LSHSS

Research Article

Segmentation and Representation of Consonant Blends in Kindergarten Children's Spellings

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Purpose: The purpose of this study was to describe the growth of children's segmentation and representation of consonant blends in the kindergarten year and to evaluate the extent to which linguistic features influence segmentation and representation of consonant blends. Specifically, the roles of word position (initial blends, final blends), class of blends, homorganicity, and nasality were considered.

Method: Forty kindergarten children completed a developmental spelling measure (26 words with initial or final blends) 3 times at 6-week intervals. Responses were analyzed for logical representation of speech sounds to describe developmental change and differential accuracy of segmentation and representation across blend types.

Results: Kindergarten children showed varied ability to segment and represent consonant blends and were differentially successful depending on the linguistic features of the blends. Children were more likely to represent initial blends than final blends, final nonnasal blends than final nasal blends, nonhomorganic blends than homorganic blends, and initial nasal blends than final nasal blends.

Conclusion: During the period of emergence, the properties of phonemes that comprise consonant blends influence children's ability to segment and represent blends. This finding has implications for how phonemic awareness and spelling instruction and intervention might proceed.

Key Words: phonemic awareness, orthographic knowledge, developmental spelling, segmentation, literacy development

There is broad agreement that phonemic awareness and orthographic knowledge underlie the development of word decoding skills and spelling (e.g., Adams, 1990; Stahl & Murray, 1994; Wagner & Torgesen, 1987). This study explored the development of one aspect of kindergarten children's phonemic awareness and orthographic knowledge: the segmentation and representation of consonant blends.

Phonemic Awareness

Phonemic awareness is a metalinguistic skill that is characterized by the ability to analyze the individual phonemes of spoken language (Mattingly, 1972; Wagner & Torgesen, 1987). To demonstrate phonemic awareness, a child must attend to the sound structure of words separate from a focus on word meaning (Snow, Burns, & Griffin, 1998). One phonemic awareness skill crucial to early literacy is phonemic segmentation. Phonemic segmentation involves breaking words into their component sounds (e.g., *cake* into /k/ /e/ /k/). Phonemic segmentation emerges as early as the late preschool years (Lonigan, 1998) and continues to develop into early elementary school. The incremental development of phonemic awareness (e.g., Uhry & Ehri, 1999) suggests that children are first able to segment words at the onset-rime level (e.g., *c-at, st-op*). From onset-rime segmentation, children proceed to segmentation of simple words in which singleton consonants (C) abut vowels (V; VC, CV, CVC). Finally, children develop the ability to segment words with consonant blends (CCVC, CVCC). For many children, skill at a lower level (e.g., CVC segmentation) does not easily generalize to other levels (e.g., CCVC segmentation; Bruck & Treiman, 1990). Rather, explicit instruction and practice at each level is needed, particularly for struggling learners (O'Connor, Jenkins, Leicester, & Slocum, 1993).

Word and sound features may influence children's success at segmenting and representing consonant blends. For example, with respect to analyzing initial singleton consonants,

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a continuant phoneme (e.g., /s/) generally is easier to segment than a stop phoneme (e.g., /p/; Marsh & Mineo, 1977), and an initial sound is more easily segmented in a short word as compared to a long word (Treiman & Weatherston, 1992). Similarly, an initial sound is more easily segmented in a CVC word as compared to a CCVC word (Treiman, 1991). Understanding the influence of word and sound features on children's segmentation success may be particularly important when designing early literacy interventions for children who are struggling learners.

Orthographic Knowledge

Another type of knowledge important in early literacy development is orthographic knowledge. Orthographic knowledge is the information that one stores in memory for how spoken language is represented in writing (for a tutorial, see Apel, 2011). Two types of knowledge comprise orthographic knowledge: (a) knowledge of orthographic patterns and (b) knowledge of mental grapheme representations (MGRs).

Knowledge of orthographic patterns. Knowledge of orthographic patterns is knowledge of the rules that govern how phonemes can be represented with graphemes within a particular language. Orthographic pattern knowledge begins to emerge as early as kindergarten (e.g., Cassar & Treiman, 1997) and includes knowledge of the alphabetic principle and of patterns and rules (e.g., ways to represent long vs. short vowels). The alphabetic principle refers to the insight that phonemes can be represented by graphemes. Children first realize that certain graphemes represent certain speech sounds. With more print experience, children gain greater understanding of grapheme–phoneme correspondences. For example, children begin to understand that single phonemes can be represented by multiple graphemes (e.g., "sh" for /ʃ/) and multiple phonemes can be represented by a single grapheme (e.g., "x" for /ks/).

Knowledge of MGRs. MGRs are mental representations of the strings of letters of specific words (Apel & Masterson, 2001). Also referred to in the literature as orthographic images (e.g., Ehri & Wilce, 1982), fully formed MGRs allow one to read and write words fluently. Children as early as preschool can form initial MGRs after as few as four exposures to a printed word (Apel, Wolter, & Masterson, 2006). When a child has a clear MGR for a word, he or she is able to fluently access meaning and does not need to use other types of linguistic knowledge (e.g., phonological or morphological) to read or write the word (Wolter & Apel, 2010).

Segmentation and Representation of Consonant Blends

What is known about the development of consonant blend segmentation as evidenced by representation has been gleaned from studies of children's early spellings. Much of this work has been undertaken by Treiman and colleagues (e.g., Treiman, 1991, 1993; Treiman, Zukowski, & Richmond-Welty, 1995), who have been interested simultaneously in phonemic awareness and early spelling acquisition. Most researchers who have investigated phonemic segmentation of consonant blends, Treiman included, have used developmental spelling measures. When children have mastered phoneme–grapheme correspondences, developmental spelling measures can capture sound structure knowledge and are considered valid measures of phonemic segmentation ability (Stahl & Murray, 1994).

