provided in Appendix 2A. The SIT-N was included as part of the pre- and post-training battery. Cronbach's alpha reliability across time points ranged from 0.91 to 0.95 for Grade 3 and from 0.92 to 0.94 for Grade 5.

Training Material

Target Words: Novel Derived Words. The target words included in the training were created by attaching made-up derivational suffixes to real-word bases. The real-word bases were selected from the SUBTLEX-UK database (van Heuven et al., 2014). To prevent any interference from the base words in understanding the target words, we selected the base words that were highly frequent (*M* = 4.66, *SD* = 0.29; van Heuven et al., 2014), highly concrete (*M* = 4.88, *SD* = 0.11, max = 5; Brysbaert et al., 2014), and with an age of acquisition younger than 5 years old (*M* = 4.29, *SD* = 1.09; Kuperman et al., 2012). Furthermore, all our bases were free nouns with a maximum length of 5 letters (*M* = 4.0, *SD* = 0.6).

For the made-up suffixes, we selected four pseudo-suffixes taken from Behzadnia et al. (2023). The pseudo-suffixes selected had the characteristics of being monosyllabic three-letter combinations (i.e., -nim, -urf, -tep, -isp) with an orthographic neighbourhood density no higher than 11 (*M* = 2.75; Balota et al., 2007). The definitions assigned to the pseudo-suffixes were based on existing suffixes and aimed to be concrete (e.g., -isp: a person who makes…, -urf: a place where… is made). Adding the made-up suffixes to the real bases resulted in fully transparent derived words (i.e., no spelling nor phonological changes in the bases when adding the suffixes) that functioned as a noun with the only exception of the suffix -tep that functioned as an adjective (e.g., rocktep: made of rock). See Appendix 2B for a complete list of all target words.

Reading Passages. To make our training more ecologically valid, we introduced the novel target words in the context of a passage, as this resembles how students usually encounter unknown words (Marinellie & Kneile, 2012). We created three reading passages, one introduced at each day of training (a sample passage is provided in Appendix 2C). Each passage contained four target words, one for each of the four made-up suffixes created. For example, passage 1 contained the target words “booturf”, “hillnim”, “coatisp”, and “mudtep”. Thus, each passage included one examples of a word for each of the suffixes created, presenting one example per training day for a total of three examples. The sentences surrounding the target words had sufficient informative context so the students could infer the word's meaning. Concerning the passages' readability statistics, the length for each passage was between 106-114 words, the Flesch-Kincaid reading ease was in a range of 86.7 to 89.9, and the readability of each passage was in the grade-level range of 3.2 to 3.7 (calculated in Microsoft Word), which is at the grade level of our youngest participants.

Training Conditions. There were two training conditions: implicit and explicit. Both types of training shared a common goal: teaching students the definition of the target words. However, these conditions diverged in their approach. For the explicit condition students were required to look inside the word and identify its constituent elements (morphemes) to analyze the word, while implicit training encouraged students to look outside the word for clues that could help them infer the meaning of the words.

Both conditions included four activities: 1) reading the day's passage and finding the target words of the lesson, 2) individually completing a worksheet, 3) working as a group on a semantic map (for the implicit condition) or a morphological matrix (for the explicit condition; Ng et al., 2022), and 4) working together to identify the correct use of the target words in a sentence (target word in context). To reduce extraneous differences between the training conditions, and to isolate the key ingredients of explicit and implicit instruction, we decided to keep the first and last activity precisely the same for both trainings. Thus, the differences between the implicit and the explicit conditions were only found in the second and third activities. We describe, by type of condition, these two activities below.

Implicit Condition. For activity two, the completion of a worksheet, the participants were asked to write the target word and one or two words found in the text that could help them figure out the meaning. The subsequent activity (activity number 3) included a semantic map, and participants had to choose which two of four words were most closely related in meaning to the target (e.g., for the target word "booturf", a boot factory, the word "machines" is more closely related in meaning than the word "clown"). For both activities, participants always discussed the rationale of their responses among themselves and with the trainer.

Explicit Condition. The worksheet for the explicit group required participants to write the target word and divide it into its base and suffix. The next consolidation activity (activity number 3) included a morphological matrix. Participants had to choose from four words the two that best functioned as a base for the target suffix, in terms of meaning (e.g., for the suffix -urf, a factory of…, the base word "coin" works better than the base word "shark").

Finally, the last activity, which was the same for both types of training, included two sentences the trainer read aloud. Both sentences included the target word, but only one used it correctly. The participants had to work as a group to choose the correct sentence. A complete example of a training session for both the implicit and the explicit condition is available at https://osf.io/tw86u/?view_only=56e0048daf8d4d3986a2a0cd8736e338

Testing for Learning (Post-training Battery)

Two post-training testing sessions, immediate and delayed, included one activity to evaluate the participants' recognition of the form of the novel pseudo-suffixes included in the target words (SIT-N task), and two activities to assess the participants' semantic knowledge of two types of words: 1) words included during training (trained words), and 2) words that were not part of the training but their meaning could be inferred as a result of the training (transfer words). The transfer words included one trained suffix attached to a base word that was never shown during training but was matched to the trained ones on frequency, length, level of concreteness, and age of acquisition. See Appendix 2B for a complete list of all transfer words.

Oral Word Definition. In this task, participants were asked to orally define a word given by the experimenter. There were 24 words divided into 12 trained words and 12 transfer words. Since answers for this task were scored with a range of 0-2 (see scoring), the maximum possible score was 48. Cronbach's alpha reliability in our sample was 0.91 for Grade 3 and 0.90 for Grade 5.

Multiple Choice. In this task, the same words from the oral definition task were tested in a multiple-choice format. Each question included the definition of one trained or transfer word along with four options that included the base of the target word attached to each one of the four trained suffixes (e.g., what word means "a boot factory"? a) bootnim, b) bootep, **c) booturf**, d) bootisp). All questions had only one correct answer, given 1 point if correct, for a maximum score of 24 points. Cronbach's alpha reliability in our sample was 0.92 for Grade 3 and 0.91 for Grade 5.

Scoring

The SIT-N and the multiple-choice tasks were scored with 1 or 0 for either correct or incorrect answers using an answer key. The oral word definition task was scored on a 3-point scale with a response criterion of 0 for incorrect responses (including omissions), 1 for partially correct responses that mentioned either the base word or the meaning of the suffix, and 2 for full credit when the response included both the base word and the correct suffix meaning. For example, the word "booturf" would receive 2 points (full credit) for a response such as *boot factory* or *the place where boots are made*, 1 point (partial credit) for a response such as *old boots*, and 0 points for responses such as *new toy*. A trained research assistant did the scoring for all tests. Furthermore, the first author independently scored a set of randomly selected tests (20% from the entire number of tests), resulting in a 98.89% agreement score. Any disagreements were resolved in consultation with the second author.

Procedure

Testing took place during the last two weeks of November (three months after the beginning of the school year in Canada). All testing and training were administered during school hours by trained research assistants. All tasks in the pre-intervention battery were administered in a quiet room in a one-on-one session that lasted approximately 20 minutes. Two to three days later, participants received one type of training (either implicit or explicit) in small groups of four to five students from the same grade level. Following ethics requirements, all training sessions started by making clear that the target words included in the activities were not real. To motivate the learning of the made-up words, we included a spy theme and told the participants we were learning the words to crack a secret code. Both types of intervention followed the same process that started with a passage read aloud by the experimenter (all participants had a copy of the passage so they could follow the reading on their own) and the identification, as a group, of the four target words for the lesson. Subsequently, each target word was studied individually with three consolidation activities aimed to reinforce its definition. Considering all activities, each target word was repeated approximately six times. The training ended with the students working together to solve a part of the secret code. Training under the two conditions lasted around 20 minutes, including the session's introduction and the secret code activity.

After three consecutive training days, participants were tested on word learning one day after (immediate post-test) and one week after (delayed post-test). Post-test sessions were divided into two parts. First, students were tested individually on the SIT-N and the oral word definition task. After all participants were tested, small groups (different from the ones in which they received the training) were created to test the participants' knowledge using the multiple-choice task. For this task, children were situated in the same room with a seating arrangement that prevented them from looking into one another's work. They were instructed to complete their work individually and in silence. Individual post-tests lasted about 15 minutes, and group post-tests ranged from 10 to 15 minutes.

Trainers

All the trainers were university students majoring in elementary education or psycholinguistics and had prior experience working with children. They underwent two training sessions in small groups of four. In the initial training session, the trainers assumed the role of children, and the first author demonstrated a session for either the implicit or explicit condition. After addressing all questions, the first author provided all the necessary materials to each trainer. Two to three days later, each trainer had an individual session, where they were required to model the first lesson of their assigned training. Each trainer received training in only one type of instruction, either implicit or explicit. Importantly, the trainers were blind to the existence of the other type of training or the purpose of the study (i.e., comparing implicit and explicit teaching methods).

Treatment Fidelity

To evaluate how well the training was implemented, the first author observed each trainer twice and scored their implementation using a 3-point scale (0= insufficient, 1= limited, and 2= proficient) that evaluated content completion, order of delivery, time management, quality of instruction, and student behaviour. The first observation happened during each trainer's first session with children. Immediate feedback was provided to the trainer (using the rubric as a guide). The second observation was done a day later and primarily focused on any issues identified during the first observation. Issues identified were mostly related to time management and student behaviour and were addressed properly by the trainers. No trainer had to be removed from the study due to problematic implementation.

Statistical Analysis

To examine the effects of both participant-level and item-level factors, we utilized mixed effects models for each outcome measure. Specifically, we fitted cumulative link mixed effects models for the word definition task with the trinomial dependent variable (coded as 0 for incorrect, 1 for partially correct, and 2 for fully correct). For the multiple-choice task and the SIT-N, we fitted logistic mixed effects models with the binomial dependent variables (coded as 0 for incorrect and 1 for correct). Because the number of observations for our models was relatively modest (ranging from 1621 to 2064), we estimated separate models for each grade and testing point. The models included the fixed effects of word reading (a composite of SWE and PDE), vocabulary, morphological knowledge (a composite of derivation and decomposition), Condition, Word type, and the interaction between Condition and Word type, as well as the between-participant random effect of Word type and the between-item random effect of Condition (see the footnotes of the tables for the model equations). Word reading, vocabulary, and morphological knowledge were centered before the analyses.

Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. The coefficient for Condition therefore reflected the relative advantage of students' performance in the explicit group over the implicit group. Word type was coded as 0 and 1 for the untrained and trained words, respectively, in the models for the word definition and multiple-choice tasks; its coefficient, therefore, reflected the advantage of students' performance for the trained items over the untrained items. On the other hand, Suffix type was coded with two contrasts for the SIT-N using the contr.sdif function in the MASS package (version 7.3-60; Venables & Ripley, 2002): -0.66, 0.33, 0.33 and -0.33, -0.33, 0.66. The first contrast tested real suffixes versus trained pseudo-suffixes; the second contrast tested trained pseudo-suffixes versus untrained pseudo-suffixes. Finally, the marginal and conditional R^2 values were calculated using the MuMIn package (version 1.47.5; Barton, 2019). Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013).

All statistical analyses were performed using R (version 4.3.0; R Core Team, 2023) via RStudio (version 2023.06.0+421; RStudio Team, 2020). The cumulative link mixed models for the definition task were fit using the clmm function in the ordinal package (version 2022.11-16; Christensen, 2018) and the logistic mixed models for the multiple-choice task and the SIT-N were fitted using the glmer function in the lmerTest package (version 3.1-3; Kuznetsova et al., 2017). The data and the analysis code for the models are available at https://osf.io/tw86u/?view_only=56e0048daf8d4d3986a2a0cd8736e338

Results

Preliminary Data Analysis

Descriptive statistics for word reading, vocabulary, and morphological knowledge are shown in Table 1.2. To test whether the pre-intervention performance levels on these variables were well-controlled across conditions, we performed 2 (Grade: Grade 3 versus Grade 5) × 2 (Condition: explicit versus implicit) ANOVAs. All assumptions for the ANOVA test were met in our sample. Results showed that the only significant differences were between Grade 3 and Grade 5 for the morphological knowledge measures, $F(1, 165) = 33.44$, $p < .001$ for derivation and $F(1, 165) = 66.94$, $p < .001$ for decomposition. In contrast, no significant differences were found between the explicit and implicit conditions, and there was also no significant interaction between Grade and Condition (all *p*s > .10), demonstrating that students' pre-intervention performance levels were well-controlled between the two conditions.

Table 1.2

Descriptive Statistics for the Word Reading, Vocabulary, and Morphological Knowledge Measures

	Grade 3				Grade 5			
	Explicit (*N* = 42)		Implicit (*N* = 41)		Explicit (*N* = 43)		Implicit (*N* = 43)	
Variables	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
SWE	105.88	11.57	103.68	13.73	103.98	13.53	101.93	11.74
PDE	103.86	9.83	102.93	15.62	103.53	15.24	103.70	13.97
Vocabulary	105.38	14.01	108.46	15.12	108.40	10.74	105.84	15.22
MK_Deriv	8.31	3.39	7.66	3.53	10.21	2.98	11.23	2.28
MK_Decom	11.33	2.70	10.63	2.90	13.77	1.36	13.67	1.25

Note. SWE = sight word efficiency; PDE = phonemic decoding efficiency; MK_Deriv = morphological knowledge_derivation; MK_Decom = morphological knowledge_decomposition.

Descriptive statistics for the word definition, multiple choice, and SIT-N tasks are shown in Table 2.2 and correlations between all variables are shown in Table 3.2. Overall, vocabulary and morphological knowledge were weakly to moderately correlated with the word definition and multiple-choice tasks. In addition, word reading, vocabulary, and morphological knowledge were weakly correlated with the SIT-N in Grade 3 but less so in Grade 5.

Table 2.2

Descriptive Statistics for the Definition, Multiple Choice, and SIT-N Tasks

	Grade 3				Grade 5			
	Explicit (*N* = 42)		Implicit (*N* = 41)		Explicit (*N* = 43)		Implicit (*N* = 43)	
Variables	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Definition (max=2)								
Immediate test								
Trained	1.74	0.25	1.54	0.37	1.87	0.17	1.71	0.31
Untrained	1.68	0.28	1.41	0.41	1.83	0.21	1.65	0.36
Delayed test								
Trained	1.67	0.29	1.46	0.35	1.72	0.30	1.54	0.37
Untrained	1.54	0.38	1.06	0.49	1.70	0.27	1.30	0.44
Multiple choice (max=2)								
Immediate test								
Trained	0.84	0.26	0.74	0.29	0.90	0.19	0.87	0.21
Untrained	0.83	0.27	0.66	0.30	0.89	0.18	0.87	0.21
Delayed test								
Trained	0.82	0.22	0.75	0.23	0.90	0.18	0.86	0.21
Untrained	0.81	0.23	0.63	0.29	0.89	0.18	0.84	0.23
SIT-N (max=1)								
Pre test								
Real suffix	0.55	0.20	0.54	0.22	0.62	0.22	0.67	0.24
Trained	0.21	0.28	0.20	0.25	0.13	0.25	0.24	0.33
Untrained	0.22	0.32	0.20	0.27	0.17	0.29	0.26	0.34
Immediate test								
Real suffix	0.66	0.17	0.65	0.17	0.73	0.21	0.77	0.18
Trained	0.77	0.27	0.66	0.32	0.72	0.34	0.66	0.31
Untrained	0.45	0.39	0.40	0.34	0.28	0.38	0.36	0.42
Delayed test								
Real suffix	0.71	0.15	0.74	0.16	0.79	0.20	0.82	0.16
Trained	0.83	0.22	0.76	0.28	0.82	0.34	0.69	0.36
Untrained	0.44	0.38	0.50	0.35	0.29	0.37	0.48	0.40

Note. SIT-N = Suffix Identification Task-Nonwords

Table 3.2

Correlations Among the Variables Used in the Study

Variables	1	2	3	4	5	6	7	8	9	10
Grade 3										
1. Word reading		.21	.29**	.12	.05	.23*	.35**	.14	.26*	.14
2. Vocabulary	.22		.32**	.28*	.40**	.21	.29*	.23*	.22	.12
3. Morphological knowledge	.34**	.32**		.35**	.36**	.44**	.38**	.19	.28*	.16
4. Definition_Immediate	.20	.30*	.39**		.81**	.66**	.72**	-.07	.13	.16
5. Definition_Delayed	.11	.42**	.36**	.84**		.60**	.68**	.04	.17	.18
6. MC_Immediate	.24*	.17	.39**	.61**	.53**		.74**	.07	.23*	.31**
7. MC_Delayed	.40	.29*	.38**	.70**	.66**	.69**		.01	.24*	.25*
8. SIT-N_Pre	.17	.25*	.23*	.00	.10	.10	.09		.35**	.14
9. SIT-N_Immediate	.26*	.27*	.26*	.19	.18	.25*	.21	.37**		.68**
10. SIT-N_Delayed	.18	.16	.13	.11	.15	.37**	.19	.20	.75**	
Grade 5										
1. Word reading		.13	.34**	.13	.02	.15	.24*	.09	.10	.08
2. Vocabulary	.16		.31**	.13	.30*	.07	.21	.07	.10	.07
3. Morphological knowledge	.35**	.33**		.24*	.40**	.20	.20	.09	.00	-.01
4. Definition_Immediate	.17	.27*	.28*		.45**	.61**	.64**	-.18	.05	.25*
5. Definition_Delayed	.01	.36**	.35**	.59**		.16	.30*	-.08	.08	.24*
6. MC_Immediate	.04	.07	.17	.68**	.27*		.63**	-.14	-.03	.14
7. MC_Delayed	.21	.20	.23*	.71**	.40**	.75**		-.15	.00	.07
8. SIT-N_Pre	.14	.02	.10	-.14	-.08	-.18	-.14		.48**	.30*
9. SIT-N_Immediate	.11	.11	-.04	.10	.09	.03	.03	.37**		.63**
10. SIT-N_Delayed	.15	.14	.08	.28*	.29*	.24*	.12	.25*	.73**	

Note. Entries below and above the diagonals are Pearson's *r*s and Spearman's ρs, respectively. SIT-N = Suffix Identification Task-Nonwords; MC = multiple choice.

**p* < .05. ***p* < .01.

Mixed Effects Models

The results of the cumulative link mixed effects models for the definition task in each grade are shown in Tables 4.2 and 5.2. For Grade 3, both Condition and Word type had a significant effect on students' performance in the immediate (Condition: estimate = 1.417, p = .004; Word type: 0.610, p = .024) and delayed tests (Condition: estimate = 1.974, p < .001; Word type: 1.515, p < .001), indicating higher scores following explicit training and for trained words. In addition, the interaction between Condition and Word type was significant in the delayed post-test (estimate = -1.112, p = .029), indicating that the difference between trained and untrained words was larger in the implicit condition than in the explicit condition (see Figure 1.2). For Grade 5, Condition, but not Word type, had a significant effect on students' performance in the immediate post-test (estimate = 1.221, p = .035), indicating higher scores following explicit training. Both Condition and Word type had a significant effect in the delayed post-test (Condition: estimate = 1.357, p = .004; Word type: 0.862, p < .001). The interaction between Condition and Word type was not significant at either testing point.

