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ORIGINAL ARTICLE

How well do schoolchildren and adolescents know the form and meaning of different derivational suffixes? Evidence from a cross-sectional study

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Abstract

As children advance through school, derived words become increasingly common in their reading materials. Previous studies have shown that children's knowledge of derivational morphology develops relatively slowly, but there is more to learn about this development. This study examined differences in knowledge of the form and meaning of suffixes across grade levels (Grades 3, 5, and 8) and different types of derivational suffixes (adjectives and nominals). We assessed 309 English-speaking children on word reading and receptive vocabulary tests and two tasks designed 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 types were mixed. While written forms of adjectives were identified more accurately than nominals across all grades, this advantage did not extend to the students' understanding of the meaning of the suffixes. These results highlight the distinction between the identification of suffixes and the understanding of their meaning. We discuss our results in relation to suffix frequency in children's reading materials.

Keywords: adjectives; derivational morphology; nominals; nonwords; suffixes

How well do schoolchildren and adolescents know the form and meaning of different derivational suffixes? Evidence from a cross-sectional study

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 (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" and "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" and "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

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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 & Katz, 2006; Ford et al., 2010; Quémart & Casalis, 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 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" and "blissful") and nominals (e.g., "citizenship" and "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, and **(d) speechless**), but it was not

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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**, and (d) mollified). Likewise, the criteria used to control sentence context informativeness across conditions were 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 & Kneile, 2012) 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., 2012; 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 & Katz, 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/.

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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 A in Supplementary material). 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 B in Supplementary material. 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 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 B in Supplementary material) 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 A in Supplementary material). 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 G and H in Supplementary material), 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 were 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 are available at https://osf.io/wx2q9/.

Results

Descriptive statistics for all the variables are presented in Table 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

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Table 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. 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.
*$p < .05$. **$p < .01$.

equal to the next highest/lowest non-outlier-score plus 1 unit of measurement before further analyses (Tabachnick & Fidell, 2012). Pearson's *r* and Spearman's ρ correlations between the variables are presented in Table 2. 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).

The results of the best-fitting models for each of the two suffix knowledge tasks are presented in Tables 3 and 4 (see Appendices E and F in Supplementary material, 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

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Table 3. 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.

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), 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). 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).

For SMT-N (see Table 4), 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

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Table 4. 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).
*$p < .05$, **$p < .01$, ***$p < .001$.

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).

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,

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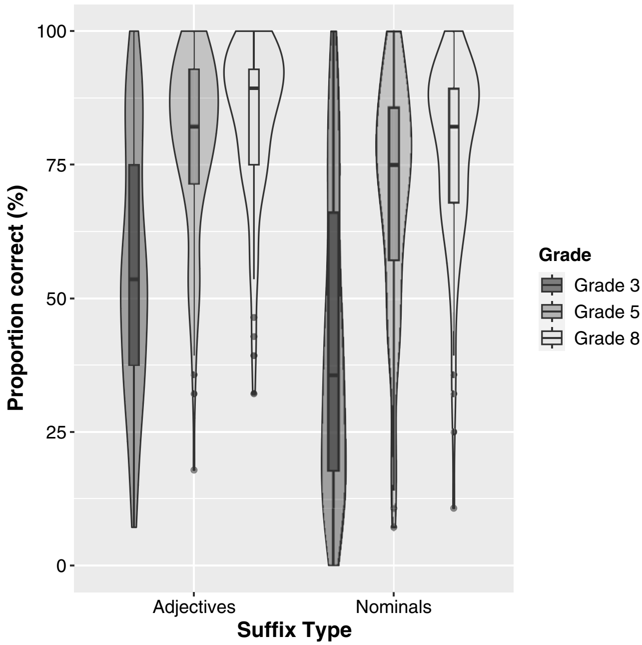

Figure 1. Performance levels of each grade on the SIT-N task.
Note. The plots are a combination of violin plots and box plots. Violin plots show the density distribution of the proportion correct, and box plots show the median, the interquartile range, and 1.5 times the interquartile range.

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 et al., 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.

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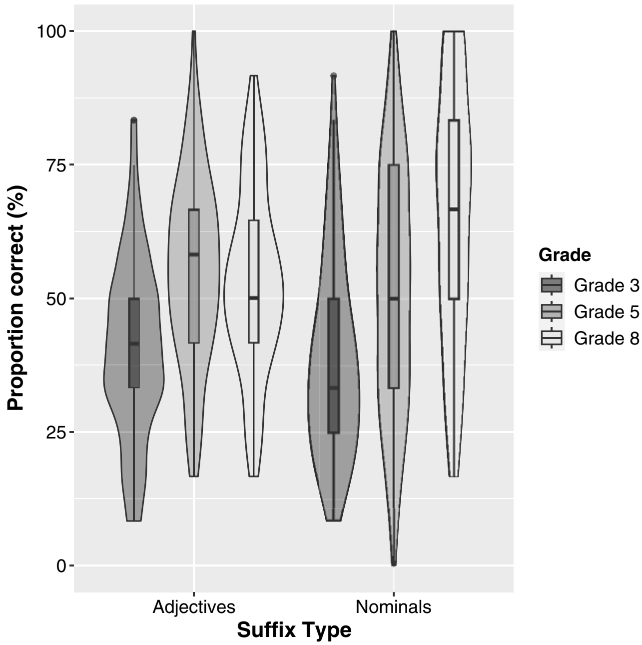

Figure 2. Performance levels of each grade on the SMT-N task.
Note. The plots are a combination of violin plots and box plots. Violin plots show the density distribution of the proportion correct, and box plots show the median, the interquartile range, and 1.5 times the interquartile range.

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" (Diependaele 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 G in Supplementary material). 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 G in Supplementary material).

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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 G in Supplementary material, 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

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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).

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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.

Replication package. The data and analysis code for all models is available at https://osf.io/wx2q9/.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S0142716424000043

Competing interests. We have no known conflict of interest to disclose.

Notes

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 and Levie (2016) for evidence in Hebrew, a morphologically rich language, and Ku and Anderson (2003) for evidence in Chinese, a non-alphabetic language.

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.

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.

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