Using developmental spelling measures, researchers have concluded that the segmentation and representation of words with consonant blends is a more difficult, later developing skill than the segmentation and representation of singletons. Additionally, the segmentation and representation of blends represents a separate achievement from the segmentation and representation of words without blends (e.g., *fast* vs. *fat*; Bruck & Treiman, 1990). When children who have little or no ability to segment and represent blends are asked to spell monosyllabic words with blends, they most commonly represent only one sound in the blend (Treiman, 1993). In words with initial blends, children nearly always represent the first sound of the blend (95% of word errors in natural writing conformed to this pattern, e.g., "sop" for *stop*; Treiman, 1991, 1993). In contrast, for final blends, children typically represent the last sound of the blend (e.g., "fat" for *fast*; 71% of errors in natural writing spellings and 95% in an experimental task conformed to this pattern; Treiman, 1993; Treiman et al., 1995).

Based on the invented spellings of 32 preschool children, Read (1975, 1986) proposed that children are differentially successful with blend segmentation and representation based on the linguistic properties of the blends, particularly the acoustic and phonetic properties of the phonemes that comprise the blend. For example, within final nasal blends, children in Read's (1975) study were more likely to represent nasal segments that were longer in duration. Because /n/ is the nasal segment with the longest duration, it is less likely to be omitted than other nasal phonemes in blends (e.g., *jump, ink*). From Read's perspective, children should show emerging ability to segment and represent consonant blends, with mastery evident after a period of protracted learning and incremental proficiency influenced by the linguistic properties of speech sounds.

There is limited research that outlines the incremental development of the segmentation and representation of consonant blends. The extant literature does not provide a clear picture of how linguistic features influence children's success in segmenting and representing consonant blends. The primary limitation of the extant literature relates to the age of children studied: Most studies of blend segmentation and representation have included first-grade children who were already proficient at segmenting and representing blends (e.g., Treiman, 1993). Thus, the developmental progression of blend segmentation and representation does not appear to have been captured, providing motivation for the current study, which included a random sample of kindergarten children. Our interest in the present study was to understand how blend segmentation and representation unfolds. That is, when children show emerging ability to segment and represent both sounds in consonant blends, what characterizes the course of development? In the following sections, we summarize the extant literature on the segmentation and representation of blends.

Initial blends. Treiman (1991, 1993) examined the natural writings of primarily first-grade children that included 390 attempts at words with initial consonant blends. When comparing blends, Treiman concluded that properties of the constituent phonemes of blends do not influence children's success at segmenting and representing initial blends. She found no difference between accuracy on voiceless stop + liquid blends (e.g., *pl*) and on voiced stop + liquid blends (e.g., *bl*), nor between s-blends (e.g., *sp*) and non-s-blends (e.g., *pl*). In addition, children in the Treiman (1991, 1993) studies did not omit sonorant[1] consonants of blends more than obstruent[2] consonants of blends. In contrast, our preliminary examination of kindergarten children's spelling of words with initial blends suggested that phonetic features of the blend do influence children's ability to segment and represent each phoneme (Spencer, Schuele, & Werfel, 2007). Participants included 439 kindergarten children (222 boys; M = 5;6 [years;months]; SD = 4.5 months). At the end of kindergarten, children completed a developmental spelling measure that included four words with initial blends (i.e., *skate, plum, float, treat*). Kindergarten children who did not yet demonstrate mastery of blend segmentation (blends represented ≤3) were differentially successful at segmentation and representation across class of blends; children were most accurate on *plum* (44%), *skate* (35%), and *float* (32%), and least accurate on *treat* (18%). When children did not represent both phonemes of the blend, they were much more likely across all blends to represent only the initial phoneme of the blend, consistent with Treiman (1991).

Final blends. Unlike with initial blends, Treiman (1993) and Treiman et al. (1995) reported substantial differences in first graders' spellings across syllable-final blends. The children in the studies included both sounds of all other types of final blends more often than they included sounds of nasal blends. In addition, the children were more likely to represent the first consonant of final blends if it was an obstruent rather than a sonorant (e.g., more likely to represent the "f" in *left* than the "l" in *held*; Treiman, 1993; Treiman et al., 1995). Children represented both phonemes in final nasal + voiced obstruent blends (e.g., *nd*) more often than in final nasal + voiceless obstruent blends (e.g., *nt, mp;* d = .49). To account for children's relative difficulty with final nasal blends, Treiman proposed that children attribute the nasal feature to the preceding vowel and thus do not recognize the need to capture the nasal consonant with a distinct symbol. However, an alternate explanation may be that final nasal blends are homorganic.

Homorganicity. Consonants that have the same place of articulation are said to be homorganic (Ladefoged, 1993). If children use articulatory cues to segment phonemes (e.g., Carroll, Snowling, Stevenson, & Hulme, 2003), homorganic blends (e.g., *st*) should be more difficult to segment than nonhomorganic blends (e.g., *sk*). When production of a blend requires a shift in the articulators between the two component phonemes, that shift may provide a salient physical cue to the presence of two phonemes; thus, the blend phonemes would be easier to segment. The empirical evidence on the influence of homorganicity is mixed. Treiman (1993) and Treiman et al. (1995) reported that homorganicity did not influence first-grade children's segmentation and representation of blends; children did not omit consonants in homorganic blends (e.g., *st*) more often than they omitted consonants in nonhomorganic blends (e.g., *sk*), regardless of the blend's word position. Conversely, van Bon and Uit de Haag (1997) reported that homorganicity influenced Dutch-speaking first graders' performance in spelling final blends but not in the predicted direction. In their study, both sounds in homorganic blends were represented more frequently (82%) than in nonhomorganic blends (71%).