Table 4.2

Cumulative Link Mixed Models for the Definition Task in Grade 3

	Immediate test				Delayed test			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	-0.044 (0.289)	-0.612	0.523	.878	-0.187 (0.252)	-0.680	0.307	.458
Vocabulary	0.027 (0.013)*	0.002	0.053	.034	0.045 (0.011)***	0.023	0.067	<.001
Morph. knowledge	0.845 (0.319)**	0.219	1.471	.008	0.583 (0.271)*	0.051	1.115	.032
Condition	1.417 (0.498)**	0.441	2.392	.004	1.974 (0.497)***	1.000	2.949	<.001
Word type	0.610 (0.271)*	0.079	1.140	.024	1.515 (0.403)***	0.726	2.304	<.001
Condition x Word type	-0.535 (0.475)	-1.466	0.396	.260	-1.112 (0.508)*	-2.107	-0.117	.029
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	2.531	1.591			2.606	1.614		
Participant (Word type)	0.061	0.247			0.651	0.807		
Items (Intercept)	0.283	0.532			0.737	0.858		
Items (Condition)	1.022	1.011			1.066	1.033		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.135	.525			.197	.541		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013). Model equation: Definition ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 + Word_type | ID) + (1 + Condition | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5.2

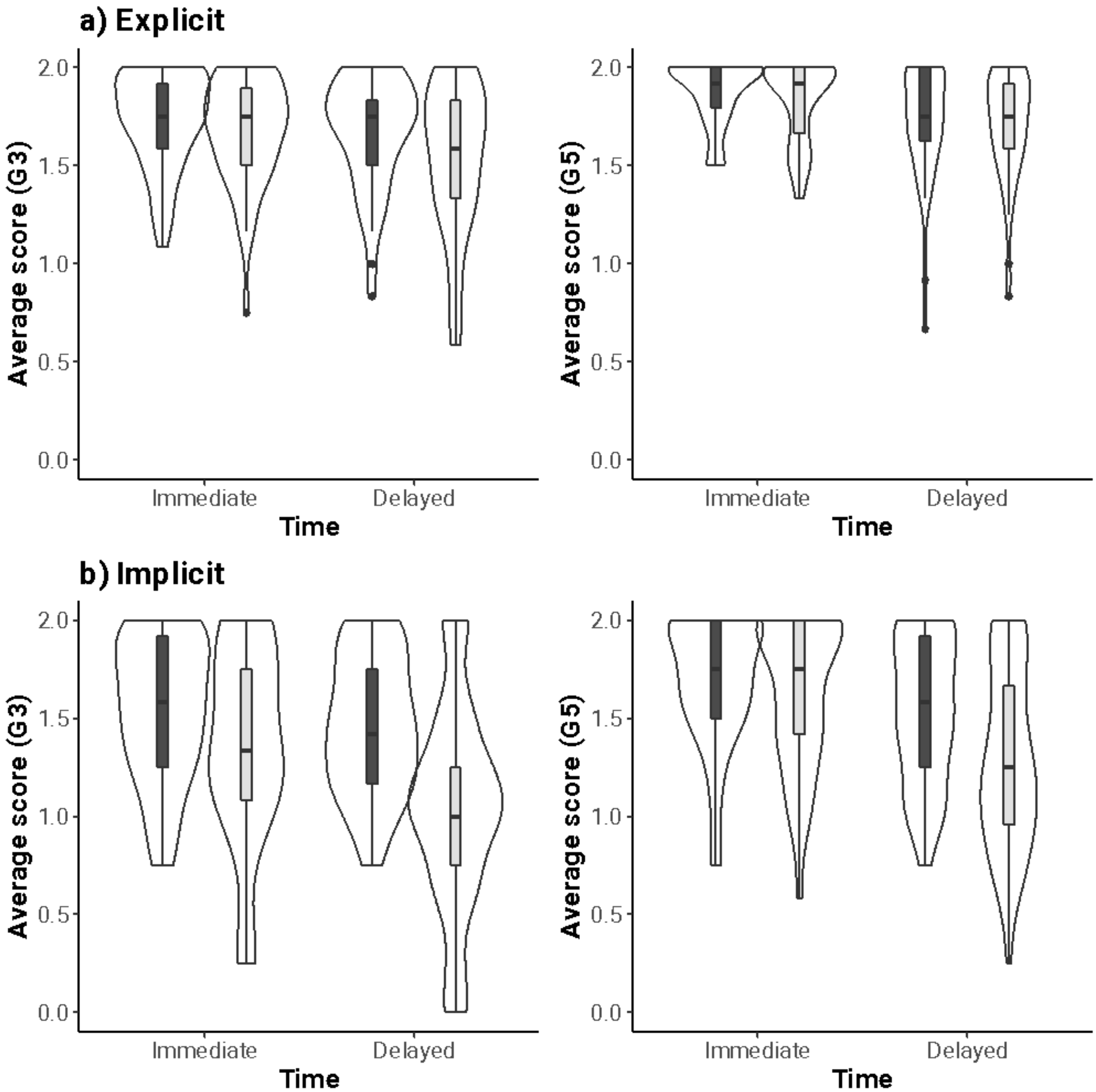
Cumulative Link Mixed Models for the Definition Task in Grade 5

	Immediate test				Delayed test			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.142 (0.412)	-0.666	0.950	.730	-0.080 (0.287)	-0.642	0.482	.781
Vocabulary	0.019 (0.021)	-0.022	0.060	.356	0.031 (0.014)*	0.003	0.059	.028
Morph. knowledge	1.021 (0.490)*	0.060	1.982	.037	0.336 (0.351)	-0.352	1.023	.339
Condition	1.221 (0.580)*	0.085	2.358	.035	1.357 (0.385)***	0.602	2.112	<.001
Word type	0.309 (0.345)	-0.368	0.986	.371	0.862 (0.210)***	0.450	1.274	<.001
Condition x Word type	-0.036 (0.440)	-0.898	0.826	.934	-0.426 (0.303)	-1.019	0.167	.159
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	4.195	2.048			2.060	1.434		
Participant (Word type)	0.001	0.015			0.001	0.004		
Items (Intercept)	0.385	0.621			0.122	0.349		
Items (Condition)	0.700	0.837			0.268	0.517		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.104	.627			.114	.473		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013). Model equation: Definition ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 + Word_type | ID) + (1 + Condition | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively. *$p < .05$. **$p < .01$. ***$p < .001$.

Figure 1.2

Box and Violin Plots for the Average Scores on the Definition Task



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark grey indicate the trained items, and plots in light grey indicate the untrained items.

Next, the results of the logistic mixed effects models for the multiple-choice task are shown in Tables 6.2 and 7.2. The random effects of Condition and Word type were dropped, as the models failed to converge or a singular fit was observed even after changing the optimizer to bobyqa and increasing the maximum iterations (Brauer & Curtin, 2018; Matuschek et al., 2017). Therefore, the models without random effects were considered the final models (see the footnotes of the tables for the model equations). For Grade 3, both Condition and Word type had a significant effect on students' performance in the immediate post-test (Condition: estimate = 1.563, p = .009; Word type: 0.566, p = .029) and delayed post-test (Condition: estimate = 1.364, p = .002; Word type: 0.821, p = .001), indicating higher scores following explicit training and for trained words. In addition, the interaction between Condition and Word type was significant in the delayed post-test (estimate = -0.746, p = .029), indicating that the difference between trained and untrained words was larger in the implicit condition than in the explicit condition (see Figure 2.2). In contrast, for Grade 5, neither the effects of Condition and Word type nor their interaction were significant at either testing point.

Table 6.2

Generalized Mixed Models for the Multiple-Choice Task in Grade 3

	Immediate test				Delayed test			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.649 (0.470)	-0.272	1.570	.167	0.846 (0.350)*	0.160	1.532	.016
Vocabulary	0.035 (0.021)	-0.007	0.076	.102	0.045 (0.016)**	0.013	0.077	.005
Morph. knowledge	1.220 (0.507)*	0.226	2.215	.016	0.719 (0.381)	-0.028	1.466	.059
Condition	1.563 (0.597)**	0.393	2.732	.009	1.364 (0.443)**	0.497	2.232	.002
Word type	0.566 (0.260)*	0.057	1.075	.029	0.821 (0.241)***	0.349	1.292	.001
Condition x Word type	-0.420 (0.288)	-0.984	0.144	.145	-0.746 (0.259)**	-1.253	-0.239	.004
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	5.003	2.237			2.767	1.664		
Items (Intercept)	0.216	0.465			0.174	0.417		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.198	.690			.218	.587		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013). Model equation: Multiple_choice ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 7.2

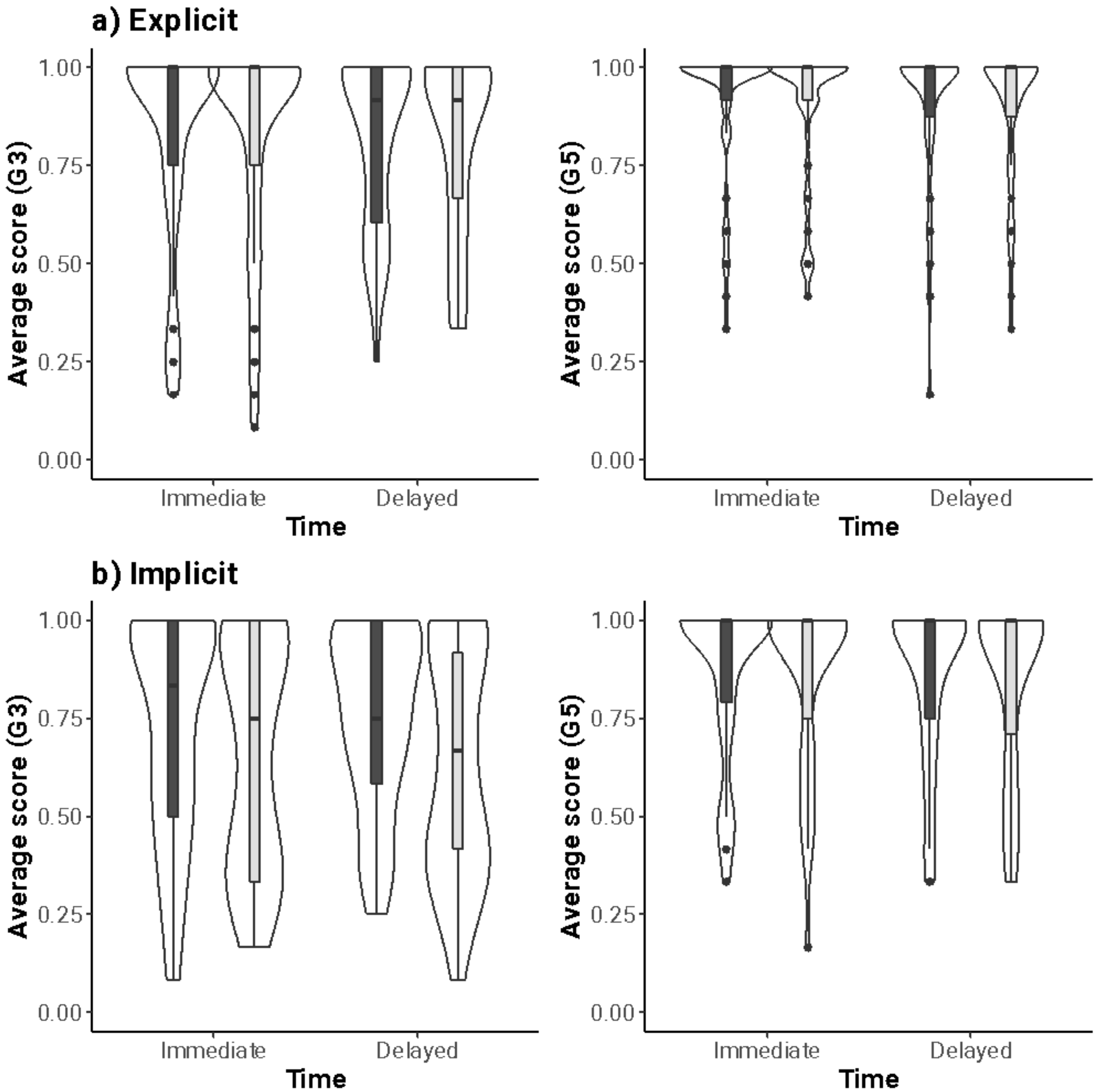
Generalized Mixed Models for the Multiple Choice Task in Grade 5

	Immediate test				Delayed test			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.598 (0.641)	-0.657	1.854	.350	0.751 (0.517)	-0.261	1.764	.146
Vocabulary	-0.001 (0.030)	-0.060	0.058	.975	0.031 (0.025)	-0.017	0.080	.207
Morph. knowledge	1.060 (0.693)	-0.298	2.419	.126	0.371 (0.596)	-0.797	1.539	.534
Condition	0.541 (0.758)	-0.944	2.025	.475	0.450 (0.636)	-0.797	1.697	.479
Word type	0.109 (0.301)	-0.481	0.699	.717	0.213 (0.258)	-0.292	0.718	.408
Condition x Word type	0.088 (0.344)	-0.586	0.763	.798	-0.026 (0.328)	-0.668	0.617	.938
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	8.000	2.828			5.578	2.362		
Items (Intercept)	0.222	0.471			0.118	0.343		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.061	.732			.073	.661		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Model equation: Multiple_choice ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively.
**p* < .05. ***p* < .01. ****p* < .001.

Figure 2.2

Box and Violin Plots for the Average Scores on the Multiple Choice Task



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark grey indicate the trained items, and plots in light grey indicate the untrained items.

Finally, the results of the logistic mixed effects models for the SIT-N are shown in Tables 8.2 and 9.2. The random effects of Condition and Suffix type were dropped from the final models as the models failed to converge or a singular fit was observed. For Grade 3, the first contrast (real suffixes versus trained pseudo-suffixes), but not the second contrast (trained pseudo-suffixes versus untrained pseudo-suffixes) of Suffix type had a significant effect on students' performance in the pre-test (estimate = -1.163, $p = .007$). In contrast, the opposite pattern was observed for the immediate and delayed post-tests: The second contrast, but not the first contrast, of Suffix type had a significant effect on students' performance in both immediate (estimate = -0.897, $p = .020$) and delayed post-tests (estimate = -0.959, $p = .006$). These results indicated that while both types of pseudo-suffixes behaved similarly in the pre-test, trained pseudo-suffixes behaved more like real suffixes than untrained pseudo-suffixes (see Figure 3.2). However, neither the effect of Condition nor the interaction between Condition and Suffix type was significant at any testing point.

Table 8.2

Generalized Mixed Models for the SIT-N in Grade 3

	Pre test				Immediate test				Delayed test			
		95% CI				95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.223 (0.184)	-0.137	0.584	.224	0.253 (0.127)*	0.004	0.501	.046	0.211 (0.128)	-0.040	0.463	.099
Vocabulary	0.010 (0.008)	-0.006	0.025	.211	0.006 (0.006)	-0.005	0.017	.276	0.007 (0.006)	-0.004	0.018	.235
Morph. knowledge	0.430 (0.196)*	0.045	0.814	.028	0.370 (0.136)**	0.104	0.636	.006	0.152 (0.136)	-0.115	0.419	.265
Condition	-0.045 (0.223)	-0.481	0.391	.840	0.093 (0.155)	-0.211	0.397	.548	-0.100 (0.157)	-0.408	0.207	.522
Suffix type (RS vs PS_T)	-1.163 (0.430)**	-2.006	-0.320	.007	0.156 (0.340)	-0.511	0.822	.648	0.137 (0.310)	-0.471	0.745	.659
Suffix type (PS_T vs PS_UT)	-0.130 (0.488)	-1.087	0.827	.790	-0.897 (0.384)*	-1.650	-0.144	.020	-0.959 (0.346)**	-1.637	-0.282	.006
Cond x ST (RS vs PS_T)	-0.281 (0.284)	-0.838	0.276	.323	0.293 (0.254)	-0.205	0.791	.248	0.314 (0.267)	-0.210	0.837	.240
Cond x ST (PS_T vs PS_T)	0.209 (0.329)	-0.435	0.853	.525	-0.208 (0.287)	-0.771	0.354	.468	-0.329 (0.295)	-0.907	0.249	.264
Random Effects	Variance	*SD*			Variance	*SD*			Variance	*SD*		
Participant (Intercept)	0.652	0.807			0.234	0.484			0.231	0.480		
Items (Intercept)	0.371	0.609			0.212	0.460			0.151	0.389		
Model fit	Marginal	Conditional			Marginal	Conditional			Marginal	Conditional		
R^2	.121	.329			.068	.179			.063	.160		

Note. CI = confidence interval; UL = upper limit; LL = lower limit; RS = real suffix; PS = pseudo-suffix; T: trained; UT = untrained; ST = Suffix type. Model equation: SIT_N ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded with two contrasts: -0.66, 0.33, 0.33 and -0.33, -0.33, 0.66; the first contrast tested real suffix versus trained pseudo-suffix; the second contrast tested trained pseudo-suffix versus untrained pseudo-suffix.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 9.2

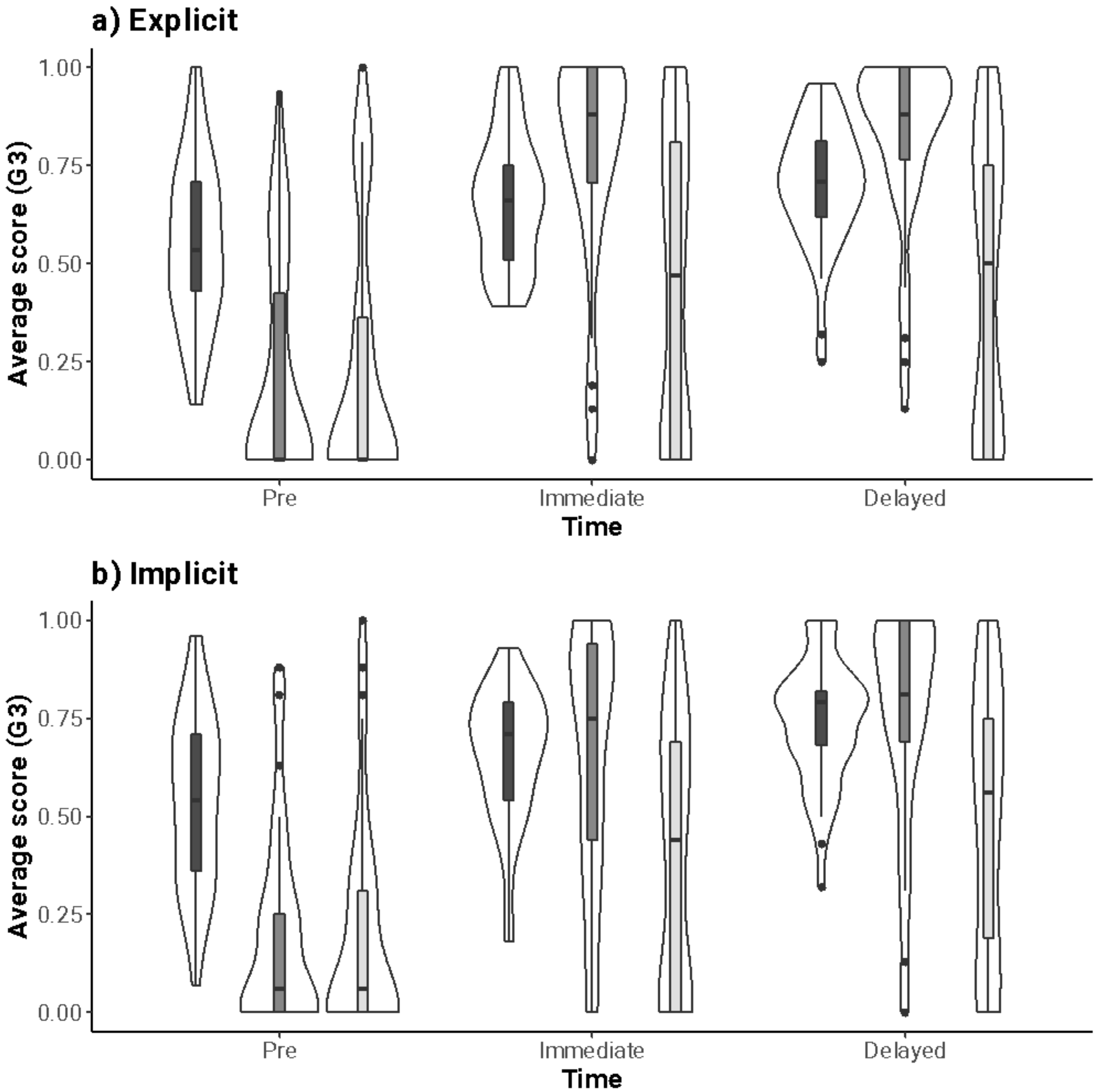
Generalized Mixed Models for the SIT-N in Grade 5

	Pre test				Immediate test				Delayed test			
		95% CI				95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.095 (0.194)	-0.285	0.475	.623	0.246 (0.132)	-0.012	0.505	.062	0.135 (0.139)	-0.138	0.408	.333
Vocabulary	0.004 (0.009)	-0.015	0.022	.699	0.009 (0.006)	-0.003	0.022	.155	0.004 (0.007)	-0.009	0.017	.575
Morph. knowledge	0.134 (0.222)	-0.301	0.569	.546	-0.067 (0.151)	-0.364	0.230	.658	0.109 (0.163)	-0.210	0.427	.503
Condition	-0.401 (0.238)	-0.867	0.065	.091	-0.116 (0.159)	-0.427	0.196	.468	-0.115 (0.169)	-0.447	0.216	.495
Suffix type (RS vs PS_T)	-1.799 (0.386)***	-2.556	-1.043	<.001	-0.506 (0.313)	-1.119	0.107	.106	-0.597 (0.261)*	-1.109	-0.085	.022
Suffix type (PS_T vs PS_UT)	0.084 (0.431)	-0.760	0.928	.845	-1.184 (0.352)***	-1.874	-0.495	<.001	-0.904 (0.284)**	-1.462	-0.347	.001
Cond x ST (RS vs PS_T)	-0.364 (0.305)	-0.961	0.233	.232	0.309 (0.250)	-0.181	0.799	.216	0.392 (0.262)	-0.121	0.905	.134
Cond x ST (PS_T vs PS_T)	0.176 (0.345)	-0.499	0.851	.610	-0.338 (0.283)	-0.894	0.217	.233	-0.771 (0.285)**	-1.329	-0.213	.007
Random Effects	Variance	*SD*			Variance	*SD*			Variance	*SD*		
Participant (Intercept)	0.808	0.899			0.276	0.526			0.337	0.581		
Items (Intercept)	0.268	0.518			0.169	0.412			0.086	0.293		
Model fit	Marginal	Conditional			Marginal	Conditional			Marginal	Conditional		
R^2	.178	.381			.126	.230			.128	.227		

Note. CI = confidence interval; UL = upper limit; LL = lower limit; RS = real suffix; PS = pseudo-suffix; T: trained; UT = untrained; ST = Suffix type. Model equation: SIT_N ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded with two contrasts: -0.66, 0.33, 0.33 and -0.33, -0.33, 0.66; the first contrast tested real suffix versus trained pseudo-suffix; the second contrast tested trained pseudo-suffix versus untrained pseudo-suffix.
**p* < .05. ***p* < .01. ****p* < .001.