Treiman (1991, 1993) concluded that syllable structure, and not the properties of the phonemes that comprise the blend, influences children's ability to represent initial blends and final blends with the exception of final nasal blends, which are particularly difficult for children. However, as noted previously, Treiman studied children who were relatively proficient at representing both sounds of consonant blends. Studying blend segmentation and representation in children with lower levels of proficiency may provide more detailed insight into any incremental development of blend segmentation and representation.

Limitations of Extant Research

Nearly all of the extant studies on blend segmentation and representation have included children in first grade (often the second half of first grade), and all studies were cross-sectional designs. Only in Treiman (1991, 1993) were kindergarten children included. However, only kindergartners who were judged to be making progress in learning early literacy skills were selected for participation, and they were reading on a first-grade level, suggesting a restricted range of ability skewed toward highly skilled readers. No growth in blend representation was realized between the first and second halves of first grade, and 70% of blends were represented by two legal consonants (i.e., consonants that both were logical

[1]A sonorant is a speech sound that is produced without restricted airflow in the vocal tract. Sonorants include vowels, nasal consonants, and liquids.

[2]An obstruent is a consonant that is produced by constricting airflow through the vocal tract. Obstruents include stops, fricatives, and affricates.

representations of the phoneme and followed conventional orthographic rules for occurring in that position of a word). By first grade, most children appear to have acquired a level of proficiency that obscures developmental differences between blends. Thus, if there is reason to believe that children will be differentially proficient across blends, researchers need to consider the point in development at which children are studied. Measuring first-grade performance may not capture the development of consonant blend segmentation and representation, but rather performance that approaches or is at mastery. To provide a more complete developmental picture, it is essential to study blend segmentation and representation over time in a group of children who have not yet reached mastery (e.g., kindergarten children).

In summary, the relation between phonemic awareness, orthographic knowledge, and early literacy is well established. There is general agreement that children must have a foundation of phonemic awareness and orthographic knowledge on which to build early word decoding and spelling skills. It is important to understand the development of blend segmentation and representation because segmentation and representation of singleton consonants and vowels (e.g., CVC, CV, VC segmentation) does not necessarily lead to segmentation and representation of consonant blends (Bruck & Treiman, 1990). That is, the segmentation and representation of consonant blends represents a distinct achievement in the acquisition of phonemic segmentation and representation. A thorough understanding of the development of blend segmentation and representation is likely necessary to address the instructional needs of the lowest performers in early reading and spelling. Intervention, particularly for struggling learners, should be informed by knowledge of the incremental development of phonemic segmentation and representation, including the development of segmentation and representation of consonant blends.

The purpose of this study was to describe the growth of children's segmentation and representation of consonant blends in the kindergarten year and to evaluate the extent to which linguistic features influence segmentation and representation of consonant blends. Specifically, the roles of word position (initial blends, final blends), class of blends, homorganicity, and nasality were considered. Kindergarten children were expected to have some skill in consonant blend segmentation and representation but not to demonstrate mastery. Thus, the spellings of a group of kindergarten children were likely to show the developmental change that would prove informative. Seven research questions were examined (see Results for hypotheses) with respect to the segmentation and representation of consonant blends:

- Do kindergarten children exhibit growth in blend segmentation and representation ability over time?
- Is blend segmentation and representation predicted by early literacy skills?
- Are children more proficient with initial blend segmentation and representation than final blend segmentation and representation?
- Does the class of blends influence children's proficiency at segmenting and representing initial blends?
- Does the class of blends influence children's proficiency at segmenting and representing final blends?
- Are children more proficient at segmenting and representing homorganic blends than nonhomorganic blends?
- Are children more proficient at segmenting and representing initial blends that include nasal consonants than final blends that include nasal consonants?

METHOD

The study protocol and procedures were approved by the Vanderbilt University Institutional Review Board.

Participants

Study participants were 40 kindergarten children (21 boys; M_{age} = 71.1 months, *SD* = 4.3 months) who spoke English as their native language and had never received speech-language treatment. Demographic information was provided by parent report; 95.6% of parents chose to provide this information (66.8% answered all questions; 33.8% answered some questions). Regarding rare/ethnicity, the majority (85%) of participants selected Caucasian, 10% selected African American, 2.5% selected Asian, and 2.5% selected other.

Children were recruited from two nonpublic schools (seven classrooms) in Nashville, TN. Children repeating kindergarten were eligible to participate (*n* = 1). Sixty-seven consent forms were returned. Ten children were excluded from data collection: Two children did not speak English as their native language, and eight children had a history of speech-language treatment. In addition, 17 children who logically represented 20 or more blends at Time 1 (max 26) were excluded from analysis because we wanted to capture development (and not proficiency) of blend segmentation and representation.

Measures

Developmental spelling. A developmental spelling measure was created to explore children's segmentation and representation of 26 two-phoneme consonant blends—18 initial blends in CCVC real words and 8 final blends in CVCC real words (see Appendix A). More initial blends were included because of the criteria imposed to select blends for the study (see below). The developmental spelling measure consisted of three word lists; each list included one word for each of the 26 blends. First, to create the developmental spelling measure, a list of all possible two-phoneme blends in English was compiled (Jakielski, 1998; Treiman, 1991; Treiman et al., 1995) and 26 blends were chosen. Blends judged to be extremely uncommon (e.g., /gw/), morphological blends (e.g., /pt/), and final blends with /l/- or /r/-colored vowels (e.g., /ld/, /rt/) were excluded. Second, three monosyllabic words (nouns, verbs, or adjectives) were chosen for each blend. These words were judged by the authors to be in kindergarten children's oral vocabulary but not likely to be sight words. All words except two appear in first-grade texts (Zeno, Ivens, Millard, & Duvvuri, 1995).[3] Third, the words for each blend were randomly assigned to one of three lists. Fourth, for each list, 10 randomized orders were created. The developmental spelling word lists are provided in Appendix A.