Figure 3.2

Box and Violin Plots for the Average Scores on the SIT-N in Grade 3

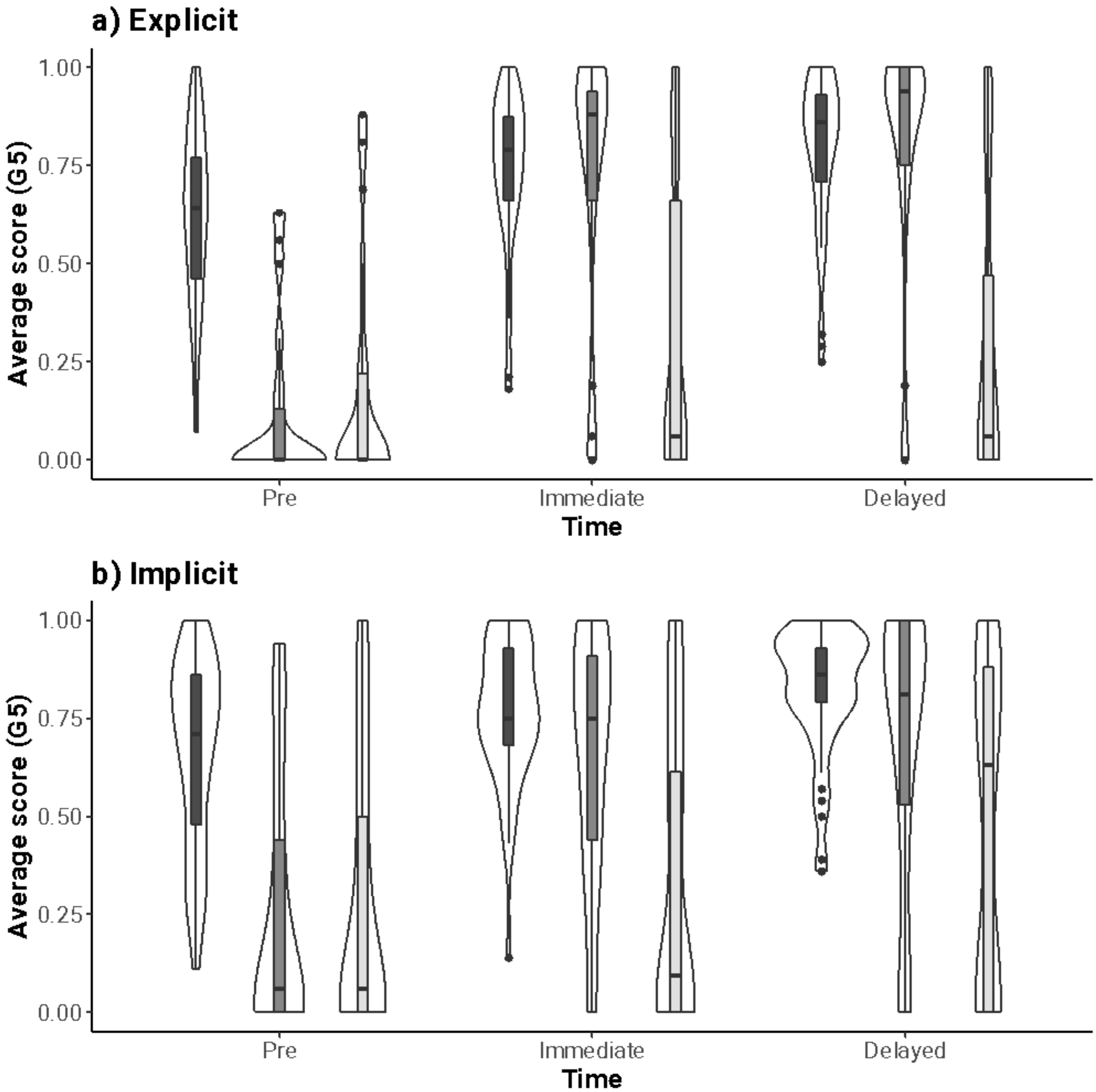


Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark gray indicate real suffixes, plots in medium gray indicate trained pseudo-suffixes, and plots in light gray indicate untrained pseudo-suffixes.

Similarly, for Grade 5, the first contrast of Suffix type (real suffixes versus trained pseudo-suffixes) had a significant effect in the pre- (estimate = -1.799, $p < .001$) and delayed post-tests (estimate = -0.597, $p = .022$), while the second contrast (trained pseudo-suffixes versus untrained pseudo-suffixes) only had a significant effect in the immediate (estimate = -1.184, $p < .001$) and delayed post-tests (estimate = -0.904, $p = .001$). In addition, the interaction between Condition and the second contrast of Suffix type was significant in the delayed post-test (estimate = -0.771, $p = .007$), indicating that the difference between trained and untrained pseudo-suffixes was larger in the explicit condition than in the implicit condition (see Figure 4.2).

Figure 4.2

Box and Violin Plots for the Average Scores on the SIT-N in Grade 5



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark gray indicate real suffixes, plots in medium gray indicate trained pseudo-suffixes, and plots in light gray indicate untrained pseudo-suffixes.

Discussion

The main goal of this study was to explore whether explicit instruction in morphological analysis provides any advantages over implicit teaching when acquiring the form and meaning of novel derivational suffixes encountered in print. The novel suffixes (e.g., -nim) were paired with real word bases (e.g., "hill" to create "hillnim") to create target novel words. Each suffix was presented three times each time with a different base (e.g., "hillnim", "desknim", "bellnim") but keeping the meaning consistent (-nim meaning a small…hill, desk, bell) to emphasize the implicit morphological information carried by the suffix. The use of the made-up suffixes ensured a uniform starting point for all participants by ruling out any prior knowledge. Additionally, these suffixes helped to carefully control the level of transparency and complexity of the target words. For three training sessions, Grade 3 and Grade 5 students were exposed to short narratives containing the target words. Throughout the training, the orthographic form and meaning of the suffixes embedded in the targets were either explicitly taught or left for students to discover independently through implicit training. By contrasting these two approaches, the present study aimed to answer two questions.

The first question concerned the overall effectiveness of explicit over implicit instruction: Is explicit instruction more effective than implicit instruction for teaching the forms and meanings of novel suffixes? To answer this question, we used one task to assess form, and two tasks to assess meaning and tested one day (immediate post-test) and one week after training ended (delayed post-test). Regarding form, we created three types of words by pairing pseudoword bases with 1) real suffixes (e.g., "trabless"), 2) trained pseudo-suffixes (e.g., "flomtep") and 3) untrained pseudo-suffixes (e.g., "mestnaf"). We then measured the students' ability to identify these suffixes. Results from both grade levels showed that before training, both types of pseudo-suffixes behaved similarly and as expected, participants' ability to identify them was significantly lower compared to real suffixes. After training, the trained pseudo-suffixes behaved more like the real suffixes, whereas the untrained pseudo-suffixes continued to exhibit significantly lower performance. These results suggest that Grade 3 and Grade 5 participants formed an orthographic representation of the trained suffixes during training, that could later be identified in an unfamiliar context. More specifically, Grade 3 results showed no effect of condition, suggesting that in both conditions (implicit and explicit) participants were able to form orthographic representations of the suffixes. This was true at both testing points. While our results contrast with previous studies favoring better outcomes in learning suffix forms following explicit training (Bryant et al., 2006; Kemper et al., 2012) there are two potential explanations for this. First, our suffixes caused no change to the bases, resulting in fully transparent target words; whereas the items used in earlier studies caused a phonological and/or orthographic shift to the bases (e.g., "magician", "education", see Bryant et al., 2006). Second, our tasks required students to identify the suffixes rather than writing or producing them. Prior studies used spelling tasks that might have been more challenging, a demand for which explicit instruction might better demonstrate its added benefits.

For Grade 5, there were no differences across conditions captured by the immediate post-test. However, in the delayed post-test, explicit teaching demonstrated an advantage. The results indicated that, at this testing point, more fifth graders in the implicit condition incorrectly identified untrained pseudo-suffixes. This observation might imply that at delayed post-test students were still aware of the presence of suffixes in the target words but struggled to accurately recall which specific ones were taught. In other words, there was more forgetting in the implicit condition than in the explicit condition.

To assess meaning, we used a multiple-choice task and a word definition task. Grade 3 students appeared to have learned suffixes' meanings significantly better under the explicit condition as shown by results from both tasks at both testing points. Results for Grade 5 students were less conclusive as only the scores from the definition task, but not the multiple-choice task, showed significantly better results following explicit over implicit instruction. This pattern held at both testing points.

Altogether, these results have two important implications. Firstly, they highlight the multidimensionality of morphological knowledge. According to the Morphological Pathways Framework (Levesque et al., 2021), morphemes carry information in multiple dimensions. For example, orthographic information aids in the process of morphological decoding, functioning at the word form level to facilitate the decomposition of morphologically complex words, a result captured by our SIT-N task. Conversely, morphological analysis operates at the level of word meaning, contributing to the understanding of such words. Within this framework, even as morphological decoding and morphological analysis interact with each other in the context of morphological analysis, they remain distinct processes. Our results support this view by providing evidence that while students can learn the form of novel suffixes implicitly, implicit instruction alone is insufficient to facilitate the acquisition of the words' meanings, which is better supported by explicit instruction.

The second implication is related to differences in our two tasks of meaning. While the benefits of explicit instruction were evident on both definition and multiple-choice assessments for students in Grade 3, this was not the case for Grade 5 students. For these more advanced readers, the difference across conditions was only detectable on the word definition task. However, results from the multiple-choice task displayed a ceiling effect under both conditions. This reflects the limitations of constrained-choice tasks (e.g., see Ursachi et al., 2015). Previous research has highlighted the advantages of using comprehensive, multifaceted tasks for assessing word meanings, especially the use of expressive tasks that can better evaluate the quality of a learner's word knowledge (Beck et al., 2013; Hadley & Dickinson, 2020; Pearson et al., 2007). Our results further support this view by illustrating how the use of different assessments can yield significantly different results. Building on the Lexical Quality Hypothesis (Perfetti, 2007) that presents word knowledge as a continuum ranging from low to high lexical quality, it is possible that our multiple-choice task tapped a shallow understanding of the suffixes that, at least for fifth graders, was acquired even without explicit instruction. Nevertheless, this "fast-mapped" knowledge proved insufficient to support more comprehensive learning (see Hadley & Dickinson, 2020). Our results suggest that a deeper understanding of the suffixes' meanings was only obtained through explicit instruction.

Our second research question concerned the possibility of knowledge transfer after each instruction: To what extent does knowledge transfer occur following implicit or explicit instruction? To answer this question, we compared the performance of both trained and transfer words at the two testing points (immediate and delayed post-test) on the meaning tasks. Our findings provide a mixed perspective on this issue, with variations in results depending on the grade level and testing point. For Grade 3, whereas there were no differences for transfer words across conditions at immediate post-test, delayed post-test scores favored explicit teaching. The results indicated that a week after training concluded, students who received implicit instruction experienced a decline in their understanding of transfer words, whereas those in the explicit condition largely sustained their learning. In other words, it appears that under both conditions children could learn the meaning of the suffixes presented, but that this knowledge was rather weak following implicit training and could not be sustained at delayed post-test. Only explicit teaching resulted in retention of the suffixes even after the training was over. The same pattern held for the word definition and the multiple-choice task.

The results from the Grade 5 students did not show significant differences between word types (trained vs. transfer) in either condition. There was evidence that older students in the implicit condition could develop some knowledge of suffix meanings even without seeing them in isolation and with only 3 examples, which is a remarkably smaller amount of contextual diversity than prior studies had used with adults (e.g., Merkx et al., 2012). However, the overall outcomes still favored explicit training for both word types and testing points (see Table 2.3). The absence of statistical differences between trained and transfer words suggested a similar decline in suffix knowledge for both groups, with consistently higher scores in the explicit group. Therefore, while there is evidence of suffix learning following implicit training in these older students, there is also evidence of an additional benefit for explicit instruction.

Our results for Grade 3 students largely align with those of previous studies comparing implicit and explicit instruction of morphological spelling rules in children within the same age range (7-to-9-year-olds; Burton et al., 2021; Kemper et al., 2012), and highlight the benefits students of this age can receive from explicit instruction to gain knowledge of the different types of information morphemes convey (orthographic, semantic). In turn, Grade 5 students seem to acquire morphological information implicitly better than Grade 3, supporting their vocabulary expansion through morphological analysis. Nonetheless, overall performance for both trained and transfer words following implicit instruction was weaker compared to explicit instruction. It is possible that having to do the morphological analysis of the words independently caused cognitive overload, limiting the information they could absorb (see Sweller, 2011, for a broader discussion about the cognitive load theory). This suggestion needs further exploration.

Taken together, our results support the use of explicit instruction when teaching morphological analysis. Notably, benefits for explicit instruction were obtained despite the minimal differences in instructional methodology between the two conditions. Our results showed that the inclusion of a 5-minute explicit morphological analysis activity led to significantly improved performance. These outcomes are consistent with prior interventions that integrated brief morphological awareness activities into their programs (see Savage et al., 2023), underscoring the effectiveness of morphological instruction even within limited timeframes. Our activities on morphological analysis, while brief, incorporated all the four fundamental instructional approaches proposed by Carlisle (2010): 1) improving awareness of morphological structure, 2) increasing knowledge of the meaning of affixes, 3) supporting morphological problem solving and, 4) developing hypotheses about meanings of unfamiliar words. More than duration, the comprehensiveness of the approach may be the contributing factor to its effectiveness. Future studies are required to tease apart the effects of instructional time (dosage) and comprehensiveness.

A few limitations of our study are worth mentioning. First, our delayed post-test took place only a week after training, which does not allow us to conclude whether the words and suffixes were truly encoded as long-term representations. Prior research has indicated that suffixes may require a consolidation period of up to two months to become fully lexicalized

(Merkx et al., 2011). As mentioned earlier, the only other study comparing implicit and explicit morphological rule instruction in young children, which also included delayed post-test, featured a two-week consolidation period (Burton et al., 2021). Future research examining these instructional approaches should incorporate more extended consolidation periods to assess whether the taught representations indeed become lexicalized (see Carlisle, 2010).

Second, as previously noted, the items in our study were entirely transparent, with well-defined boundaries between the base words and the suffixes. This transparency heightened the implicit cues for morphological decomposition present within the words. These characteristics might have obscured the added benefits of explicit teaching for form learning. Although students at both grade levels could grasp the form of the suffixes despite never being exposed to them in isolation (implicitly) we cannot guarantee this would be the case for obscure words in which the added suffixes produce a phonological (e.g., heal-health) and/or orthographic shift (e.g., produce-production). Further research using different types of words is needed to elucidate this matter, particularly because derived words that undergo transformations are not uncommon in children's texts (Dawson et al., 2023).

Finally, although we built on previous studies by assessing not only the form but also the meaning of the novel suffixes, we did not include a task to measure the use of the words. Considering that syntax is one of the different levels of information morphemes convey, and that use (i.e., put words into action) is an important aspect of high-quality lexical representations (Perfetti, 2007), future studies should consider testing the use of the target suffixes in context perhaps by including, for example, a cloze task.

Conclusion

The present study examined the potential benefits of receiving explicit morphological analysis instruction on learning the form and meaning of novel suffixes in upper elementary students. Although there was little evidence of a benefit for explicit instruction when learning the forms of transparent novel derivational suffixes, our results showed that explicit instruction had benefits over implicit instruction for learning the meaning of the suffixes. There was a clear benefit for explicit instruction in Grade 3, and whereas Grade 5 students in the implicit condition were able to extract the meanings of suffixes to some extent, Grade 5 students in the explicit condition performed significantly better. Notably, results in the explicit condition were superior not only for the trained words but also for the transfer words. Explicit instruction also led to better retention of the suffixes. Thus, our results provide evidence of the added benefits of explicit instruction in morphological analysis at both grade levels and suggest that explicit instruction of morphological analysis may be an effective component of approaches to vocabulary instruction in the upper primary grades.

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Chapter 4: The Effects of Explicit Morphological Analysis Instruction in Early Elementary Spanish Speakers

Introduction

An awareness of words' morphemic structure and the ability to manipulate it, referred to as morphological awareness, is crucially important in reading across languages (e.g., Carlisle, 2003; Deacon & Kirby, 2004; Marks et al., 2022; Verhoeven & Perfetti, 2011). Recognition of familiar morphemes can facilitate the accuracy and speed of reading morphologically complex words (i.e., words having more than one morpheme, e.g., Carlisle, 2000, 2003; Carlisle & Katz, 2006; D'Alessio et al., 2018; Marcollini et al., 2011; Roman et al., 2009; Singson et al., 2000), and also support reading comprehension (e.g., Deacon & Kirby, 2004; Levesque et al., 2017; Liu et al., 2024; Sparks & Metsala, 2023). Given the positive relation between morphological awareness and literacy outcomes, there has been a growing interest in the role of morphological instruction (see Ng et al., 2022). Previous meta-analyses have reported a positive effect of morphology instruction on literacy skills at both the lexical (e.g., word reading, spelling, and vocabulary) and supralexical (e.g., reading comprehension) levels (Bowers et al., 2010; Goodwin & Ahn, 2010 Reed, 2008). For example, Goodwin and Ahn (2013) synthesized findings from 30 independent studies and reported a moderate overall effect size of morphological instruction (d = 0.32) on literacy measures such as morphological knowledge (d = 0.44), phonological awareness (d = 0.48), vocabulary (d = 0.34), decoding (d = 0.59), and spelling (d = 0.30).

Although current evidence supports the benefits of morphological instruction, most studies have been conducted in English, a language with low grapheme-to-phoneme consistency and low morphological complexity (Borleffs et al., 2017; Seymour et al., 2003) and it remains unclear if similar effects can be obtained in other alphabetic orthographies like Spanish that present a higher morphological complexity in its spoken form (Borleffs et al., 2017). To obtain a more universal understanding of the effects of instruction in morphology, the present study explored the impact of explicit and implicit morphological analysis instruction (i.e., the strategic use of the word's morphological structure to infer the word's meaning; Anglin, 1993) in a sample of Grade 3 Spanish monolingual students.

Morphological Analysis Instruction

Instruction in morphology can include activities to improve awareness of the morphological structure of words, increase knowledge of the meaning of affixes, and develop hypotheses about the meanings of unfamiliar words (Carlisle, 2010). Instruction can be explicit, where objectives and rules are clearly outlined; or implicit, where learning occurs implicitly through exposure to multiple examples without any reference to the specific rules (Burton et al., 2021). The few studies comparing implicit and explicit instruction in morphology in English concur that explicit instruction yields better results for learning orthographic morphological rules (e.g., Bryant et al., 2006), fostering morphological analysis skills (Author, 2023), and consolidating long-lasting learning (Burton et al., 2021). For example, Bryant et al. (2006) compared implicit versus explicit teaching of the spelling differences between the suffixes -ian and -ion to 9-year-old students. The explicit group was provided with the morphological rule distinguishing the spellings. The implicit group was left to discover this rule independently based on the implicit morphological cues in the words (e.g., "magician", "vegetarian", vs. "education", "institution"). The findings revealed that those who received explicit instruction performed better at a spelling task, especially when it came to words requiring knowledge transfer (i.e., words not included in the training, but whose spelling could be inferred following the same morphological rule). The benefits of explicit over implicit instruction in English have been reported to persist even up to two weeks after receiving instruction (Burton et al., 2021).