Early literacy. Participants' early literacy skills were captured with three early literacy measures. Knowledge of sound–symbol correspondences was assessed with the Letter Sounds subtest from the Phonological Awareness and Literacy Screening—Kindergarten (PALS–K; Invernizzi, Meier, Swank, & Juel, 2001; test–retest reliability is .88). Children's reading ability was evaluated using Word Identification Fluency (WIF; Fuchs & Fuchs, n.d.), a curriculum-based measure of reading real words with 100-word lists. Alternate-form reliability of the WIF is .88 (Fuchs, Fuchs, & Compton, 2004). Children's awareness of 11 of the 12 individual phonemes that comprised the 26 blends measured in the developmental spelling task was assessed with Initial Sounds, a measure that was developed for this study.[4]

Procedure

Children participated in three assessments (Time 1, Time 2, Time 3) at 6-week intervals from November to May (see Table 1). All assessments were administered at school. At each time point, children participated in one individual session (early literacy measures) and one group session (developmental spelling measure). Examiners included two certified speech-language pathologists (SLPs) and two speech-language pathology graduate students. The examiners met before data collection to review the assessment protocols and study procedures and to clarify any points of confusion.

[3]Both words not occurring in first-grade texts contained final –sp blends. According to Zeno, Ivens, Millard, and Duvvuri (1995), "gasp" occurred in second-grade texts but not first grade, and "lisp" occurred rarely in texts. A search for monosyllabic words ending in –sp and beginning with a singleton consonant yielded no words that occurred more frequently in children's texts.

[4]Our intent was to create a measure that would verify that these children were able to represent as singletons the 12 phonemes that comprised the 26 blends. A review of the measure at the conclusion of data collection revealed that we had inadvertently omitted G – /g/. Nevertheless, we believe that Initial Sounds provided a valid measure of the children's ability to segment and represent the phonemes used to assess blend representation.

Table 1. Sequence of the constructs that were measured at each of the three time points.

Time 1 (0 weeks) *November–January*	*Time 2 (6 weeks)* *February–March*	*Time 3 (12 weeks)* *March–May*
Letter Sounds	Letter Sounds	Letter Sounds
Initial Sounds	Initial Sounds	Initial Sounds
Word Reading		Word Reading
Developmental Spelling	Developmental Spelling	Developmental Spelling

Note. Letter Sounds = subtest from the Phonological Awareness and Literacy Screening—Kindergarten (PALS–K; Invernizzi, Meier, Swank, & Juel, 2001), Initial Sounds = researcher-constructed measure, Word Reading = Word Identification Fluency (WIF; Fuchs & Fuchs, n.d.), Developmental Spelling = researcher-constructed measure.

Letter sounds. The examiner followed the standardized administration procedures for the Letter Sounds subtest from the PALS–K. The examiner asked the child to produce the sound associated with the letter(s) on a page of 26 uppercase letters and letter combinations (*CH, SH,* and *TH*). One demonstration item illustrated the task for the child. Errors were not corrected. One point was given for each correct response, for a maximum score of 26.

Word reading. The examiner presented the practice list (total of 5 columns, 20 words per column) and said, "I'm going to show you some words. Here are some practice words. You'll start here (pointing to the top of the column) and read as many as you can. These are words that big kids read; so it's okay if you don't know all of them. Do the best you can. If you don't know a word, you can skip it." The examiner demonstrated by reading two words, skipping the third word, and reading the fourth word. Subsequently, the examiner presented the test list (same format as the practice list) and continued giving instructions, "Here's your list. Start here (pointing to the top of the first column) and read as many as you can. I'll tell you when to stop. Go." Participants were awarded one point for each word they read correctly in 1 min, for a maximum score of 100. A different test list was used for each time point.

Initial sounds. The examiner laid out 11 cards, each with a single capital letter. The child was shown a page with "__EP" on it. The examiner gave instructions and an example to the child, "Let's try to spell some silly words. You just need to figure out the beginning of the word. I'll say the word and then you pick a card. Let's try this one. ZEP. We can say it slowly: ZZZEEEP. The beginning of ZEP is /z/. So I would pick this card. Now it's your turn." Test item instructions were as follows: "Remember, I'm going to say a silly word and you show me the beginning of the word I say. You can point to it or put the card in the blank. [WORD (e.g., NEP)]." Errors were not corrected. One point was awarded for each correct representation, for a maximum score of 11.

Developmental spelling. For ease of administration, at Time 1, children were assigned to groups of two or three based on similar word reading performance. In these groups, children completed the developmental spelling measure after completing the early literacy measures. The children were positioned at a table or on the floor with dividers to ensure that each child was unable to see his or her peers' spellings. Children were instructed to write their responses on a form that included the alphabet in capital and lowercase letters at the top of the page and 26 numbered lines for responses (13 on each side). Inclusion of the alphabet on the response page assured that children's performance was not hindered by an inability to recall the form of individual letters. The examiner said each word aloud two times and repeated words upon child request. To encourage children to think about the sounds of words rather than meaning, words were not used in sentences. Children's responses were not restricted by time. To assure accuracy in interpretation of child responses, the examiner copied the child's response in capital letters on the spelling response form after the list was administered. If the examiner was unsure of what letters the child had written, she asked the child to "tell me the letters you wrote here for [word]." At each time point, approximately one-third of the participants completed each of the three randomized lists. Lists were randomly assigned to groups.