Studies comparing implicit and explicit morphological instruction in languages other than English are even scarcer (e.g., Morin, 2003; Kemper et al., 2012) and have provided mixed results. For example, Kemper et al. (2012) compared explicit and implicit teaching of two Dutch spelling rules for pluralization: a morphological spelling rule that involved a phonological shift (i.e., a t-d change in pronunciation but not in spelling when going from singular to plural, e.g., *hond* /hont/ – *honden* /honden/), as well as an orthographic spelling rule (e.g., *kroon* = "crown" to *kronen* = "crowns"). Their sample of early elementary students was divided into two groups that received a list of base words along with their plural form. Students in the implicit group were told that they were going to practice words that had some mismatches between their writing and their pronunciation and were asked to think of such words. After that, the trainer would present a base word and instruct students to write the plural form. Students were provided with the correct spelling without an explanation and asked to correct their errors. The explicit group received an additional explanation for the spelling of the words. In a spelling task assessing both trained and transfer words (i.e., words not included in the training, but whose correct spelling could be inferred by applying the rule) significantly higher scores were observed for the learning of the morphological rule following explicit instruction, particularly for transfer words. For the orthographic rule, the explicit instruction did not provide any additional benefits, arguably because this rule is more complex than the morphological one, requiring more extensive training. Nonetheless, considering the advantages of explicit instruction for learning morphological rules, the authors advocated for explicit instruction over implicit instruction, especially when generalization is the objective.

In a different study, Morin (2003) compared the effects of implicit and explicit instruction on morphological analysis in a sample of English-Spanish second-language learners at the college level. In her study, Morin divided the participants into four groups by type of instruction (implicit vs explicit) and level of proficiency in Spanish (beginner and advanced). The implicit group received vocabulary instruction using a variety of classroom activities such as semantic maps, picture descriptions, etc. Conversely, the explicit group's learning activities focused mostly on the identification of co-occurring suffixes and an analysis of how these affected the words' meanings. Participants received training twice a week for a full semester and were tested in receptive and expressive vocabulary tasks. Notably, the results significantly differed by proficiency level with students who had more knowledge in Spanish benefiting more from explicit instruction than beginners. These results suggest that instruction may be received differently depending on the level of mastery of Spanish. However, these were adult learners of Spanish as a second language, and thus compared to monolingual students, other factors could contribute to the results. For example, second language learners have been shown to process language differently and focus on different cues when learning new words compared to monolinguals (e.g., Brojde et al., 2012; Kovelman et al., 2008). Furthermore, there is also the possibility of cross-language transfer, wherein individuals can use their skills in word formation from their first language to support their understanding of this process in a secondary language (see Leonet et al., 2020). Research shows that cross-linguistic influence can facilitate morphological awareness development in a new language (Candry et al., 2017; Ke & Xiao, 2015; Pasquarella et al., 2011). The effectiveness of explicit morphological instruction for children who are native Spanish speakers is still an open question.

Spanish Morphological Complexity and Orthographic Consistency

There are reasons to believe that the effectiveness of explicit morphological instruction might be different in a language like Spanish. First, Spanish morphological complexity is significantly higher than that of English (Borleffs et al., 2017). Three important morphological features increase Spanish morphological complexity (Rodríguez & Carretero, 1996). First, Spanish uses gender (male or female) and number (singular and plural) derivations for adjectives and nouns. For example, the noun *perro* (dog) has three inflections: *perra* (female, singular), *perros* (male, plural), and *perras* (female, plural). Second, there are three different verb conjugations in Spanish depending on the endings (-ar, -er, -ir) of its infinitive form and each conjugation has more than 40 temporal derivations. Finally, some verb derivations are generated by adding a pronominal form at the end of a verb to communicate information on the direct and indirect object of the sentence. For example, the suffixes *-me*, *-te*, *-se*, *-nos*, *-lo(s)*, and *-la(s)* can be added to the verb *amar* to create the words *amar<u>me</u>* (love me), *amar<u>te</u>* (love you), *amar<u>nos</u>* (love us), and *amar<u>lo</u>* (love him or love it). Furthermore, two suffixes can be attached simultaneously (e.g., *ajustár<u>melo</u>*: adjust it to me), which greatly increases the morphological complexity.

The morphological characteristics of a language have been shown to influence its speakers' morphological development. For example, the high occurrence and productivity of affixation in French aligns with faster acquisition of morphological awareness among French speakers compared to English speakers (Duncan et al., 2009). Therefore, the same may be true for Spanish. If we consider that Spanish speakers are immersed in a language environment that is morphologically richer than English (Borleffs et al., 2017), students may have developed the necessary skills to engage in morphological analysis independently. If they are already relatively proficient at morphological analysis, this could mean that they derive less of a benefit from explicit instruction as compared to implicit instruction.

Furthermore, the orthographic depth of a language (i.e., the degree of correspondence between graphemes and phonemes) seems to influence both the size of the processing units used by young readers and the type of reading instruction they receive (see the psycholinguistic grain size theory; Ziegler & Goswami, 2005). In Spanish, mastery of the alphabetic principle (symbol-to-sound mapping) suffices for accurate reading of most words, and this has implications for instructional practices. In Mexico (the country where we collected the data for this study), reading instruction focuses on learning the names and sounds of individual letters and decoding by putting together syllables (Kalman, 2017; Reese et al., 2012), and instruction on morphology is not stated in the curricula (Subsecretaría de Educación Básica, 2023) nor is a common practice in the classrooms (Kalman, 2017; Munguía, 2015). Thus, despite the morphological richness of *spoken* Spanish, the orthographic transparency of the language may mean that morphemes are not an especially useful unit of processing when it comes to *written* Spanish.

There is some empirical evidence that challenges this perspective, indicating that even without explicit instruction, Spanish-speaking students develop a sensitivity to the morphemic structure of written words (e.g., Jaichenco & Wilson, 2013; Suárez-Coalla & Cuetos, 2013). For example, D'Alessio et al. (2018) assessed Grade 2, 4, and 6 Spanish-speaking students using a word-naming task where morphologically complex words (e.g., anillero) were matched in length to pseudowords with no morphological structure (e.g., anullaro). Their results showed that words with a morphological structure were read faster. Nevertheless, there was no word type effect when accuracy was assessed. Similar results from word naming tasks in Italian, a language with an orthographic depth similar to Spanish (Seymour et al., 2003), have been reported (Burani et al., 2008; Marcolini et al., 2011). These findings suggest that for shallow orthographies, children seem to develop sensitivity to morphological units that can later be used to support their reading, particularly in terms of efficiency. Is this morphological knowledge enough to further support morphological analysis – that is, to support the strategic use of morphological knowledge to develop word meaning?

According to Tyler and Nagy (1989), different aspects of knowledge about suffixes may not be acquired simultaneously. Arguably, knowledge that helps children identify the form of morphemes seems to develop before their understanding of the syntactic and semantic use conveyed by these morphemes, as well as before their practical use. In a recent study with Grades 2, 5, and 8 students who were assessed on their knowledge of the form and meaning of highly frequent derivational suffixes, we found better knowledge of form compared to meaning across all grades tested (Martínez et al., 2023). Hence, while Spanish speakers may have implicitly acquired morphological knowledge that helps them recognize the suffixes in writing, there is no guarantee that this level of knowledge is sufficient to effectively support more complex tasks, such as morphological analysis. From a theoretical point of view, the characteristics of Spanish morphology and orthography seem to have contradictory effects on the potential benefits of explicit instruction. On the one hand, the morphological richness of Spanish provides children with ample examples of morphologically complex words, offering them more opportunities to develop implicit morphological knowledge. This could facilitate their engagement in morphological analysis without the necessity for explicit instruction. On the other hand, the high level of orthographic transparency and lack of instructional emphasis on morphemes in reading might impose a challenge to Spanish speakers trying to access written morphological information. To date, studies investigating how Spanish speakers make use of the morphological information conveyed in words have centered on visual word processing (D'Alessio et al., 2018; Jaichenco & Wilson, 2013; Suárez-Coalla & Cuetos, 2013). The question of whether Spanish-speaking students can independently use their morphological knowledge for engaging in morphological analysis, or if explicit instruction continues to offer additional benefits, remains open.

The Present Study

This study aimed to assess the effectiveness of implicit and explicit instruction in morphological analysis in a sample of Grade 3 Spanish monolingual students. Following Martínez et al. (2023) we created a short training program to instruct participants on target words containing experimenter-designed suffixes. We used novel suffixes to guarantee that all participants were learning truly novel words and were not influenced by previous experience (e.g., Martínez et al., 2023; Merkx et al., 2011; Rastle et al., 2021). For three training days, children were presented with paragraphs containing the target words. The meaning of the novel suffixes remained consistent (i.e., -epa describing something as small, in target words such as "colinepa": a small hill, or "mesepa": a small table). Participants undergoing explicit training received guidance on how to break down the words' constituent elements (morphemes) to understand their meaning. Conversely, implicit training focused on using words surrounding the targets as hints for meaning, never guiding the participant's attention to the co-occurrence of the suffixes in the targets. Because morphological knowledge is multidimensional (e.g., Levesque et al., 2021), we decided to test the learning of the novel suffixes' form and meaning.

Finally, because the ultimate goal of morphological analysis is to equip students with a generative tool that enables independent vocabulary expansion (see Carlisle, 2010, for a more detailed discussion), we also tested children on both trained and transfer words (i.e., words that were not shown during training but included a trained suffix; thus, their meaning could be obtained only through morphological analysis). We set out to answer the following two research questions:

RQ1: Is explicit morphological analysis instruction more effective than implicit morphological analysis instruction when teaching the form and meaning of novel suffixes?

RQ2: To what extent can knowledge transfer occur following implicit and explicit instruction?

Given that this is the first study to make a direct comparison between implicit and explicit instruction on morphological analysis in Spanish, we did not formulate any specific hypotheses. However, the characteristics of the Spanish language lead to two contradictory predictions. On the one hand, the high level of morphological complexity of Spanish suggests that children might have relatively good existing implicit knowledge and may not derive added benefits from explicit instruction. On the other hand, the language's high orthographic consistency directs the reader's attention to individual graphemes or even syllables, rather than morphemes. Considering that children are not used to looking out for morphemes during their reading, another possibility is that children in Spanish may benefit from explicit instruction that can aid them in this process.

Method

Participants

To select our participants, we first sent letters describing the study to the families of 123 Grade 3 students attending two public elementary schools in Cuernavaca Morelos, Mexico. The schools were located in different parts of the city and served mostly middle-class families (based on the location of the schools and teachers' reports regarding families' socioeconomic status). All children had Spanish as their first and only language and had no formal diagnosis nor report of intellectual, behavioral, or sensory difficulties (based on school records). We obtained parental consent from 104 students of which four students were absent during the pre-training assessment, leaving us with a sample of 100 students that were tested on word reading efficiency as part of the pre-training battery. Based on their results, six students were further removed from the study due to very low reading scores (following the Indicadores Dinámicos del Éxito de la Lectura (IDEL) Fluidez de la Lectura Oral (FLO) Grade 3 criteria for students at risk) as they would not be able to complete the activities included in the training.

The remaining 94 students were randomly assigned to a training condition, either implicit or explicit, through the use of an online random group generator (https://www.randomlists.com/team-generator). Once the study concluded, the data from 10 students was further removed due to absences during testing or training. This left us with a final sample of 84 students, 40 in the implicit condition group (20 females, $M_{\text{age}} = 8.8$ years; $SD = 0.34$) and 44 in the explicit condition group (23 females, $M_{\text{age}} = 8.9$ years; $SD = 0.36$). Ethics approval for this study was obtained from the University of Alberta (Pro00130051).

Research Design

The study followed an experimental design, with the same pre- and post-tests administered to all participants with three training days in between. We created two types of training to teach novel-derived words presented in the context of short narratives. The novel words were created by attaching made-up derivational suffixes to real word bases. Each training session started by reading a passage that contained the target words, followed by three activities to help consolidate the meaning of the targets. Once training was completed, the knowledge of the form and meaning of the suffixes was tested one day (i.e., immediate post-test) and one week after training (i.e., delayed post-test).

Materials

Pre-training Battery (Background Measures)

Reading Efficiency. To assess reading efficiency, we administered two measures. First, two Grade 3 level reading passages from Indicadores Dinámicos del Éxito de la Lectura, Fluidez de la Lectura Oral (IDEL-FLO) were administered. An average score was obtained and the Grade 3 criteria for readers at risk (less than 49 words in a minute) was used as an exclusion criterion for the study. IDEL-FLO is a standardized, individually administered test of accuracy and fluency with connected text using passages that are calibrated for the goal level of reading for each grade level. Student performance is measured by having students read a passage aloud for one minute. Words omitted, substituted, and hesitations of more than three seconds are scored as errors. Words self-corrected within three seconds are scored as accurate. The number of correct words per minute from the passage is the oral reading fluency rate. The alternate-form reliability of passages in the middle of the first, second, and third grades ranges from .87 to .94 (Baker et al., 2007).

Second, we administered a word reading fluency task taken from Martínez et al. (2021) to assess sight word efficiency (SWE) and phonemic decoding efficiency (PDE).

Participants were presented with two cards containing items in a list format. The first card, used to assess SWE, comprised 84 words organized into four columns of 21 words, and the second card used to assess PDE, included 48 pseudowords arranged in three columns of 16. The difficulty of the items on both cards progressively increased. Children were asked to read through the lists as quickly as possible, moving from top to bottom. Before the actual testing, a brief practice session with an 8-word/pseudoword list was administered to ensure participants understood the requirements of each test. Each list of words was assessed separately, and a participant's score reflected the total number of correctly read words/pseudowords within a 1-minute time limit. A composite score calculated by averaging the *z*-scores of the two tests was used in the analysis as a word reading measure. The correlation between the two tests in our sample was .81.

Vocabulary Knowledge. We administered the Test de Vocabulario de Imágenes de Peabody (TVIP; Dunn & Dunn, 1997). The TVIP is an untimed measure of receptive Spanish vocabulary. Participants were asked to listen to a word provided orally by the examiner and then select one of four pictures that best depicted the word's meaning. The items on the test increase in difficulty as the task progresses. Following the administrative guidelines, the examiner begins on a predetermined item based on the child's age. If a basal is not achieved (eight consecutive items correct) the examiner works backwards to achieve a basal. Once a basal is established the participant continues until obtaining six consecutive errors. A participant's raw score was the total number of correct responses which was then converted to a standard score using the test manual. Cronbach's alpha reliability has been reported to be .92 for children between the ages of 8 and 9 years (Dunn & Dunn, 1997).

Morphological Knowledge. The morphological knowledge task was adapted from Carlisle's (2000) morphological structure test. The task was divided into two sections, section 1 for derivation (e.g., Farm. My uncle is a _____ [farmer]) and section 2 for decomposition (e.g., Driver. Children are too young to _____ [drive]), of 15 items each. The items were of increasing difficulty, with the first items in each section being transparent (e.g., pan-panadero) and the final items having orthographic and phonological transformations (e.g., libre-libertad, nuevo-novedad). Both sections included a practice item that allowed for feedback. The section 1 derivation task was discontinued after four consecutive errors. Once the discontinuation rule was reached, or after all items were attempted, the participant proceeded to section 2. The same instruction and discontinuation rule was applied to section 2. Each section was scored separately, and the participant's score was the total number of correct responses (max =15 per section). A composite score, calculated by averaging the *z*-scores of the two sections, was used in the analysis. The complete task is available at https://osf.io/avkyw/?view_only=ed80739c5c68400883c3567b7df8630c

Suffix Identification Task - Nonwords (SIT-N). The SIT-N was adapted from Apel et al. (2013). The SIT-N assessed the participant's ability to identify the form of the trained novel suffixes in a new context. To test this ability, three types of nonwords were included in the task: 1) nonword bases + real suffixes (e.g., "runtación"), 2) nonword bases + trained pseudo-suffixes (e.g., "permembe"), and 3) nonword bases + untrained pseudo-suffixes (e.g., "dapalica"). All nonwords bases were created using the Wuggy software, a pseudoword generator that allows for the generation of written polysyllabic pseudowords that obey a given language's phonotactic constraints (Keuleers and Brysbaert, 2010). At pre-test, we expected that participants would obtain similar and significantly lower scores for both types of pseudo-suffixes (trained and untrained) compared to real suffixes in the pre-test. After training, we expected that the trained pseudo-suffixes would resemble real suffixes more closely, while the untrained pseudo-suffixes would continue to display significantly lower performance.

The real suffixes used were highly frequent derivational suffixes (-ista, -ero, -azo, -ear, -ismo, -ción, -dor) taken from the Morfolex database (Zacarías, 2016). The two types of pseudo-suffixes included the four used to create the targeted training words (-isba, -epa, -embe, -ispe; pseudo-suffixes created by taking the suffixes from the Morfolex database with the lowest frequency and changing one or two letters) and four untrained pseudo-suffixes that never appeared during training (-inta, -enle, -esmo, -ica). The untrained pseudo-suffixes were generated using the same method used to create the trained pseudo-suffixes and matched the trained suffixes in length (3 four-letter items and 1 three-letter item). After generating both the trained and untrained pseudo-suffixes, we verified that they were non-existent by cross-referencing with the Morfolex database.

Each suffix/pseudo-suffix appeared four times for a total of 28 items that included real suffixes, 16 items that included trained pseudo-suffixes, and 16 items that included untrained pseudo-suffixes, which added up to 60 items. All the resulting pseudowords that appeared in the task ranged from three to four syllables and were five to seven letters in length ($M = 8.2$). The task was done in silence without a discontinuation rule. Instructions given to the participants are provided in Appendix 2A. The SIT-N was included as part of the pre- and post-training battery. Cronbach's alpha reliability in our sample across time points was .94.

Training Material

Target Words: Novel Derived Words. The target words included in the training were created by attaching novel derivational pseudosuffixes to real-word bases. The real-word bases were selected from the Lexmex corpus (Silva-Pereyra et al., 2014), with the characteristics of having two-to-three syllables and being three-to-seven letters long ($M =$

5.2). To prevent any interference from the base words in understanding the target words, we selected highly frequent base words[5] (*M* = 40.16, *SD* = 38.4; Silva-Pereyra et al., 2014) with no homophones except for the word "libro" (book).

For the novel suffixes, we created four pseudo-suffixes by selecting the suffixes with the lowest frequency from the Morfolex database (Zacarías, 2016) and changing one or two letters. The pseudo-suffixes selected had the characteristics of being bisyllabic three-to-four-letter combinations (i.e., -isba, -epa, -embe, -ispe). The definitions assigned to the pseudo-suffixes were based on existing suffixes and were designed to be as concrete as possible (e.g., -embe: a person who makes…, -isba: a place where… is made). Adding the novel suffixes to the real bases resulted in semi-transparent derived words in which the last letter of the bases underwent an orthographic shift (e.g., "bota" + -isba, the final "a" in the base was dropped to create the target word "botista"). We decided to include an orthographic shift to mirror the usual effect a derivational suffix exerts on a base in Spanish (Silva-Pereyra et al., 2014; Zacarías, 2016). To aid with the orthographic opacity of the targets, all paragraphs included the base word, which appeared once before introducing the target (e.g., *no es una colina muy alta, es apenas una colinepa*). All target words functioned as nouns with the only exception of the suffix -ispe, that functioned as an adjective (e.g., piedrispe: describes something as made of rock). See Appendix 3B for a complete list of all target words.

Reading Passages. To make our training more ecologically valid, we introduced the novel target words in the context of a passage, as this resembles how students usually encounter unknown words (Marinellie & Kneile, 2012). We created three reading passages,

[5] Lexmex is a corpus obtained from 32 different digital periodical publications in Mexico sampled for nine months (March to November 2012) during which more than 2.5 million words were obtained. The frequency reported is a standard measure independent of the corpus size, and is defined as the number of times a word appears, divided by the size of the Lexmex corpus (2,530,523), multiplied by 1 million.

one introduced at each day of training (a sample passage is provided in Appendix 3C). Each passage contained four target words, one for each of the four made-up suffixes. For example, passage 1 contained the target words “botisba”, “colinepa”, “mochilembe”, and “lodispe”. Thus, participants were presented with a total of three examples of words for each novel suffix, presenting one example per training day. The sentences surrounding the target words provided sufficient informative contexts so the students could infer the word’s meaning. Each passage ranged between 107 and 115 words, 183 to 196 syllables, 7 to 10 sentences, and 10 to 15 words per sentence.

Training Conditions. There were two training conditions: implicit and explicit. Both types of training shared a common goal: teaching students the definition of the target words. However, these conditions diverged in their approach. For the explicit condition students were required to look inside the word and identify its constituent elements (morphemes) to analyze the words’ meaning, while implicit training encouraged students to look outside the word for clues that could help them infer the meaning of the words.

Both conditions included four activities: 1) reading the day’s passage and finding the target words of the lesson, 2) individually completing a worksheet, 3) working as a group on a semantic map (for the implicit condition) or a morphological matrix (for the explicit condition; Ng et al., 2022), and 4) working together to identify the correct use of the target words in a sentence (target word in context). To reduce extraneous differences between the training conditions, and to isolate the key ingredients of explicit and implicit instruction, we decided to keep the first and last activity precisely the same for both training conditions. Thus, the differences between the implicit and the explicit conditions were only found in the second and third activities. We describe, by type of condition, these two activities below.

Implicit Condition. For activity two, the completion of a worksheet, the participants were asked to write the target word and one or two words found in the text that could help them figure out the meaning. The subsequent activity (activity number 3) included a semantic map, and participants had to choose which two of four words were most closely related in meaning to the target. During the completion of activity 3, the trainer facilitated discussions to guide participants in exploring which options were more suitable and the reasons behind those choices (e.g., for the target word "botisba", a boot factory, the word "machines" is more closely related in meaning than the word "clown")

Explicit Condition. The worksheet for the explicit group required participants to write the target word and divide it into its base and suffix. The next consolidation activity (activity number 3) included a morphological matrix. Participants had to choose from four words the two that best functioned as a base for the target suffix, in terms of meaning. During the completion of activity 3, the trainer facilitated discussions to guide participants in exploring which options were more suitable and the reasons behind those choices (e.g., for the suffix -isba, a factory of…, the base word "bottle" might work better than the base word "shark").

For both conditions, the correct definition of the target words was given by the trainer once the students' possible definitions were discussed. Finally, the last activity, which was the same for both types of training, included two sentences the trainer read aloud. Both sentences included the target word, but only one used it correctly. The participants had to work as a group to choose the correct sentence. A complete example of a training session for both the implicit and the explicit condition is available at https://osf.io/avkyw/?view_only=ed80739c5c68400883c3567b7df8630c

Testing for Learning (Post-training Battery)

Two post-training testing sessions, immediate and delayed, included one activity to evaluate the participants' recognition of the form of the novel pseudo-suffixes included in the target words (SIT-N task), and two activities to assess the participants' semantic knowledge of two types of words: 1) words included during training (trained words), and 2) words that were not part of the training but their meaning could be inferred as a result of the training (transfer words). The transfer words included one trained suffix attached to a base word that was never shown during training but was matched to the trained ones on frequency and length. See Appendix 3B for a complete list of all transfer words.

Oral Word Definition. In this task, participants were asked to orally define a word given by the experimenter. There were 24 words divided into 12 trained words and 12 transfer words. Since answers for this task were scored with a range of 0-2 (see scoring), the maximum possible score was 48. Cronbach's alpha reliability in our sample was .93 for the immediate post-test and .96 for the delayed post-test.

Multiple Choice. In this task, the same words from the oral definition task were tested in a multiple-choice format. Each question included the definition of one trained or transfer word along with four options that included the base of the target word attached to each one of the four trained suffixes (e.g., what word means "a boot factory"? a) botembe, b) botispe, **c) botisba**, d) botepa). All questions had only one correct answer, given 1 point if correct, for a maximum score of 24 points. Cronbach's alpha reliability in our sample was .82 for the immediate post-test and .89 for the delayed post-test.

Scoring

The SIT-N and the multiple-choice tasks were scored with 1 or 0 for either correct or incorrect answers using an answer key. The oral word definition task was scored on a 3-point scale with a response criterion of 0 for incorrect responses (including omissions), 1 for partially correct responses that mentioned either the base word or the meaning of the suffix, and 2 for full credit when the response included both the base word and the correct suffix meaning. For example, the word “botisba” would receive 2 points (full credit) for a response such as *boot factory* or *the place where boots are made*, 1 point (partial credit) for a response such as *old boots*, and 0 points for responses such as *new toy*. The first author, whose first language is Spanish, did the scoring of all tests.

Procedure

Testing took place during the last two weeks of June (at the end of the school year in Mexico). All testing and training were administered during school hours by trained research assistants. All tasks in the pre-intervention battery were administered in a quiet room in a one-on-one session that lasted approximately 20 minutes. Two to three days later, participants received one type of training (either implicit or explicit) in small groups of four to five students from the same grade level. Following ethics requirements, all training sessions started by making clear that the target words included in the activities were not real. To motivate the learning of the made-up words, we included a spy theme and told the participants we were learning the words to crack a secret code. Both types of intervention followed the same process that started with a passage read aloud by the trainer (all participants had a copy of the passage so they could follow the reading on their own) and the identification, as a group, of the four target words for the lesson. Subsequently, each target word was studied individually with three consolidation activities aimed to reinforce its definition. Considering all activities, each target word was repeated approximately six times. The training ended with the students working together to solve a part of the secret code. Training under the two conditions lasted around 20 minutes, including the session's introduction and the secret code activity.

After three consecutive training days, participants were tested on word learning one day after (immediate post-test) and one week after (delayed post-test). Post-test sessions were divided into two parts. First, students were tested individually on the SIT-N and the oral word definition task. After all participants were tested, small groups (different from the ones in which they received the training) were created to test the participants' knowledge using the multiple-choice task. For this task, children were situated in the same room with a seating arrangement that prevented them from looking into one another's work. They were instructed to complete their work individually and in silence. Individual post-tests lasted about 15 minutes, and group post-tests ranged from 10 to 15 minutes.

Trainers

All the trainers were university students majoring in psychology and had prior experience working with children. They underwent two training sessions in small groups of four. In the initial training session, the trainers assumed the role of children, and the first author demonstrated a session for either the implicit or explicit condition. After addressing all questions, the first author provided all the necessary materials to each trainer. Two to three days later, each trainer had an individual session, where they were required to model the first lesson of their assigned training. Each trainer received training in only one type of instruction, either implicit or explicit. Importantly, the trainers were blind to the existence of the other type of training or the purpose of the study (i.e., comparing implicit and explicit teaching methods).

Treatment Fidelity

To evaluate how well the training was implemented, the first author observed each trainer twice and scored their implementation using a 3-point scale (0 = insufficient, 1 = limited, and 2 = proficient) that evaluated content completion, order of delivery, time management, quality of instruction, and student behaviour. The first observation happened during each trainer's first session with children. Immediate feedback was provided to the trainer (using the rubric as a guide). The second observation was done a day later and primarily focused on any issues identified during the first observation. Issues identified were mostly related to time management and student behaviour and were addressed properly by the trainers. No trainer had to be removed from the study due to problematic implementation.

Statistical Analysis

All statistical analyses were performed using R (version 4.3.0; R Core Team, 2023) via RStudio (version 2023.09.1+494; RStudio Team, 2020). The data and code used for the analyses, including our final model syntax specification, have been made publicly available at https://osf.io/avkyw/?view_only=ed80739c5c68400883c3567b7df8630c. For the definition task, cumulative link mixed-effects models (CLMMs) with the trinomial dependent variable (coded as 0 for incorrect, 1 for partially correct, and 2 for fully correct) were fitted using the *clmm* function in the ordinal package (version 2023.12-4; Christensen, 2018). For the multiple-choice task and the SIT-N, logistic mixed-effects models (LMMs) with the binomial dependent variables (coded as 0 for incorrect and 1 for correct) were fitted using the *glmer* function in the lmerTest package (version 3.1-3; Kuznetsova et al., 2017). The marginal and conditional R^2 values were calculated using the MuMIn package (version 1.47.5; Barton, 2019).

Because the numbers of observations for each model were relatively modest (2,016 for the word definition and multiple-choice tasks and 2,486 or 2,487 for the SIT-N), we estimated separate models for each testing point (i.e., pre-, immediate post-, and delayed post-tests). The models for the word definition and multiple-choice tasks included the fixed effects of word reading (a composite of SWE and PDE), vocabulary, morphological knowledge (a composite of derivation and decomposition), condition (coded as 0 and 1 for the implicit and explicit conditions, respectively), word type (coded as 0 and 1 for the untrained and trained words, respectively), and the interaction between condition and word type. By implementing this coding scheme, the coefficient for condition represents the relative advantage of students' performance in the explicit group over the implicit group, while that of word type represents the advantage of students' performance for the trained items over the untrained items. In addition, the models included the between-participant random effect of word type and the between-item random effect of condition (see the footnotes of the tables for the model equations). Word reading, vocabulary, and morphological knowledge were grand mean centered before the analyses.

Similarly, the models for the SIT-N included the fixed effects of the background measures (word reading, vocabulary, and morphological knowledge), condition, suffix type (coded with two contrasts using the *contr.sdif* function in the MASS package version 7.3-60; Venables & Ripley, 2002), and the interaction between condition and suffix type. The first contrast of suffix type tested the difference between real suffixes and trained pseudo-suffixes, while the second contrast tested the difference between trained and untrained pseudo-suffixes. Therefore, the coefficient for the first contrast represents the relative advantage of students' performance on real suffixes over trained pseudo-suffixes; the coefficient for the second contrast represents the advantage of students' performance on trained pseudo-suffixes over untrained pseudo-suffixes. In addition, the models included the between-participant random effect of suffix type and the between-item random effect of condition (see the footnotes of the tables for the model equations).

Results

Preliminary Data Analysis

Tables 1.3 and 2.3 report the descriptive statistics for the background measures (word reading, vocabulary, and morphological knowledge) and the outcome measures (word definition, multiple-choice, and SIT-N), respectively. All assumptions of normality in our sample were met. Welch's *t*-tests showed no significant differences between the explicit and implicit condition groups for any background measures (see Table 1.3), indicating that students' pre-intervention performance levels were well controlled between the groups.

Table 1.3

Descriptive Statistics for the Word Reading, Vocabulary, and Morphological Knowledge Measures for Each Group

	Explicit (*n* = 44)		Implicit (*n* = 40)				
Variables	Mean	*SD*	Mean	*SD*	Welch's *t*	*df*	*p*
SWE	42.25	15.45	44.52	11.02	0.70	76.56	.489
PDE	23.75	7.24	25.92	6.95	1.46	80.64	.148
Vocabulary	88.25	7.41	90.75	7.13	1.58	81.73	.119
MK-Derivation	6.55	3.57	6.88	3.43	0.43	81.75	.667
MK-Decomposition	10.57	3.01	10.43	3.25	-0.40	75.86	.690

Note. SWE = sight word efficiency; PDE = phonemic decoding efficiency; MK = morphological knowledge.

Table 2.3

Descriptive Statistics for the Definition, Multiple-choice, and SIT-N

	Explicit (*n* = 44)						Implicit (*n* = 40)					
	Pre-Test		Immediate Post-Test		Delayed Post-Test		Pre-Test		Immediate Post-Test		Delayed Post-Test	
Variables	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Word definition (max: 2)												
Trained	–	–	1.15	0.35	1.27	0.34	–	–	1.02	0.31	1.05	0.26
Untrained	–	–	1.10	0.30	1.25	0.31	–	–	0.97	0.25	1.08	0.20
Multiple-choice (max: 1)												
Trained	–	–	0.59	0.21	0.66	0.25	–	–	0.62	0.20	0.65	0.23
Untrained	–	–	0.43	0.21	0.51	0.25	–	–	0.38	0.19	0.46	0.22
SIT-N (max: 1)												
Real suffix	0.19	0.18	0.42	0.24	0.45	0.28	0.20	0.19	0.43	0.22	0.46	0.23
Trained	0.08	0.15	0.48	0.34	0.52	0.37	0.13	0.19	0.26	0.29	0.31	0.29
Untrained	0.06	0.13	0.29	0.28	0.37	0.36	0.10	0.18	0.27	0.28	0.30	0.28

Note. No pre-test was administered for the word definition and multiple-choice tasks because they used only pseudo-suffixes. SIT-N = Suffix Identification Task-Nonwords.

Table 3.3 reports the correlations (Pearson's *r* and Spearman's ρ coefficients) between all the variables. Among the background measures, word reading and morphological knowledge were weakly to moderately correlated with all outcome measures, except for the SIT-N at the pre-test in the explicit condition group. On the other hand, vocabulary was only weakly correlated with the SIT-N in the explicit condition group.

Table 3.3

Correlations between the Variables for Each Group

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Explicit condition group										
1. Word reading		.26	.34*	.41*	.27	.46**	.43**	.00	.37*	.34*
2. Vocabulary	.18		.39*	.22	.17	.13	.13	.11	.36*	.28
3. Morphological knowledge	.34*	.38*		.39*	.33*	.30	.24	.26	.46**	.28
4. Definition_Immediate	.41*	.20	.38*		.72**	.58**	.67**	.05	.42**	.42**
5. Definition_Delayed	.28	.12	.32*	.73**		.60**	.78**	.14	.56**	.50**
6. MC_Immediate	.40*	.12	.27	.57**	.62**		.73**	.00	.42*	.31*
7. MC_Delayed	.38	.03	.21	.61**	.77**	.73**		.05	.62**	.59**
8. SIT-N_Pre	-.09	.01	.35*	.05	.22	-.04	.15		.28	.15
9. SIT-N_Immediate	.35*	.31*	.44**	.45**	.60**	.43**	.63**	.37*		.87**
10. SIT-N_Delayed	.35*	.21	.32*	.42**	.53**	.34*	.63**	.29	.86**	
Implicit condition group										
1. Word reading		.17	.56**	.46**	.31	.31	.36*	.35*	.31	.15
2. Vocabulary	.22		.33*	.22	.01	-.16	-.02	.14	.13	.09
3. Morphological knowledge	.53**	.34*		.52**	.35*	.14	.24	.32	.30	.29
4. Definition_Immediate	.55**	.13	.47**		.74**	.30	.51**	.09	.24	.28
5. Definition_Delayed	.36*	.00	.34*	.75**		.32*	.61**	.04	.36*	.37*
6. MC_Immediate	.33*	-.11	.11	.31	.33*		.62**	.01	.21	.21
7. MC_Delayed	.40*	.07	.21	.53**	.55**	.61**		-.02	.16	.12
8. SIT-N_Pre	.19	-.07	.25	.01	-.09	-.04	-.04		.52**	.38*
9. SIT-N_Immediate	.29	.04	.33*	.26	.36*	.19	.27	.42*		.78**
10. SIT-N_Delayed	.15	.00	.29	.23	.29	.17	.11	.32*	.77**	

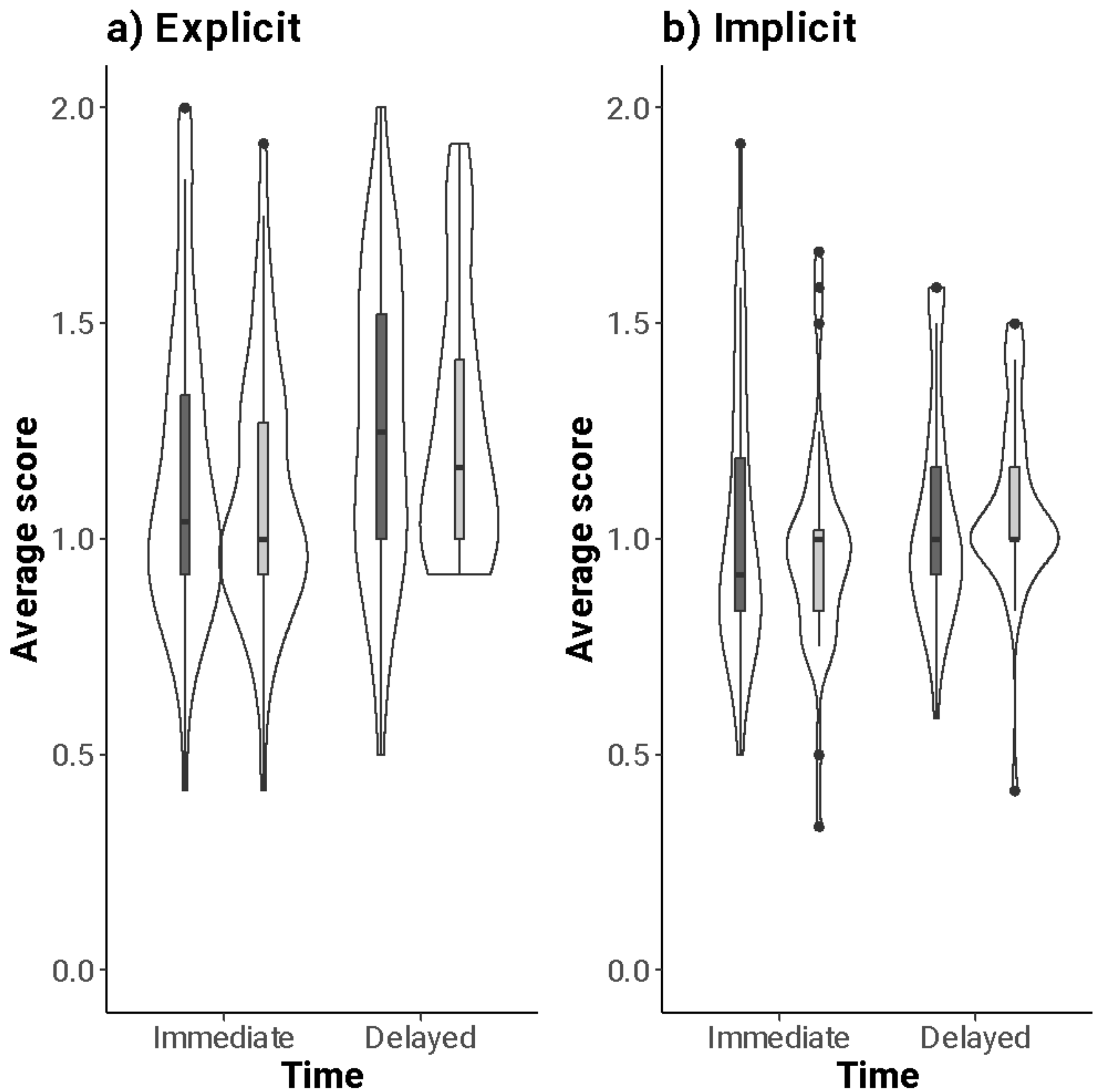
Note. Entries below and above the diagonals are Pearson's *r*s and Spearman's ρs, respectively. SIT-N = Suffix Identification Task-Nonwords; MC = multiple choice. *$p < .05$. **$p < .01$.

Mixed Effects Models

Figure 1.3 shows the students' performance on the word definition task, and Table 4.3 reports the results of the CLMMs for the word definition task. The effect of condition, but not word type, was statistically significant at both the immediate (estimate = 0.780, p = .009) and delayed post-tests (estimate = 0.874, p = .002) after controlling for the effects of the background measures. This indicates that students' performance levels were higher in the explicit condition group than in the implicit condition group across the word types and test points. On the other hand, the interaction between condition and word type was not significant at any test point.

Figure 1.3

Box and Violin Plots for the Average Scores on the Definition Task



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark grey indicate the trained items, and plots in light grey indicate the untrained items.