Analysis of Developmental Spelling Responses

The second author reviewed the copied words for all child responses to identify any questionable copied letters. The two authors discussed all disagreements to arrive at a mutual agreement on the spellings. For each child response, the first author determined which letter(s) of each response represented the consonant blend. The second author or one of the other examiners reviewed the letter determinations of the child responses. Any disagreements of letter determination were discussed, and agreement was reached by the authors. Reliability is reported in the following paragraphs.

Development of scoring guide. Before scoring any child responses, a scoring guide was developed and informed by Invernizzi et al. (2001) and Johnston, Invernizzi, and Juel (1998). The goal in formulating the guide was (a) to identify all logical possibilities that children might generate to represent the phonemes of the 26 blends that were evaluated in the developmental spelling measure, and (b) to standardize procedures for scoring. Because we had not anticipated fully the variety of child responses, some refinements to the guide were made while scoring Time 1 responses. These refinements were made as a result of discussion between the two authors. No further changes to the guide were made while scoring Time 2 and Time 3 responses.

The purpose of the study was to explore the segmentation and representation of consonant blends; therefore, the objective was to credit spellings that represented logical possibilities for the representation of the phonemes in each blend. Although conventional spelling did not drive the scoring system, conventional spellings of the blends represented one logical possibility for representation of the speech sounds. In addition, children were given credit for substitutions of letters that represent (a) sounds that differ only in voicing (e.g., b for /p/), (b) sounds produced as a result of co-articulation in speech (e.g., ch for /t/, as in *train*), and (c) developmental speech substitutions in children (e.g., w for /r/). Additionally, the insertion of a vowel or "h," presumably to capture the aspiration feature or exaggerated pronunciation, between the letters of a blend (e.g., "feree" or "fhree" for *free*) was accepted if the child attempted to represent the remainder of the word. Thus, for any blend, a number of logical possibilities were identified. For example, the blend at the onset of *plum* could be logically represented (underlined letters) as plum, pulum, phlum, pwum, puwum, phwum, blum, bulum, bhlum, bwum, buwum, or bhwum, based on the phonetic properties of place, manner, and voicing of the speech sounds in the consonant blend.

Hierarchical linear modeling (HLM). HLM was used for analysis in this study because HLM provides many advantages over traditional repeated measures analysis (e.g., analysis of variance; Raudenbush & Bryk, 2002). For example, HLM allows for examination of both individual and collective growth, as well as correlates of growth, whereas traditional approaches only examine incremental or mean growth. Because this study had three time points, linear models were used. For a more detailed discussion of the utility of HLM for individual growth curve analysis, see Francis, Schatschneider, and Carlson (2000).

Reliability. Child responses were scored by the first author. For each round of data collection, a reliability examiner (second author or study examiner) checked the first author's scoring. Reliability was calculated based on the number of words for which the reliability examiner agreed with the first author's scoring of the first sound of the blend represented, second sound of the blend represented, and blend represented. Reliability for each round, respectively, was 97%, 99%, and 99%.

RESULTS

Descriptive statistics of study measures are provided in Table 2. Children knew the majority of letter sounds and were quite proficient in matching letters to the speech sounds that were included in the developmental spelling measure when they occurred at the beginning of CVC words. Because children exhibited adequate letter-sound knowledge and singleton segmentation ability to logically represent sounds of words, performance on these tasks provides support for use of a developmental spelling measure to tap representations of segmented phonemes in this group of children.

Table 2. Means and standard deviations of the study measures.

	Time 1		*Time 2*		*Time 3*	
	M	SD	M	SD	M	SD
Letter Sounds	19.73	3.89	21.65	3.08	22.67	2.72
Word Reading	12.23	15.46	—		21.20	2.84
Initial Sounds	10.10	1.58	10.55	0.82	10.93	0.27
Blend Representation	10.13	5.67	13.70	7.80	14.92	7.77

Note. The word reading measure was only administered at Times 1 and 3. Maximum raw score for Letter Sounds = 26, Initial Sounds = 11, Word Reading = 100, Blend Representation = 26.

Participants' mean word reading score (max 100) was 12.23 at Time 1 (median = 7.00) and 21.20 at Time 3 (median = 12.50). Thus, the children in this study were emerging readers but by no means were reading proficiently on a first-grade level like the children in the Treiman (1991, 1993) studies.[5]

Correlations between measures are presented in Table 3. As expected, performance on several study measures was correlated. Children's performance on letter sounds was related to their performance on word reading and blend representation. In addition, children's performance on initial sounds was related to their performance on blend representation.

Growth Model of Blends Variables

The first objective of this study was to describe the growth of segmentation and representation of consonant blends in the kindergarten year. Pursuant to this objective, rate of growth and final status for each blend variable (i.e., blend representation, initial blends, final blends, initial l-blends, initial r-blends, initial s-blends, final nasal blends, final nonnasal blends, homorganic blends, nonhomorganic blends, and initial nasal blends, as measured by the developmental spelling assessment; see Appendix B for blends included in each variable) were modeled using HLM 6 (Raudenbush, Bryk, & Congdon, 2004). HLM 6 also was used to evaluate the extent to which early literacy skills measured at Time 1 (i.e., letter sound knowledge, initial sounds, and word reading) served as both individual and collective predictors of growth in blend representation.