Table 4.3

Cumulative Link Mixed Models for the Definition Task

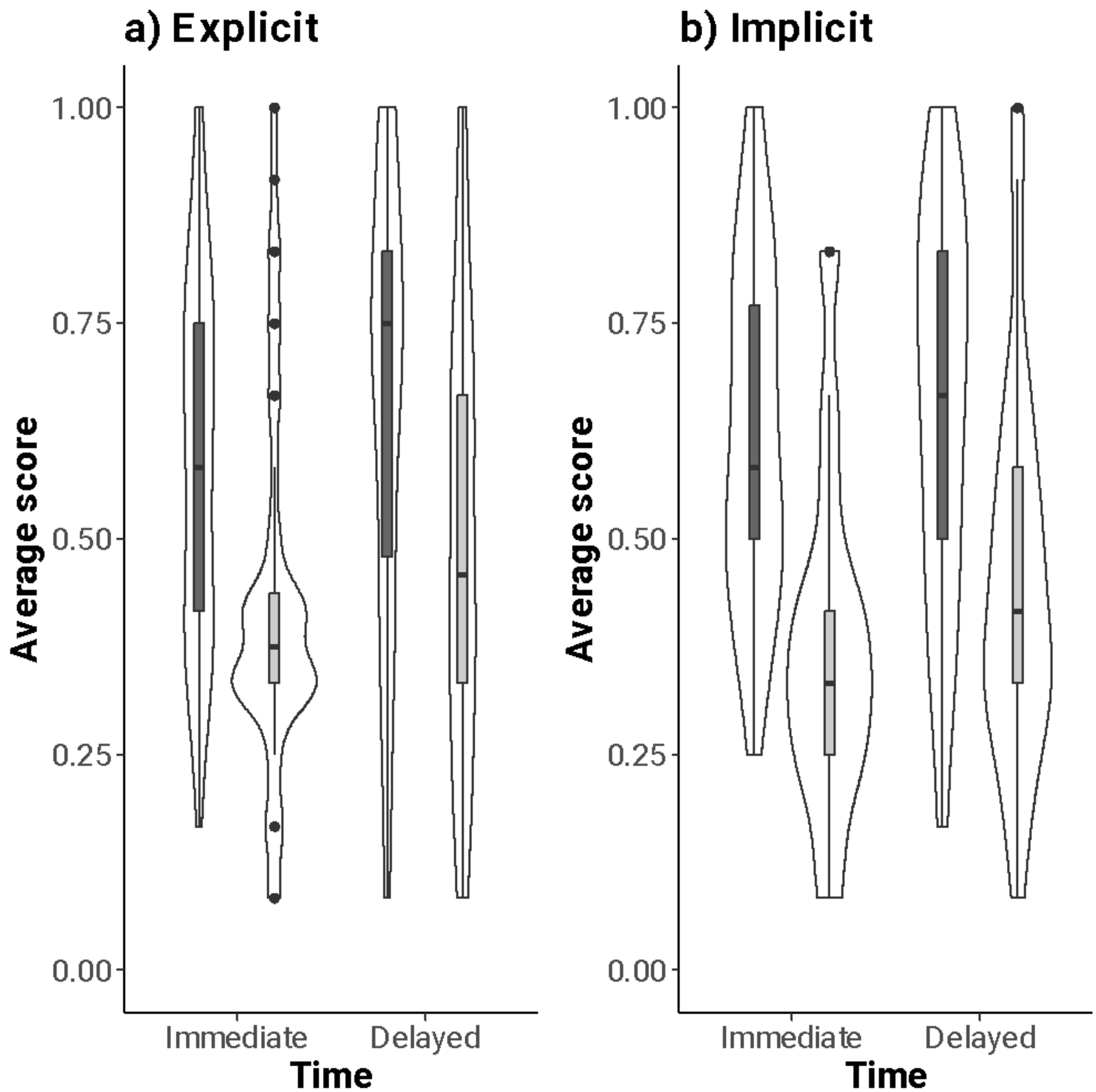
	Immediate Post				Delayed Post			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.390 (0.165)*	0.066	0.715	.018	0.180 (0.149)	-0.111	0.471	.225
Vocabulary	0.003 (0.020)	-0.037	0.042	.898	-0.019 (0.019)	-0.056	0.018	.307
Morph. knowledge	0.342 (0.182)	-0.016	0.699	.061	0.472 (0.167)**	0.146	0.799	.005
Condition	0.780 (0.298)**	0.196	1.365	.009	0.874 (0.282)**	0.321	1.427	.002
Word type	0.264 (0.335)	-0.392	0.919	.430	0.378 (0.643)	-0.883	1.639	.557
Condition x Word type	-0.007 (0.259)	-0.516	0.501	.978	0.198 (0.251)	-0.295	0.690	.431
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	1.222	1.106			0.908	0.953		
Participant (Word type)	0.299	0.547			0.044	0.209		
Items (Intercept)	0.495	0.704			2.317	1.522		
Items (Condition)	0.065	0.255			0.088	0.296		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.081	.410			.073	.535		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013). Model equation: Definition ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 + Word_type | ID) + (1 + Condition | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively. *$p < .05$. **$p < .01$. ***$p < .001$.

Figure 2.3 shows the students' performance on the multiple-choice task, and Table 5.3 reports the results of the LMMs for the multiple-choice task. The random effects of condition and word type were dropped from the initial models, as the models failed to converge or a singular fit was observed even after changing the optimizer to *bobyqa* and increasing the maximum iterations (Brauer & Curtin, 2018; Matuschek et al., 2017). Therefore, the models without random effects were considered the final models. The results showed that the effect of word type, but not condition, was statistically significant at both the immediate (estimate = 1.460, p = .003) and delayed post-tests (estimate = 1.236, p = .003) after controlling for the effects of the background measures. This indicates that students' scores were higher for the trained items than for the untrained items across the conditions and test points (see Figure 2.3). On the other hand, the interaction between condition and word type was not significant at any test point.

Figure 2.3

Box and Violin Plots for the Average Scores on the Multiple-choice Task



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark grey indicate the trained items, and plots in light grey indicate the untrained items.

Table 5.3

Generalized Mixed Models for the Multiple-choice Task

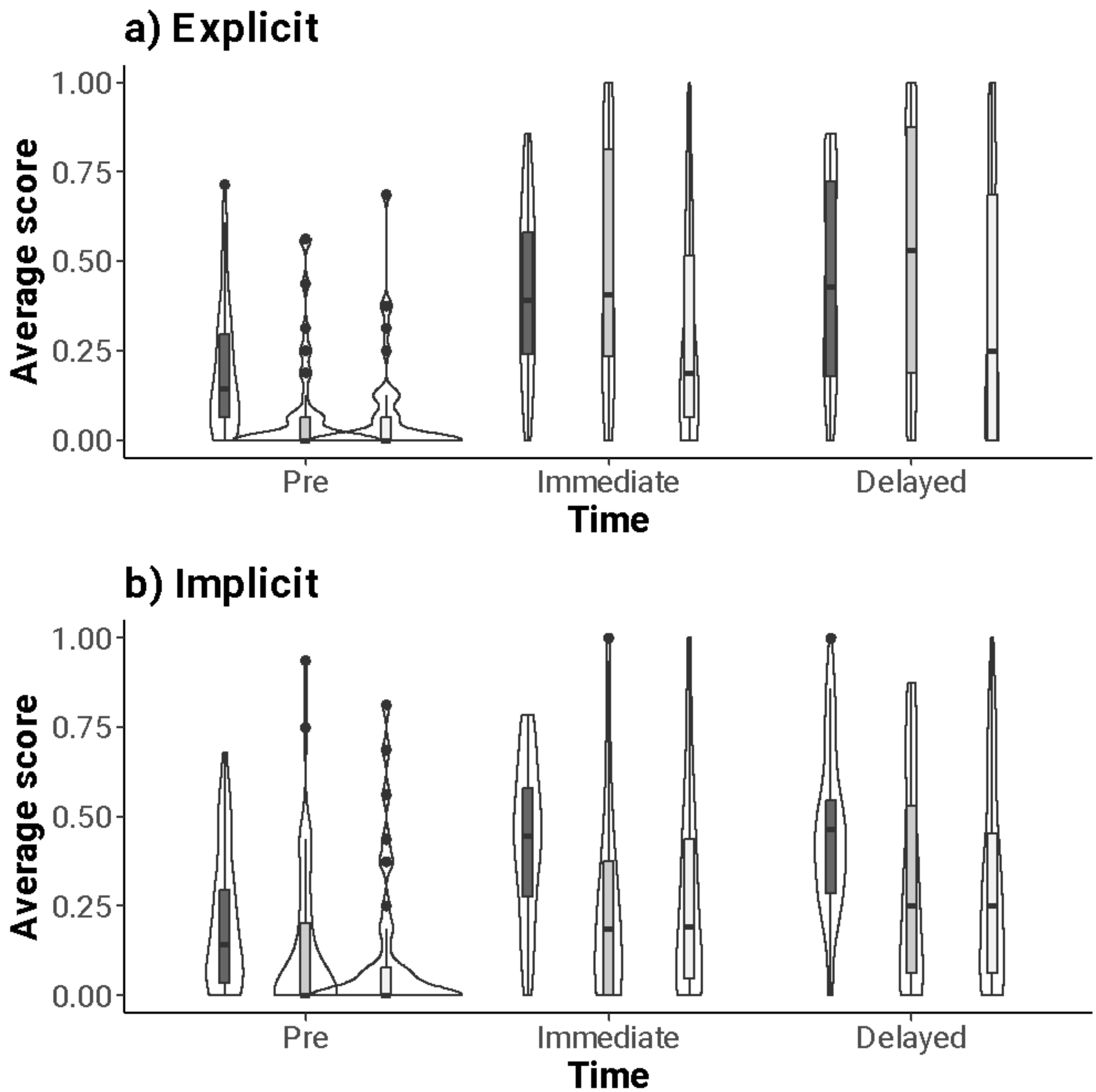
	Immediate test				Delayed test			
		95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	0.423 (0.113)***	0.202	0.644	< .001	0.422 (0.133)**	0.162	0.682	.002
Vocabulary	-0.007 (0.014)	-0.035	0.021	.617	-0.013 (0.017)	-0.046	0.020	.434
Morph. knowledge	0.031 (0.127)	-0.217	0.279	.807	0.099 (0.149)	-0.194	0.392	.509
Condition	0.350 (0.224)	-0.089	0.790	.118	0.419 (0.254)	-0.079	0.917	.099
Word type	1.460 (0.496)**	0.488	2.432	.003	1.236 (0.416)**	0.420	2.051	.003
Condition x Word type	-0.387 (0.209)	-0.797	0.023	.064	-0.280 (0.208)	-0.688	0.128	.179
Random Effects	Variance	*SD*			Variance	*SD*		
Participant (Intercept)	0.539	0.734			0.835	0.914		
Items (Intercept)	1.314	1.146			0.889	0.943		
Model fit	Marginal	Conditional			Marginal	Conditional		
R^2	.198	.690			.218	.587		

Note. CI = confidence interval; UL = upper limit; LL = lower limit. Marginal R^2 represents the variance explained by fixed effects, and conditional R^2 represents the variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013). Model equation: Multiple_choice ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded as 0 and 1 for the untrained and trained words, respectively. *$p < .05$. **$p < .01$. ***$p < .001$.

Finally, Figure 3.3 shows the students' performance on the SIT-N, and Table 6.3 reports the results of the LMMs for the SIT-N. The random effects of condition and word type were dropped from the initial models as the models failed to converge or a singular fit was observed (see the footnotes of the table for the final model equation). The results showed that the interaction between condition and the first contrast of suffix type (i.e., real suffixes vs. trained pseudo-suffixes) was statistically significant at all test points (pre-test: estimate = -0.823, p = .006; immediate post-test: estimate = 0.987, p < .001; delayed post-test: estimate = 0.806, p < .001). Specifically, the interaction effect was negative at the pre-test, indicating that the difference between real suffixes and trained pseudo-suffixes was relatively larger in the explicit condition group than in the implicit condition group before training. In contrast, the same interaction effect was positive at the immediate and delayed post-tests, indicating that after training, the difference between real suffixes and trained pseudo-suffixes was smaller in the explicit condition group than in the implicit condition group (see Figure 3.3). In addition, the interaction between condition and the second contrast of suffix type (i.e., trained vs. untrained pseudo-suffixes) was significant at the immediate and delayed post-tests (immediate post-test: estimate = -0.893, p < .001; delayed post-test: estimate = -0.511, p = .040). The interaction effect was negative at both test points, indicating that the difference between trained and untrained pseudo-suffixes was larger in the explicit condition group than in the implicit condition group after training.

Figure 3.3

Box and Violin Plots for the Average Scores on the SIT-N



Note. Box plots show the median, the interquartile range, 1.5 times the interquartile range, and outliers. Violin plots show the density distribution of the proportion correct. Plots in dark gray indicate real suffixes, plots in medium gray indicate trained pseudo-suffixes, and plots in light gray indicate untrained pseudo-suffixes

Table 6.3

Generalized Mixed Models for the SIT-N

	Pre				Immediate Post				Delayed Post			
		95% CI				95% CI				95% CI		
Fixed Effects	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*	Estimate (*SE*)	LL	UL	*p*
Word reading	-0.053 (0.169)	-0.385	0.278	.752	0.223 (0.102)*	0.022	0.423	.030	0.153 (0.123)	-0.087	0.393	.212
Vocabulary	-0.024 (0.021)	-0.064	0.017	.254	0.001 (0.013)	-0.024	0.027	.912	0.005 (0.015)	-0.025	0.036	.728
Morph. knowledge	0.796 (0.188)***	0.428	1.164	< .001	0.175 (0.116)	-0.052	0.401	.131	0.190 (0.139)	-0.082	0.462	.171
Condition	-0.442 (0.297)	-1.024	0.139	.136	0.373 (0.183)*	0.015	0.732	.041	0.281 (0.217)	-0.144	0.707	.195
Suffix type (RS vs PS_T)	-0.341 (0.351)	-1.028	0.347	.331	-0.736 (0.191)***	-1.110	-0.362	< .001	-0.638 (0.163)***	-0.958	-0.318	< .001
Suffix type (PS_T vs PS_UT)	-0.348 (0.403)	-1.138	0.443	.388	0.160 (0.217)	-0.265	0.585	.460	-0.004 (0.187)	-0.370	0.362	.984
Cond x ST (RS vs PS_T)	-0.823 (0.296)**	-1.404	-0.242	.006	0.978 (0.216)***	0.555	1.400	< .001	0.806 (0.216)***	0.382	1.231	< .001
Cond x ST (PS_T vs PS_T)	0.264 (0.360)	-0.442	0.971	.463	-0.893 (0.249)***	-1.382	-0.405	< .001	-0.511 (0.249)*	-1.000	-0.023	.040
Random Effects	Variance	*SD*			Variance	*SD*			Variance	*SD*		
Participant (Intercept)	1.258	1.122			0.473	0.688			0.743	0.862		
Items (Intercept)	0.217	0.466			0.029	0.171			0.007	0.082		
Model fit	Marginal	Conditional			Marginal	Conditional			Marginal	Conditional		
R^2	.121	.393			.048	.174			.035	.214		

Note. CI = confidence interval; UL = upper limit; LL = lower limit; RS = real suffix; PS = pseudo-suffix; T: trained; UT = untrained; ST = Suffix type. Model equation: SIT_N ~ Word_reading + Vocabulary + Morphological_knowledge + Condition + Word_type + Condition:Word_type + (1 | ID) + (1 | Item). Condition was coded as 0 and 1 for the implicit and explicit conditions, respectively. Word type was coded with two contrasts: -0.66, 0.33, 0.33 and -0.33, -0.33, 0.66; the first contrast tested real suffix versus trained pseudo-suffix; the second contrast tested trained pseudo-suffix versus untrained pseudo-suffix.

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Discussion

The main goal of this study was to explore whether explicit instruction in morphological analysis provides any advantages over implicit teaching in learning the form and meaning of novel suffixes in Spanish, a language characterized by high morphological complexity and high orthographic consistency. More specifically, we aimed to address two research questions. The first question concerned the overall effectiveness of explicit over implicit instruction: Does employing an explicit approach in morphological analysis instruction prove more effective than an implicit approach when teaching the forms and meanings of novel suffixes? To answer this question, we used one task to assess form, and two tasks to assess meaning, conducted both at immediate and delayed post-test. While not unanimous, our results predominantly support the effectiveness of explicit instruction. At both testing points, explicit instruction yielded better results for the learning of the form of the suffixes and for the meaning of the suffixes, as measured by the word definition task but not by the multiple-choice task. These results suggest that Grade 3 Spanish-speaking students formed an orthographic representation of the presented suffixes only after receiving explicit instruction. This was true at both testing points. Our results on suffix form learning align with those of previous studies that compared explicit and implicit teaching of morphological orthographic rules in English and Dutch (Bryant et al., 2006; Kemper et al., 2012), favouring explicit teaching.

The fact that explicit instruction continues to show added benefits in the learning of the form of written novel suffixes in Spanish can have two potential explanations. First, our suffixes caused orthographic changes to the bases (mirroring how derivational suffixes usually affect words in Spanish; Silva-Pereyra et al., 2014; Zacarías, 2016); thus, increasing the difficulty of finding them in the target words, which in tandem amplifies the need for explicit instruction. Second, the search for morphemes during reading is not a common practice for our participants, nor is it a process reinforced by instruction. Consequently, students might store an orthographic representation of the complete words without an awareness of the morphemes that constitute them, suggesting that such learning only occurs after explicit instruction.

Concerning the acquisition of suffix meanings, we used a multiple-choice task and a word definition task to measure this. Results from the multiple-choice task suggest that irrespective of how the suffixes were taught (implicit or explicit), there was a limited amount of overall suffix learning. The predominant form of learning seems to be instance-based as the results showed a significant effect for trained words regardless of condition, but there was little evidence of transfer to untrained words. For the expressive task that assessed a deeper knowledge of the word, the results were significantly better following explicit instruction. Conversely, it appears that implicit instruction did not lead to meaningful learning at a deeper level, as evidenced by scores that were consistently close to 1 (ranging from 0.97 to 1.08; see Table 2.3). Notice that scores of 1 were assigned to responses where participants mentioned either the base word or the meaning of the suffix. An examination of the students' responses showed that following implicit instruction, many students mentioned only the base word when asked about the meaning of the word (e.g., for "sombrerembe", students responded with "a type of hat = sombrero"). While explicit instruction outperformed implicit instruction, the improvement was not substantial (ranged from 1.10 to 1.27; Table 2), indicating that, although superior to implicit instruction, not much learning occurred under the explicit condition either.

Although ours is not a cross-linguistic study, Duncan (2018) has previously suggested that two separate single-language studies using similar methods and stimuli can provide valuable insights into possible cross-linguistic differences. The present study was based on a study with English speakers in Canada (Authors, submitted) and followed the same methodology. Therefore, although not a direct comparison, our results suggest that children in Spanish were having a harder time learning the novel suffixes, even after receiving explicit instruction, compared to English-speaking students. A possible explanation is that although the methodology used for both studies was the same, the target words used in English were fully transparent (coat + isp → coatisp = coat maker) and the words in Spanish included an orthographic shift (sombrero + embe → sombrerembe = hat maker, notice that to create this word we drop the "o" in "sombrero"). This may have caused the lower scores (average word definition score of 1.1 in Spanish compared to an average score of 1.5 in English).

Taken together, our results have two important implications regarding the added benefits of explicit instruction. First, our findings may imply cross-linguistic differences in learning the form of suffixes. Our results indicate that students were able to grasp the form of the suffixes only when provided with explicit instruction. Interestingly, when evaluating English-speaking students using a task with the same format (Authors, 2023), no differences were observed across conditions. This suggests that English-speaking students could form orthographic representations of the suffixes implicitly. This discrepancy may be due to the transparency of the items used in the study with English speakers, but it might also indicate that readers in orthographies where the sound-to-letter correspondence is opaque may be more attuned to morphological information in written forms, and this may help them to learn the orthographic form of novel suffixes implicitly. In languages with a transparent sound-to-letter correspondences like Spanish, students might need explicit guidance on where to direct their attention to learn the orthographic form of suffixes. It is important to view this suggestion with some caution, given that this is not a cross-linguistic study and the items across the two studies were not matched. However, it does align with the psycholinguistic grain size theory, which proposes that different languages may employ units of different sizes when reading, influenced by the orthographic depth of the language (Ziegler & Goswami, 2005).