Do kindergarten children exhibit growth in blend segmentation and representation ability over time? The linear model for each variable was fitted on the data for all participants. Time was centered at the end (–2, –1, 0); thus, the intercept represents expected performance at the last time of testing (Time 3). For example, the actual mean for blend representation at Time 3 was 14.92 (see Table 2). The estimated mean from the fitted growth model for blend representation was 15.30 (see Table 4). The slope term indicates the average amount of growth in blend representation expected over the assessment period (3 months). Children represented an average of 2.24 more blends at each time point (see Table 4). The kindergarten children in this study exhibited incremental growth in representing blends over the study period. There was no significant variance in slope (p = .13); thus, subsequent models were run using a fixed slope.

Is blend segmentation and representation predicted by early literacy skills? The conditional models for blend representation are presented in Table 5 (individual predictors) and Table 6 (collective predictors). Static predictors, children's scores on early literacy measures at Time 1, were used in this study. It was expected that children's performance on measures of early literacy would predict later skill in representing blends. Letter sounds, initial sounds, and word reading were significant individual predictors of blend representation (see Table 5). The collective model for blend representation is presented in Table 6. In this model, only letter sounds was a significant predictor of blend representation.

Effects of Properties of Blends

The second objective of this study was to evaluate the extent to which linguistic features influence the segmentation and representation of consonant blends. Specifically, we were interested in the roles of word position (initial blends, final blends), class of blends, homorganicity, and nasality. Pursuant to this objective, comparisons are presented in Table 7. Ordinary least squares statistics were obtained from linear models run in HLM 6. Paired sample t tests were used to compare performance on word position, class of blends, homorganicity, and nasality (dependent variables calculated as percentage correct). Because three classes of initial blends (l-blends, r-blends, and s-blends) were examined, a one-way analysis of variance (ANOVA) was used to compare performance on initial class of blends. The five research questions pertaining to these properties are addressed in the following paragraphs.

Are children more proficient with initial blend segmentation and representation than final blend segmentation and representation? It was hypothesized that the position of blends in words would influence children's ability to represent blends. Because segmenting initial sounds of CVC words is easier than segmenting final sounds, we anticipated that initial blends would be easier for children to represent than final blends. Children represented initial blends (M = 61.32, SD = 33.76) with greater accuracy than they represented final blends (M = 53.23, SD = 30.28; p = .02; d = 0.25). Effect

[5]Compton et al. (2010) reported a mean of 29.81 on the word reading measure for average-performing children in the fall of first grade. WIF scores for first graders are highly correlated with Woodcock Johnson III Word ID scores (.91; D. Compton, personal communication, May 6, 2011).

Table 3. Correlation of study measures at each time.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1. LS1	—	.82**	.77**	.37*	.47**	.61**	.02	.03	.40**	.51**	.28
2. LS2		—	.87**	.42**	.47**	.33*	–.04	–.00	.32*	.42**	.13
3. LS3			—	.38*	.47**	.31*	–.20	.14	.29	.43**	.10
4. WR1				—	.91**	.24	.06	.07	.28	.36*	.29
5. WR3					—	.27	.03	.09	.29	.30	.25
6. IS1						—	.04	–.04	.40*	.45**	.35*
7. IS2							—	–.16	.32*	.34*	.40*
8. IS3								—	–.11	.10	–.28
9. BR1									—	.66**	.29
10. BR2										—	.49**
11. BR3											—

Note. LS = Letter Sounds, WR = Word Reading, IS = Initial Sounds, BR = Blend Representation. Numbers following measure names indicate time (i.e., 1 indicates Time 1, 2 indicates Time 2, and 3 indicates Time 3).

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

size indicates a small effect of position of blends in words (Cohen, 1988). Follow-up *t* tests at each time indicated that the children were more successful at segmenting and representing initial blends than final blends only at Time 2 (p = .00; d = 0.38).

Does the class of blends influence children's proficiency at segmenting and representing initial blends? It was hypothesized that children would be differentially successful with initial blends based on class (Spencer et al., 2007). We anticipated that children would be more successful representing l-blends and s-blends than r-blends. Contrary to our hypothesis, children were not differentially successful with initial blends based on class (p = .25). However, within r-blends, blends in which phonemes' coarticulation creates affricates (i.e, /tr/ and /dr/; M = 25.00, SD = 32.03) were more difficult for children to represent than other r-blends (M = 38.00, SD = 35.32, p = .00, d = .39). In addition, when limiting the analysis set to children who performed <30% proficiency at Time 1 (n = 15), a simple examination of the means suggested possible differences in blend representation based on initial class (Time 1 means: l-blends 23.33, s-blends 17.78, r-blends 7.62; Time 2 means: l-blends 37.33, s-blends 25.33, r-blends 26.67; Time 3 means: l-blends 32.00, s-blends 33.33, r-blends 25.71).

Table 4. Unconditional model of blend representation growth.

	Fixed effects			*Random effects*	
	Coefficient	SE	t	*Variance*	χ^2
Intercept	15.30	1.27	12.08***	55.54	291.48***
Slope	2.24	0.40	5.55***	1.51	49.24

*p < .05. **p < .01. ***p < .001.

Does the class of blends influence children's proficiency at segmenting and representing final blends? It was hypothesized that children would be differentially successful with final blends based on class. Read (1975), Treiman (1993), and Treiman et al. (1995) reported substantial differences across final blends; final nasal blends were the most difficult for children to represent. Thus, we anticipated that children would be more successful representing final nonnasal blends than final nasal blends. Children were more successful at representing final nonnasal blends (M = 67.08, SD = 32.38) than final nasal blends (M = 30.14; SD = 41.23; p = .00; d = 1.00). Effect size indicates a large effect of final class of blends.