Second, in terms of meaning, our results differed by task, with explicit instruction showing added benefits in the expressive task but not in the multiple-choice task. Building on the Lexical Quality Hypothesis (Perfetti, 2007) that presents word knowledge as a continuum ranging from low to high lexical quality, each of our tasks may tap into different levels of word knowledge, and the multiple-choice task may have been less sensitive to fine-grained differences in knowledge. It appears that a deeper understanding of the suffixes' meanings was only obtained through explicit instruction, as suggested by the results from the word definition task. Although the only other study that compared implicit and explicit teaching in morphological analysis in Spanish was done with adult English-Spanish second-language learners, our results seem to align. In her study, Morin (2003) divided her participants by level of proficiency (beginner and advanced) and type of instruction (implicit vs. explicit) and provided vocabulary instruction using semantic maps and picture descriptions (implicit group) or by instruction in morphological analysis (explicit group). Interestingly, their results were moderated by task type and proficiency level. The highest scores were obtained by advanced students on an expressive task following explicit teaching. There were no differences between groups on the receptive tasks. Moreover, the observation that students with higher proficiency in Spanish made more gains following explicit training compared to beginners implies that more advanced learners may possess some foundational knowledge tapped by explicit instruction. This allows them to engage in more complex strategies compared to learners who have less knowledge of Spanish. Although this conclusion seems to resonate with our findings, ours and Morin's studies cannot be compared. There are many potential differences between monolingual Spanish-speaking children and adult learners of

Spanish. For example, English-speaking learners of Spanish may already be attuned to look for morphological cues in orthography.

Our second research question concerned the possibility of knowledge transfer following the two distinct types of instruction: To what extent can knowledge transfer occur following implicit and explicit instruction? To answer this question, we compared the performance of both trained and transfer words at the two testing points (immediate and delayed post-test) on the meaning tasks. Our findings were mixed. For multiple-choice, the trained words had better outcomes across conditions and testing points, whereas for word definition there was no significant effect for word type. The multiple-choice results suggest instance-based learning, where participants primarily acquired knowledge of the specific items included in the training, rather than learning the suffixes for subsequent morphological analysis. This was true irrespective of how children were instructed. In contrast, the results for word definitions showed no significant effects for word type across conditions, with students in the explicit instruction condition scoring higher for both word types. There is an important difference between tasks that we must consider. The multiple-choice was a written task and the word definition was oral. One possibility is that students could have better learned the definition of the suffixes when explicitly taught but that this learning was not strong enough to support their use in reading, particularly because as expressed before, the identification of morphemes as a reading strategy is not common in Mexico nor reinforced by instruction. Although our results showed that explicit instruction did lead to the learning of the form of the suffixes, this may represent only the initial stage of derivational suffix learning, as suggested by Tyler and Nagy (1989), and additional instruction may be necessary for consolidating their meaning and use in different contexts. Nevertheless, we should also consider the possibility that the multiple-choice task was less sensitive to individual differences. Therefore, the effect of the type of instruction on the trained items was not detectable in this type of task.

Taken together, our results support the use of explicit instruction when teaching the form and meaning of novel written suffixes. Although there was not much evidence showing that participants could later use this knowledge to engage in morphological analysis (i.e, untrained words), the results did show significantly higher scores for trained and transfer words following explicit instruction. Notably, benefits for explicit instruction were obtained after receiving a brief 5-minute morphological analysis activity over three days. According to Duncan (2018), the availability of morphological knowledge seems to be influenced by the prevalence and productivity of morphological information in the spoken language. In cases where there is early access to morphological knowledge, as is the case for Spanish, whether beginning readers utilize this knowledge may still be influenced by the characteristics of the orthography they are learning. One possibility is that our participants possessed strong morphological knowledge in spoken language that was accessible in written language only after receiving explicit instruction. Therefore, albeit small, significant results were obtained even after minimal instruction.

A few limitations of our study are worth mentioning. First, our study included only one language; thus, the comparisons made to other languages need to be viewed with some caution. Cross-linguistic studies comparing the effects of explicit morphological analysis instruction are needed to discern the degree to which its effectiveness is moderated by the language of instruction. Furthermore, future studies might consider following a mixed-methods approach that can include teacher surveys related to their morphological knowledge and whether they include some type of morphological instruction that goes beyond what is expressed in the curricula. Finally, although we built on previous studies by assessing not only the form but also the meaning of the novel suffixes, we did not include a task to measure the use of the words. Considering that syntax is one of the different levels of information morphemes convey, and that use (i.e., put words into action) is an important aspect of high-quality lexical representations (Perfetti, 2007), future studies should consider testing the use of the target suffixes in context perhaps by including, for example, a cloze task. Moreover, incorporating a task to assess syntactic learning can provide additional insights into the process of acquiring suffix knowledge.

Conclusion

The present study examined the added benefits of receiving explicit morphological analysis instruction over implicit instruction on the learning of the form and meaning of novel suffixes in a sample of Spanish monolingual Grade 3 students. While small, the benefits of explicit instruction were significant. We suggest that the rich morphology of the Spanish language might provide students with ample oral morphological knowledge but given the orthographic characteristics of the language and the focus of the reading instruction, it may remain dormant until explicit instruction is provided. As we become more aware of the benefits of explicit instruction in morphology, English-speaking countries are shifting their attention and support toward explicitly teaching the morphemic structure of words in early grade levels (see Alberta Education, 2023). Given the relatively limited research conducted in languages other than English, further cross-linguistic research is essential to expand the body of evidence supporting explicit teaching in morphology in languages other than English.

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Chapter 5: General Discussion

This present dissertation focused on derivational morphology, comprising one study that assessed students' knowledge of adjectival and nominal derivational suffixes in terms of form and meaning, alongside two studies that compared the effects of implicit and explicit teaching of novel derivational suffixes. Furthermore, these last two studies examined the influence of grade level (Study 2) and language characteristics (Study 3) on the effectiveness of morphological analysis instruction. For the following discussion, I will first provide a summary of the primary findings. Next, I will discuss these results in the context of the existing literature, followed by the presentation of their educational implications.

Summary and Review

The strong relation between morphological knowledge and literacy skills is well documented (e.g., Law et al., 2018; Layes et al., 2017; Levesque et al., 2017; Liu et al., 2024; Kalindi & Chung, 2018; Sparks & Metsala, 2023; St-Pierre, 2018) and evidence on the positive effects of instruction in morphology is growing (e.g., Burton et al., 2021; Leonet et al., 2020; Ng et al., 2022; Torkildsen, 2022; Vaknin-Nusbaum & Rahev, 2019). Nevertheless, many different factors can contribute to the development of implicit morphological knowledge and such factors should be considered individually. The knowledge of derived words (e.g., "friendly"), for example, is influenced by both base morpheme (e.g., "friend") and derivational suffix morpheme (-ly) characteristics such as frequency, family size, and length (see Ford et al., 2010, see also Carlisle & Stone, 2005; Carlisle & Katz., 2006). Furthermore, the orthographic, semantic, and grammatical changes the derivational suffixes exert on the base morphemes of derived words seem to also influence their acquisition (e.g., Carlisle et al., 2001; Nippold & Sun, 2008; Quémart & Casalis, 2014). Given the interconnected nature of these factors in the assessment of derived words, it is important to examine derivational suffix knowledge in isolation, independent of the influence of lexical vocabulary knowledge (see, Mitchell & Brady, 2014). The understanding of suffixes alone constitutes an important aspect highlighted in a comprehensive definition of morphological knowledge (Apel, 2014) and it is at the core of morphological analysis skills that enables children to expand their vocabulary beyond instructed words.

Although students can develop morphological knowledge implicitly (Burani et al., 2018; Carlisle & Stone, 2005; D'Alessio et al., 2018; Larsen & Nippold, 2007), they still benefit from explicit morphology instruction. Similar to implicit knowledge, the effectiveness of this instruction also appears to be influenced by various factors. For example, the latest meta-analysis on morphology intervention in typically developed children revealed that the effect sizes were mediated by grade level; the effects being higher in early elementary grades (see Goodwin & Ahn, 2013). Furthermore, there are theoretical grounds to suggest that language characteristics could impact the effectiveness of morphology intervention. Unfortunately, the only meta-analysis that considered language as a moderator could not identify enough studies in languages other than English to provide empirical evidence for this claim (see Bowers et al., 2010). Although the few studies comparing implicit and explicit approaches to morphology instruction concur that explicit instruction yields superior results, further exploration into grade level, language-specific effects, and approach type (implicit vs. explicit) is necessary to gain deeper insights into the specifics regarding when and how to effectively teach novel derivational suffixes, an important aspect of morphological knowledge.

Three studies were developed to address specific questions concerning derivational suffix knowledge and the effectiveness of two approaches, implicit and explicit, in morphological analysis. The first study tested the knowledge in form and meaning of adjectival and nominal derivational suffixes among Grade 3, Grade 5, and Grade 8 English-speaking students attending public elementary schools in Alberta, Canada. In Study 2, Grade 3 and Grade 5 English-speaking students in Alberta, Canada underwent a three-day training session following either an implicit or an explicit approach to learn novel derivational suffixes. One day and one week after training, participants were tested on the form and meaning of these novel suffixes in the context of both trained and transfer words. For Study 3, we followed the same methodology as in Study 2 with a sample of Grade 3 Spanish-speaking students attending public elementary schools in Morelos, Mexico.

The Knowledge of Derivational Morphemes

The first study (Chapter 2) assessed the knowledge in form and meaning of highly frequent derivational suffixes and whether the results would vary by grade level (Grades 3, 5, and 8) and suffix type (adjectives and nominals, the two most frequent types of derivational morphemes, see Nippold, 2018). Anticipated differences by grade level were rooted in the notion that children accumulate implicit morphological knowledge as they encounter more examples of morphologically complex words as they progress through school (Dawson et al., 2023; Kearns & Hiebert, 2022). Differences by suffix type were expected on the observation that certain word types offer more systematic information than others facilitating their acquisition (Marinellie & Kneile, 2012; Nippold & Sun, 2008). For example, adjectives typically precede nouns, whereas a wider range of words can follow nouns. In line with this, Nippold and Sun (2008) suggested better knowledge of adjectives over nominals. The results from our study corroborate the expected differences across grade levels. This held for knowledge on both the form and meaning of the derivational suffixes. Notably, the performance improvement was not consistent across all grades, as the results showed that the differences between Grade 3 and Grade 5 were larger than those observed between Grade 5 and Grade 8 students.

Our results partially aligned with those of Nippold and Sun (2008). More specifically, we found superior performance in the recognition of adjectival suffixes across all grades. However, differences by suffix type in the understanding of suffix meanings were only noticeable in the results of Grade 8 students, with higher scores observed for nominals. Our results aligned better with data on suffix frequency reported by Dawson et al. (2023). In their study, Dawson et al. (2023) quantified derivational suffix knowledge in the reading material of children organized into three groups: ages 5 to 7 (Stage 1), ages 7 to 11 (Stage 2), and ages 11 to 14 (Stage 3). Interestingly, their results indicated a notable increase for both adjectives and nominals when comparing stages 1 and 2. Nevertheless, from stages 2 to 3, the increase in frequency for nominals was not as pronounced and for adjectives, there was a decline with reading materials in Stage 3 having a smaller number of adjectival suffixes than those found in Stage 2. Dawson et al.'s (2023) frequency report could explain why the differences in suffix knowledge were larger between Grades 3 and 5 and less pronounced between Grades 5 and 8. Differences in frequency could also explain why nominals had significantly higher scores in the suffix definition task compared to adjectives. One possibility is that adjectives might be easier to grasp, indicated by the adjective superiority when the form of the suffixes was assessed, but since their frequency declines in older grades, this effect no longer permeates into consolidating the knowledge of their meaning for which more practice is required. Therefore, these results might suggest that beyond suffix type, it is suffix frequency that plays a stronger influence on their acquisition. Given the limited number of studies examining differences in suffix acquisition based on their part of speech (i.e., suffix type), this conclusion must be taken with some caution. Intervention studies that teach novel suffixes differentiating by suffix type can offer some insight in this regard, yet to our knowledge, only one study has examined this matter. In their study, Marinellie and Kneile (2012) presented 106 Grade 4 students with short passages that included novel-derived words (targets) created by combining made-up bases with real adjectival and nominal derivational suffixes (e.g., "froneful", "creatness"). All passages were matched on the number of adjectives and nominals included as well as length and reading complexity. Immediately after reading the passages, students were tested on multiple-choice questions that included both general comprehension and target word knowledge questions. Interestingly, their results showed comparable learning outcomes for adjectives and nominals, supporting the notion that when equal opportunities for interaction and practice with the suffixes are provided, there appears to be no significant difference in how they are processed based on suffix type. The alignment of these findings places significant emphasis on suffix instruction that can guarantee students get exposed to multiple examples of the suffixes and their use, providing ample practice opportunities, and thereby ensuring their acquisition.

Intervention Outcomes

For Studies 2 (Chapter 3) and 3 (Chapter 4), I delved into intervention. Both studies compared the effectiveness of implicit and explicit instruction on morphological analysis following a similar methodology. For three days participants were trained on novel derived words (targets) built by attaching derivational pseudo suffixes (i.e., made-up suffixes) to real word bases. Participants were tested immediately and one week after training on the form of the novel suffixes and on the meaning of trained and transfer words. For Study 2, the focus was to explore the effectiveness of both approaches (i.e., implicit and explicit) across Grades 3 and 5. The results showed that for both grade levels, children's scores on the suffix form task did not differ by condition. This held at both testing points, suggesting that students as young as Grade 3 could implicitly spot and learn orthographic co-occurrences found in print. Although these results differed from previous studies comparing implicit and explicit teaching of morphological spelling rules (e.g., Bryant et al., 2006; Kemper et al., 2012), the tasks that assessed the spelling of the suffixes across studies significantly differed. Previous studies have used spelling-to-dictation tasks to assess knowledge of the form of the suffixes, whereas in the present study, participants were required to identify and circle the suffixes learned. According to Kirby et al. (2018), knowledge of the morphemic units of words can be implicit, supporting language and reading without conscious awareness, or explicit, wherein students are aware of how words need to be manipulated to get to the right response, for example in word analogy tasks (e.g., tooth-teeth, mouse- _____ [correct response: mice]). Given the difference in nature of the tasks used across studies, it is possible that mine, compared to previous studies, measured different types of knowledge, with participants in my study not being aware of how they were using their knowledge to complete the task (i.e., implicit knowledge). Therefore, the present and previous findings may not necessarily conflict.

Results on suffix meaning were also in favour of explicit instruction in both grade levels, with explicit instruction yielding better results for the learning of both types of words (i.e., trained and transfer). Moreover, explicit instruction also showed benefits for learning that could endure past one week after training. This is particularly true for transfer words that require knowledge generalization. Results showed that following explicit instruction accuracy rates in Grade 3 went from 84% at the immediate post-test to 77% at the delayed post-test (a decline of 7%); and in Grade 5, scores were at 91.5% and 85% for immediate and delayed post-test, respectively (a decline of 6.5%). Nonetheless, following implicit instruction, this type of word suffered a significant decline at the delayed post-test. For example, Grade 3 correct-response rates declined from 70.5% to 53% when assessed a week after training. For Grade 5, the results showed a similar decline from 82.5% at immediate to 65% at delayed post-test (a decline of 17.5% for both grade levels). These results suggest that although Grade 5 students show consistently higher scores for both types of training compared to Grade 3 students, the effects of not receiving explicit instruction seem to be comparable across both grade levels particularly when knowledge generalization is the aim of instruction.

Is there a developmental stage at which students can have similar benefits from implicit and explicit morphology instruction? To our knowledge, very few studies have carried out an intervention targeting the teaching of novel suffixes and they included young adults (Merkx et al., 2011; Tamminen et al., 2015). For example, Merkx et al. (2011) trained university students on novel morphologically structured words (e.g., “wheathoke”, “coinhoke”) with made-up suffixes that consistently influenced the meanings of the bases (e.g., -hoke denoting a tool). Participants were presented with individual words followed by their definitions, without receiving any explicit instruction on how the words were created or exposure to the suffixes in isolation. Their results showed that participants could acquire knowledge of the novel suffixes and apply it to new words. Notably, their results showed an accuracy rate of 94% for trained words and 72% for generalized (i.e., transfer) words. Although their scores are remarkably high considering their participants received implicit training, there is room for further improvement, particularly in knowledge that can be generalized, as the scores reported are far from being at ceiling. A comparison with explicit training was beyond the researchers’ aim, leaving the question of whether their participants could have performed significantly better following explicit instruction unanswered.

For Study 3, the aim was to assess whether our results from Study 2 could be replicated in a different language (Spanish). Consequently, I conducted a similar intervention to the one presented in Study 2, this time targeting Grade 3 Spanish speakers in Morelos, Mexico. Contrary to the results of Study 2, we found significant differences across conditions for the learning of the form of the suffixes, with better results obtained from explicit instruction. These findings highlight important differences between oral and written morphology. Although Spanish is morphologically rich (Borleffs et al., 2017; Rodríguez &

Carretero, 1996), written morphology relies heavily on orthography (Deacon et al., 2008; Egan & Pring, 2004; Nunes & Bryant, 2006) and since looking for morphemes is not part of regular reading instruction in Mexico, our results showed that children greatly benefit when explicitly instructed to do so. The benefit of being immersed in a language with ample examples of morphologically complex words does not equip children with the ability to identify derivational suffixes in print unless explicit instruction is provided. Importantly, participants derived benefits only after three sessions, suggesting that students might possess a strong implicit knowledge of morphology and not much instruction is needed to activate it. Although not reported in the results as the study was quantitative, instructors of the explicit condition reported that during the first session, children were confused by the concepts "base" and "suffix" and were unaware of the interplay between these two to construct words. Once the concept of word formation became clear to the students, the next two sessions went by smoothly with children finding suffixes quickly not only in the words included in the session but also in words used in their everyday interactions.

Regarding meaning, results also favoured explicit instruction, particularly when word knowledge was assessed using a word definition task. Interestingly, explicit instruction showed stronger benefits not only for knowledge transfer but also for the words included in the training. The reason why explicit instruction is better for knowledge transfer is understandable, as one of the activities in the explicit condition required children to combine the trained suffixes with different bases using a word matrix, yet the reason why explicit instruction is also better for the trained items is not that evident. Ng et al. (2022) proposed that word matrices assist in organizing information by prioritizing new over known information. This emphasis on new information facilitates easier retrieval later on. For example, the bases used to create the target words in my study were known by the participants, thus by observing the targets in the matrix divided by base and suffix, for example, “bota” (boot) + -isba (novel suffix), it was easier to understand that the only novel information participants needed to learn was the suffix. In contrast, children following implicit instruction never saw the suffixes in isolation, and they had to remember full words (e.g., “botisba”). In view of this, students in the explicit group may have recognized that they only needed to learn four new elements (i.e., the novel suffixes: -isba, -ispe, -embe, -epa) compared to students in the implicit training group that may have focused their attention on learning the 12 target words (three for each of the novel suffixes; e.g., -isba: “botisba”, “cajisba”, aretisba”). This may explain why explicit instruction on the morphological structure of words provides an advantage compared to instruction that overlooks the role of morphology in word formation, not only for knowledge transfer but also for the words covered in the lesson.

The Importance of Explicit Instruction

The results from this dissertation contribute to the existing evidence supporting explicit morphology instruction (e.g., Bryant et al., 2006; Burton et al., 2021; Kemper et al., 2012; Ng et al., 2022). Notably, our results expand on past literature by showing that these benefits contribute not only to the enhancement of the spelling of morphologically complex words but also to the learning of their meaning. Moreover, this acquired knowledge tends to be better sustained compared to that obtained through implicit instruction.

The effectiveness of explicit morphology instruction has previously been attributed to how information is both physically and mentally organized when following this type of instruction. Additionally, Daigle et al. (2018) have suggested that active learning and scaffolded co-construction of knowledge are two additional factors that contribute to the effectiveness of this approach. Active learning occurs when students are provided with opportunities to link prior knowledge to new information, prompting them to use metacognitive strategies to establish connections between existing and new knowledge.

When explicitly taught how to identify morphemes within words, students can later use this knowledge actively to infer the meaning of novel words through morphological analysis and word analogies (e.g., teacher and painter, -er denotes a person who…), thus connecting known information to new contexts. Regarding scaffolding and co-construction of knowledge, Daigle et al. (2018) suggested that teachers play a mediating role by arranging lessons and activities that facilitate students' gradual development into independent learners. To achieve this, instructional approaches should provide sufficient challenge without inducing excessive frustration for students. Arguably, explicit instruction in morphology hits this optimal point by demonstrating the rules of word formation and encouraging students to apply this knowledge to new contexts, thereby providing both support in modelling word formation and a challenge by asking students to work independently in applying this technique to new words.