Are children more proficient at segmenting and representing homorganic blends than nonhomorganic blends? Contrary to the evidence reported for children proficient at blend segmentation and representation (e.g., Treiman, 1993), it was hypothesized that homorganicity would influence children's success at representing consonant blends early in development. Children might use articulatory cues early in development and, thus, would be more successful at representing nonhomorganic blends (i.e., blends whose phonemes had different places of articulation) than homorganic blends. Children were more successful at representing nonhomorganic blends (M = 62.78, SD = 32.67) than homorganic blends (M = 47.20, SD = 34.75; p = .00; d = 0.46). Effect size indicates a medium effect of homorganicity for kindergarten children. As previously discussed, children have particular difficulty segmenting and representing final nasal blends, and all final nasal blends are homorganic. Follow-up *t* tests indicated that when only initial blends were analyzed (n = 18), there were no differences between homorganic and nonhomorganic blends (p = .66, .27, .41

Table 5. Conditional models of blend representation growth using individual predictors.

	Fixed effects			Random effects	
	Coefficient	SE	t	*Variance*	χ^2
Individual predictors					
Letter Sounds					
Intercept	0.92	0.18	5.09***	27.41	293.69***
Word Reading					
Intercept	0.16	0.06	2.74**	34.32	358.13***
Initial Sounds					
Intercept	2.06	0.62	3.31**	29.59	313.99***

Note. Predictor variables are values from Time 1.
*p < .05. **p < .01. ***p < .001.

at each time, respectively). In addition, when final blends were analyzed without final nasal blends (n = 5), there were no differences between homorganic and nonhomorganic blends (p = .45, .68, .56 at each time, respectively).

Are children more proficient at segmenting and representing initial blends that include nasal consonants than final blends that include nasal consonants? Following up on Treiman (1993) and Treiman et al.'s (1995) speculation that children's difficulty with final nasal blends can be attributed to vowel nasalization, we compared children's performance on initial nasal blends (e.g., *small*) to their performance on final nasal blends (e.g., *jump*). Vowels are nasalized when they are followed by nasal consonants but not when nasal consonants precede vowels. It was hypothesized that the position of nasal blends in words would influence success such that children would be more successful at representing initial nasal blends than final nasal blends. We wanted to document that children's difficulty with nasal blends is exclusive to final nasal blends and is not a property of nasal blends in general. Children were more successful at representing initial nasal blends (M = 62.92, SD = 39.81) than final nasal blends (M = 30.14, SD = 41.23; p = .00; d = 0.81). Effect size indicates a large effect of the position of nasal blends in words.

Analyses to Evaluate Scoring System

Because our scoring system was more liberal than those previously reported in the literature, we performed several analyses to confirm that our results were not affected by certain scoring decisions we made. Specifically, we performed these analyses to ensure that letter-sound knowledge, MGRs, or allowing the insertion of vowels between the two blend phonemes did not affect outcomes.

Recall that our scoring system credited "logical" representations of phonemes but did not allow for the possibility that children might analyze the blend as containing two sounds but then misrepresent one or both sounds due to low letter-sound knowledge. Table 8 presents the percentage of children's spellings of blends based on letter-sound knowledge. Child responses were coded based on children's use of letters to represent sounds. Overall, 50% of the spellings used two logical consonants (e.g., "plum" or "pwum" for /pl/). Forty-one percent of the spellings had one logical consonant and one omitted consonant (e.g., "p" for /pl/), likely indicating a lack of segmentation. Approximately 5% of the spellings included one logical consonant and one illogical consonant (e.g., "fl" for /pl/). Spellings with one illogical consonant and one omitted consonant (e.g., "f" for /pl/) and

Table 6. Conditional models of blend representation growth using collective predictors.

	Fixed effects			Random effects	
	Coefficient	SE	t	*Variance*	χ^2
Intercept				26.16	259.71***
Letter Sounds	0.50	0.25	1.96*		
Word Reading	0.07	0.07	1.11		
Initial Sounds	1.10	0.61	1.82		

Note. Predictor variables are values from Time 1.
*p < .05. **p < .01. ***p < .001.

Table 7. Percentage correct (*M, SD*) based on the properties of the blends.

	Mean	SD	t or F	d
Position				
Initial blends	61.32	33.76		
Final blends	53.23	30.28	2.385*	0.25
Class-Initial				
l-blends	69.42	31.22		
r-blends	55.77	29.87		
s-blends	60.67	32.12	1.389	–
Class-Final				
Nonnasal	67.08	32.38		
Nasal	30.14	41.23	5.834***	1.00
Homorganicity				
Nonhomorganic	62.78	32.67		
Homorganic	47.20	34.75	4.634***	0.46
Nasality-Position				
Initial Nasal	62.92	39.81		
Final Nasal	30.14	41.23	4.828***	0.81

Note. *F* reported for Class-Initial; *t* reported for all others.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

spellings with two omitted consonants (e.g., no letters to represent the blend; "um" for *plum*) accounted for 1.5% of the spellings each. Less than one percent of spellings included two illogical consonants (e.g., "fs" for /pl/). Blend representations with illogical consonants accounted for less than 7% of the spellings; thus, we are confident that our scoring adequately captured children's analysis of phonemes.

Additionally, our scoring system allowed for the insertion of a vowel (or an "h" but this never occurred) between the two phonemes of a blend, which is different from previously reported developmental spelling scoring schemes. We allowed for these responses that presumably captured aspiration or exaggerated pronunciation of phonemes. Analyses revealed that <3% of blend representations ($n = 37$) contained a vowel between the two phonemes of the blends. The majority of such responses occurred with r-blends ($n = 12$) and l-blends ($n = 17$). Only five such instances occurred with final blends. Such a small percent of overall representations does not appear to have affected the study outcomes.