Implicit and explicit instruction are not necessarily contradictory approaches; rather, more researchers are now advocating for their complementary use (see Daigle et al., 2018; Kirby et al., 2018). For example, Structured Word Inquiry (SWI) is an instructional approach where students take on the role of "detectives" to investigate the connections between sounds, spelling patterns, and the meaning of words. In SWI, students analyze words by breaking them down into their morphological components, such as roots, prefixes, and suffixes, to understand their meaning and how they are constructed. Although the morphemic units within words are made explicit, students are encouraged to derive rules and explanations through an emphasis on discovery, active inquiry, and critical thinking, thereby combining elements of both implicit and explicit instruction (see Bowers & Kirby, 2010; Georgiou et al., 2021, for studies using SWI).

The importance of explicit morphology instruction has permeated the curriculum of some English-speaking countries. For example, the provinces of Ontario and Alberta, Canada, in their 2023 English Language Arts (ELA) curricula incorporate morphology instruction as early as Grade 1, with the explicit teaching of compound words, and highly frequent inflectional suffixes such as the -s and -es for plurals and -ed for regular past tense verbs (see Alberta Education, 2023; Ontario Education, 2023). Instruction in morphology in early grades has been previously advised (e.g., Bowers et al., 2010; Carlisle & Stone, 2005; Nunes & Bryant, 2006) as it provides students with a generative tool that can help them grow their reading, spelling, and vocabulary independently.

In Mexico, morphology instruction was included in the past ELA curriculum starting in Grade 5 by following an affix-centred approach in which the definition of highly frequent suffixes was explicitly taught (Subsecretaría de Educación Básica, 2018). Nevertheless, the newest curriculum released in 2023 (Subsecretaría de Educación Básica, 2023) removed this learning outcome, claiming that this instruction was too drilling and shifted towards lessons that involved more learning by discovery. Study 3 from the present dissertation provided evidence in support of explicit instruction in Spanish, as an approach that aims for knowledge generalization but that has also proven to be more effective than implicit training to the learning of the words included in the lesson. Nevertheless, more evidence is needed to make a strong case why explicit morphology instruction needs to be reinstated in the language arts curriculum in Mexico, perhaps following an approach similar to SWI that combines both explicit instruction on the morphemic structure of words with current discovery and critical thinking practices.

The Importance of Comprehensive Testing

The results from the three studies included in this dissertation showed significant differences by type of knowledge being evaluated (form and meaning) and by task type (multiple-choice and word definition). These findings emphasize the need for a comprehensive assessment of the gains obtained from morphology instruction. Failing to do so might result in an incomplete view of a student's skills and an overgeneralization of what students can do. For example, in Study 2, the morphology intervention in English, students scored similarly across conditions when the form of the suffixes was evaluated. Furthermore, differences across conditions for Grade 5 were not picked up by the multiple-choice task. Similarly, the results from the intervention study in Spanish showed the biggest differences across conditions when using the word definition task but not the multiple-choice task. Should we have only used the multiple-choice task to measure learning, this could have led to the conclusion that explicit instruction does not provide additional benefits. Kirby et al. (2018) considered morphological knowledge to be a continuum ranging from very implicit to very explicit knowledge and stressed that the different measures to assess this knowledge also vary along the continuum depending upon test items, instructions, and learner characteristics. Our results further support this view and advocate for the use of a comprehensive battery of tests to get a finer picture of children's morphological knowledge.

Limitations

Some limitations in this dissertation should be noted. First, even though I mentioned earlier that we examined whether language characteristics can moderate the results of explicit/implicit instruction, we did not directly compare the results across the two languages (English and Spanish) because it would also require that the test items in the different assessments would be matched across languages, something that we did not do. Thus, the role of orthography in our results remains to be examined in a more direct way. Second, and related to the first limitation, there is no agreed-upon classification of languages along a morphological complexity continuum. Consequently, it remains unclear how morphologically distant English is from Spanish. For my dissertation, I relied on Borleffs et al.'s (2017) suggested measures of morphological complexity such as the number of morphemes in a typical sentence, number of morpheme categories (e.g., inflexional, derivational), and number of morpheme types (e.g., prefixes, suffixes). Nevertheless, the measures reported do not classify complexity by oral and written morphology an important distinction when examining the effect of morphology instruction across languages. Second, in this dissertation, I focused on derivational suffixes. A future study may explore also the knowledge and learning of the form and meaning of prefixes. Previous studies have shown processing differences between prefixes and suffixes, but this evidence comes mostly from visual word processing tasks (see Beyersmann et al., 2015). Finally, because my dissertation included Grade 3, 5, and 8 students, it is possible that some of them had received some morphology instruction in the past. Unfortunately, it was not possible to get an estimate of how much instruction these students may have received and the extent to which that prior knowledge may have influenced the current results.

Conclusion and Future Implications

This dissertation examined students' knowledge of the form and meaning of derivational suffixes by grade level and suffix type, and the effectiveness of two morphology instructional approaches (implicit and explicit) to teach the form and meaning of novel derivational suffixes in two grade levels (Grades 3 and 5) and two languages (English and Spanish). Overall, the results showed that suffix knowledge increases by grade level and that beyond suffix type what appears to be behind their learning is suffix frequency. These findings overscore the importance of instruction as an opportunity to provide students with ample examples of derived words and chances to explore the function of derivational suffixes in word formation, thereby consolidating their learning. Building on instruction, results from the intervention provide evidence that explicit instruction offers additional benefits compared to implicit instruction in the learning of the form and meaning of novel suffixes across the two grade levels and the two languages tested. Notably, our results varied by task characteristics, thereby also emphasizing the importance of comprehensive testing of morphology.

Overall, this dissertation contributes to our understanding of derivational morphology with results regarding derivational suffix knowledge and learning. Given that our results support explicit morphology teaching, this study advocates for the integration of early morphology instruction, a practice already embraced by countries like Canada, but still awaiting adoption in countries such as Mexico. A future study should consider delivering an intervention similar to the one presented in this dissertation, this time implemented by teachers in the regular classroom. This could serve two purposes: first, to provide teachers with training on morphological analysis instruction, and second, to allow teachers to experience the benefits of explicit instruction firsthand.

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Appendix 1A. Examples of items contained on the SIT-N (top) and SMT-N (bottom)

sneedish	grushable	ploomory
trabless	mirlette	meckose
mippist	gampic	bracken
snaditis	blorkian	slenny

Spooch.
Which one means something like "full of spooch"?
A. Spoochable
B. Spoochen
C. Spoochish
D. Spoochful

Weaf.
Which one means something like "the study of weaf"?
A. Weafogy
B. Weafer
C. Weafant
D. Weafory

Appendix 1B. Target suffixes used in the SIT-N and SMT-N

Suffix type	Suffix	Family size	Frequency	Length
	-y	2486	3870233	1
	-ish	252	161977	3
	-less	368	158354	4
	-ine	30	18081	3
	-ous	9	2108	3
	-ive	580	1037354	3
Adjectives	-ful	343	429561	3
	-ate	937	2569118	3
	-able	872	1227992	4
	-ar	129	533962	2
	-ose	13	2108	3
	-en	204	655590	2
	-ic*	1014	1472797	2
	-ile*	10	5460	3
Mean		517.64	867478.21	2.8
SD		668.40	1135040.68	0.8
	-ity	580	1647588	3
	-ist	462	382916	3
	-ment	288	1423689	4
	-itis	16	5021	4
	-er	2274	4569119	2
Nominals	-ian	174	394113	3
	-ory	356	725186	3
	-ant	464	1534593	3
	-ette	14	6920	4
	-ogy	1	80	3
	-ism	271	218200	3
	-let	14	9586	3
	-ness*	1243	181553	4
	-ance*	323	977837	4
Mean		462.86	862600.07	3.3
SD		613.96	1222258.43	0.6

Note. Suffixes marked with an asterisk were the ones removed from the SMT-N. Adjectival and nominal suffixes were matched on family size, frequency, and length; $t(26) = 0.23$, $p = 0.82$, $t(26) = 0.01$, $p = 0.99$, $t(24) = -1.86$, $p = 0.08$.

Appendix 1C. Accuracy scores for the SIT-N for each suffix type by grade level

	Suffix	*Grade 3 (N=103)*	*Grade 5 (N=120)*	*Grade 8 (N=86)*
Adjectives	-ile	39%	77%	83%
	-ine	42%	72%	83%
	-ose	42%	72%	79%
	-ous	45%	87%	87%
	-able	45%	76%	89%
	-less	52%	85%	91%
	-ive	52%	85%	89%
	-ic	53%	66%	70%
	-ish	54%	86%	87%
	-ate	55%	78%	73%
	-y	64%	65%	53%
	-ar	78%	81%	89%
	-en	80%	85%	92%
	-ful	83%	96%	99%
Nominals	-itis	18%	45%	59%
	-ette	24%	49%	63%
	-ance	29%	62%	73%
	-ity	30%	59%	76%
	-ogy	30%	54%	74%
	-ory	34%	65%	74%
	-ment	35%	66%	76%
	-ian	39%	75%	78%
	-ness	45%	81%	94%
	-let	51%	85%	90%
	-ism	51%	84%	90%
	-ist	54%	78%	74%
	-ant	60%	86%	87%
	-er	86%	76%	69%

Appendix 1D. Accuracy scores for the SMT-N for each suffix type by grade level

	Suffix	*Grade 3 (N=103)*	*Grade 5 (N=120)*	*Grade 8 (N=86)*
	-ose	15%	28%	21%
	-ive	16%	26%	22%
	-ous	28%	59%	63%
	-ate	28%	28%	38%
	-ine	31%	37%	26%
Adjectives	-en	32%	46%	37%
	-ar	36%	63%	38%
	-ish	46%	69%	79%
	-y	47%	52%	52%
	-able	49%	73%	78%
	-less	80%	90%	93%
	-ful	80%	90%	90%
	-ette	27%	50%	62%
	-ant	29%	43%	62%
	-ory	29%	43%	62%
	-ity	30%	30%	40%
	-itis	34%	56%	62%
	-ogy	35%	50%	69%
Nominals	-let	38%	46%	60%
	-ian	41%	53%	55%
	-ism	42%	53%	78%
	-ist	47%	61%	83%
	-ment	51%	51%	63%
	-er	63%	81%	81%

Appendix 1E. Model comparisons for the SIT-N task

	Fixed effects	Random effects		Model fit			LRT against the nested model		
		Participant	Item	AIC	BIC	LL	Comparison	*df*	χ^2
Model 0 (Null)	-	intercept	intercept	16929.3	16952.6	-8461.7	–	–	–
Model 1	WR + Voc	intercept	intercept	16909.8	16948.6	-8449.9	M0 vs. M1	2	23.58^{***}
Model 2	WR + Voc + Grade + Suffix_type	intercept	intercept	16780.0	16842.0	-8382.0	M1 vs. M2	3	135.79^{***}
Model 3	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept	intercept	16773.1	16850.6	-8376.5	M2 vs. M3	2	10.91^{**}
Model 4	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept, Suffix_type	intercept	16727.0	16820.1	-8351.5	M3 vs. M4	2	50.09^{***}
Model 5	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept	intercept, Grade	16454.9	16571.2	-8212.4	M3 vs. M5	5	328.21^{***}
Model 6	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept, Suffix_type	intercept, Grade	16398.1	16530.0	-8182.1	M5 vs. M6	2	60.72^{***}

Note. The analysis code for the models are available https://osf.io/wx2q9/?view_only=e27f169880c640d6929b96dc28555687 (link anonymized for blind review). LRT = likelihood ratio test; WR = word reading; Voc = vocabulary; LL = log-likelihood.
$^{**}p < .01$, $^{***}p < .001$.

Appendix 1F. Model comparisons for the SMT-N task

	Fixed effects	Random effects		Model fit			LRT against the nested model		
		Participant	Item	AIC	BIC	LL	Comparison	*df*	χ^2
Model 0 (Null)	-	intercept	intercept	9040.9	9061.7	-4517.5	–	–	–
Model 1	WR + Voc	intercept	intercept	8983.3	9017.9	-4486.7	M0 vs. M1	2	61.61***
Model 2	WR + Voc + Grade + Suffix_type	intercept	intercept	8887.8	8943.1	-4435.9	M1 vs. M2	3	101.52***
Model 3	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept	intercept	8859.1	8928.2	-4419.5	M2 vs. M3	2	32.73***
Model 4	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept, Suffix_type	intercept	8844.2	8927.2	-4410.1	M3 vs. M4	2	18.87***
Model 5	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept	intercept, Grade	8842.6	8946.3	-4406.3	M3 vs. M5	5	26.45***
Model 6	WR + Voc + Grade + Suffix type + Grade:Suffix_type	intercept, Suffix_type	intercept, Grade	8827.8	8945.3	-4396.9	M5 vs. M6	2	18.83***

Note. The analysis code for the models are available https://osf.io/wx2q9/?view_only=e27f169880c640d6929b96dc28555687 (link anonymized for blind review). WR = word reading; Voc = vocabulary; LL = log-likelihood.
**$p < .01$, ***$p < .001$.

Appendix 1G. SIT-N and SMT-N item frequency scores by type and Key Stage taken from Dawson et al. (2023)

Suffix type	Suffix	Stage 1 (ages 5-7)	Stage 2 (ages 7-11)	Stage 3 (ages 11-14)	Dif. Between Stages 1 and 2	Dif. Between Stages 2 and 3
Adjectives	-able	13804	16400	18897	2596	2497
	-ar	7823	10157	9954	2334	-203
	-ful	33171	24772	17252	-8399	-7520
	-ic	7893	12647	13279	4754	632
	-ine	1634	1532	2161	-102	629
	-ous	16551	18230	17316	1679	-914
	-ish	5424	7451	9215	2027	1764
	-ive	5494	9581	11510	4087	1929
	-less	4555	6038	5266	1483	-772
	Mean	10705.44	11867.56	11650	1162.11	-217.56
	SD	9616.80	7041.16	5681.99	3857.09	2988.73
Nominals	-ant	22566	31984	34003	9418	2019
	-ette	209	266	1080	57	814
	-ism	104	1371	1188	1267	-183
	-itis	0	48	320	48	272
	-ity	11300	20795	28163	9495	7368
	-ory	11127	16176	16495	5049	319
	-ness	9318	15234	16933	5916	1699
	-ment	11022	18850	22369	7828	3519
	-let	70	986	1188	916	202
	Mean	7301.78	11745.56	13526.56	4443.78	1781.00
	SD	7820.25	11542.15	13066.77	3958.35	2397.88

Note. Negative numbers show a decrease in frequency between stage comparisons

Appendix 2A. Instructions given for the SIT-N task.

"*This activity has lots of silly words you have never seen before. These words have endings that you may recognize. These endings are called suffixes, and they add meaning to the word".* The examiner would show the example of the word "cars", circle the -s at the end of the word and say, "*For example, the word "cars" has the suffix -s that means more than one. You use and have seen many of these endings (or suffixes) before. Your job is to find and circle them. Let's try with a different example, but this we will look at silly words".* Next, the examiner would show the participant two nonwords (e.g., "pleemed") in written form and ask the participant to circle the suffix in each example. The examiner answered all questions and confirmed the correct response for all practice trials. In cases where the participant provided an incorrect response, the tester would show the correct response and explain using real words to emphasize why it was the correct answer. For instance, in the word "pleemed", the tester would highlight that we needed to circle -ed because we find and use this ending -or suffix- to indicate that something happened in the past, for example in words such as "played". The participant was then encouraged to identify and circle any suffixes within a printed list of items. Additionally, they were reassured that it was acceptable to abstain from circling certain items if they believed a word did not have a suffix, though they were encouraged to attempt all items.

Appendix 2B. Target words included in training and testing (up) and transfer words included only in testing (bottom).

Base word	**Made-up suffix**	**Target word**	**Definition**
Boot Box Ring	-urf	Booturf Boxurf Ringurf	A boot factory/ A place where boots are made A box factory/ A place where boxes are made A ring factory/ A place where rings are made
Chair Coat Clock	-isp	Chairisp Coatisp Clockisp	A person who makes chairs A person who makes coats A person who makes clocks
Mud Rock Gold	-tep	Mudtep Rocktep Goldtep	Something made of mud Something made of rock Something made of gold
Desk Hill Bell	-nim	Desknim Hillnim Bellnim	A small desk A small hill A small bell

Base word	**Made-up suffix**	**Transfer word**	**Definition**
Book Shirt Toy	-urf	Bookurf Shirturf Toyurf	A book factory/ A place where books are made A shirt factory/ A place where shirts are made A toy factory/ A place where toys are made
Clock Lamp Door	-isp	Clockisp Lampisp Doorisp	A person who makes clocks A person who makes lamps A person who makes doors
Snow Wool Tin	-tep	Snowtep Wooltep Tintep	Something made of snow Something made of wool Something made of tin
Bus Cat Cloud	-nim	Busnim Catnim Cloudnim	A small bus A small cat A small cloud

Appendix 2C. Sample passage for training.

We are going hiking this weekend and I am not ready! I forgot to pick up my boots from the booturf downtown. They make the best boots - but now they are closed, and I only have my sneakers. That is okay! We are only hiking a hillnim so we won't walk much. I will also wear my favorite jacket. The coatisp who made this jacket put in lots of pockets so that I can bring home all the cool things I find. My mom told me that this hike is special because we will see some mudtep houses. I have no idea how those houses are still up after the rain!

Note: Target words are highlighted here to facilitate their identification in the text. The passages given to the participants during training did not have the target words highlighted.

Appendix 3A. Instructions given for the SIT-N task.

"*This activity has lots of silly words you have never seen before. These words have endings that you may recognize. These endings are called suffixes, and they add meaning to the word".* The examiner would show the example of the word "carros", circle the -s at the end of the word and say, "*For example, the word "carros" has the suffix -s that means more than one. You use and have seen many of these endings (or suffixes) before. Your job is to find and circle them. Let's try with a different example, but this we will look at silly words".* Next, the examiner would show the participant two nonwords (e.g., "plumbito") in written form and ask the participant to circle the suffix in each example. The examiner answered all questions and confirmed the correct response for all practice trials. In cases where the participant provided an incorrect response, the tester would show the correct response and explain using real words to emphasize why it was the correct answer. For instance, in the word "plumbito", the tester would highlight that we needed to circle -ito because we find and use this ending -ito to describe things as small, as in the word "carrito". The participant was then encouraged to identify and circle any suffixes within a printed list of items. Additionally, they were reassured that it was acceptable to abstain from circling certain items if they believed a word did not have a suffix, though they were encouraged to attempt all items.

Appendix 3B. Target words included in training and testing (up) and transfer words included only in testing (bottom).

Base word	**Made-up suffix**	**Target word**	**Definition**
Bota Caja Arete	-isba	Botisba Cajisba Aretisba	A boot factory/ A place where boots are made A box factory/ A place where boxes are made An earring factory/ A place where earrings are made
Mochila Silla Corona	-embe	Mochilembe Sillembe Coronembe	A person who makes backpacks A person who makes chairs A person who makes crowns
Lodo Piedra Oro	-ispe	Lodispe Piedrispe Orispe	Something made of mud Something made of rock Something made of gold
Mesa Colina Campana	-epa	Mesepa Colinepa Campanepa	A small desk A small hill A small bell

Base word	**Made-up suffix**	**Transfer word**	**Definition**
Llanta Libro Reloj	-isba	Llantisba Librisba Relojisba	A wheel factory/ A place where wheels are made A book factory/ A place where books are made A watch factory/ A place where watches are made
Vestido Juguete Sombrero	-embe	Vestidembe Juguetembe Sombrerembe	A person who makes dresses A person who makes toys A person who makes hats
Arena Algodón Metal	-ispe	Arenispe Algodonispe Metalispe	Something made of sand Something made of cotton Something made of metal
Puerta Ventana Lampara	-epa	Puertepa Ventanepa Lamparepa	A small door A small window A small lamp

Appendix 3C. Sample passage for training.

Me mudaré a Ciudad de México pronto. A ver, ¿qué me hace falta? Necesito encontrar a alguien que pueda ayudarme a cargar mis mesas. Son unas mesas **piedrispe** ¡y la piedra puede ser muy pesada! También necesito pasar a la **cajisba** porque necesito unas cajas especiales para mis sillas, el **sillembe** de la colonia las hizo y son hermosas, realmente quiero llevármelas conmigo. El otro mueble que también me quiero llevar es mi **mesepa**, pero esa mesa no ocupa mucho espacio así que estará bien, seguro que todo cabe en un camión. Eso es genial porque no quiero hacer dos viajes, ¡Ciudad de México está algo lejos!

Note: Target words are bolded here to facilitate their identification in the text. The passages given to the participants during training did not have the target words bolded.