Finally, it is possible that children were able to represent both phonemes of a consonant blend not because of analysis of sound, but rather as a result of possessing a clear MGR of the target word. Table 9 presents the percentage of children's spellings of words that indicated that the child had a complete MGR (i.e., a conventional spelling) of the target word. Child responses were coded based on children's spelling of the entire word. If the entire word was spelled conventionally, we coded the spelling as a complete MGR. Overall, only 13% of the children's spellings were words that were spelled conventionally, and only 4% of the children's spellings were conventional spellings of words that required an MGR to spell correctly (i.e., words that did not have one-to-one letter-sound mappings). These results suggest that the children in our study rarely relied on a complete MGR to spell words.

DISCUSSION

Unlike previous studies examining the segmentation and representation of consonant blends in first-grade children (e.g., Treiman, 1991, 1993), the results of the present study suggest that kindergarten children show an emerging ability to segment and represent consonant blends. The kindergarten children in this study on average represented ~50% of consonant blends with two logical letters at Time 1. Importantly, the ability to segment and represent consonant blends varies during this early period of emergence depending on the linguistic and phonetic features of the blends (e.g., word position, blend class, homorganicity), consistent with Read (1975, 1986). These findings are somewhat inconsistent with those of Treiman's (1991, 1993) studies of first-grade children.

Developmental Change

Unlike Treiman's (e.g., 1991, 1993) studies, which captured late development to proficiency, this study captured earlier developmental change in segmentation and representation of blends. When all data are collapsed, ~70% of consonant blends in Treiman's (1991, 1993) studies were

Table 8. Percentage of blend representations based on letter-sound knowledge.

	Time 1	*Time 2*	*Time 3*	*Overall*
Both sounds logically represented	40.29	52.50	57.50	50.10
No sounds represented	2.02	1.63	1.06	1.57
One sound illogical + one sound omitted	1.92	1.25	1.54	1.57
One sound logical + one sound omitted	48.08	39.52	36.15	41.25
One sound logical + one sound illogical	7.02	4.13	2.98	4.71
Both sounds illogically represented	0.67	0.96	0.38	0.67

Table 9. Percentage of spellings indicating a complete mental grapheme representation (MGR).

	Time 1	*Time 2*	*Time 3*	*Overall*
Conventional spelling (i.e., MGR)	8.08	12.69	18.56	13.11
Unconventional spelling	91.92	87.31	81.44	86.89

represented with two legal graphemes (i.e., the sound can be represented by that letter in English), whereas only 50% of blends in the present study were represented with two logical graphemes, using a much more liberal scoring procedure. At Time 1, 21% of the children scored <25% on blend representation and 47% scored <50%. In addition, Treiman's studies provide a cross-sectional picture of proficiency, whereas this study captured developmental change by following the same group of children across the latter half of kindergarten. To our knowledge, this study provides the only analysis of the growth of children's blend segmentation over time. Thus, the present study provides a different perspective with regard to the development of children's ability to segment consonant blends. When examined earlier in development, there appear to be differences in segmentation and representation across blend types.

Predictors of blend representation. Individually, letter sounds, initial sounds, and word reading were all significant predictors of blend segmentation and representation. However, in the collective model, only letter sounds remained as a significant predictor. Thus, children's knowledge of letter sounds is the most robust predictor of their ability to segment and represent blends. We hypothesized that initial sounds and word reading would also predict blend segmentation and representation, but when evaluated with letter sounds, neither remained a significant predictor. Recall that initial sounds was an experimental task of phonemic segmentation that we designed for this study. It may be that the lack of significance was due to the lack of variance on this task rather than the skill of segmentation. In addition, we expected word reading to predict blend segmentation and representation. However, the relation may in fact be that blend segmentation and representation predicts word reading. Finally, we did not include an oral segmentation task to use as a predictor. Future studies can evaluate these possibilities.

Word position. Several researchers have reported that children are first able to segment consonants at the beginning of words and thereafter consonants at the end of words (e.g., Stahl & Murray, 1994). The results of this study suggest that this distinction may not be as important in the case of consonant blend segmentation and representation. Although the difference in segmenting and representing initial and final blends was statistically significant in favor of initial blends, the effect size was small (d = .25), and significance remained only at Time 2 when this difference was examined at each time. In addition, raw scores indicated that children were more proficient at segmenting and representing both sounds of final s-blends than any other type of blend, including initial s-blends. Future research can provide a more detailed exploration (e.g., multiple exemplars per blend) of the effect of word position on children's ability to segment and represent blends.

Blend class. Class of blends appears to be an important factor in children's proficiency at segmenting and representing final blends but not initial blends. Children were much more likely to segment and represent final s-blends than final nasal blends. The effect size (d = 1.0) indicated a very large effect of class on final blend segmentation and representation. In contrast to final blend class, the difference among initial classes of blends was not significant. However, an analysis of the lowest performing children suggested possible differences in blend segmentation and representation based on initial class early in development. Perhaps different properties of the phonemes that comprise blends may influence children's ability to segment and represent blends at different points throughout development of the skill. Class of initial blends may be most important very early in the development of blend segmentation and representation. Future research should explore in more depth blend segmentation and representation among the least proficient emergent readers and writers who may have unique learning needs.

Homorganicity. In the current study, homorganicity proved to be important in children's segmentation and representation of blends when all blends were considered together. Children were more successful with blends that included two phonemes with different places of articulation than blends that included two phonemes with the same place of articulation (d = .46). Thus, salient kinesthetic cues available when adjacent consonants have different places of articulation may play a role in the ease of segmentation and representation of consonant blends at least at some points in development. These results contradict van Bon and Uit De Haag (1997), who concluded that children were more proficient at segmenting and representing homorganic blends than nonhomorganic blends, as well as Treiman (1993), who concluded that homorganicity did not influence children's blend segmentation and representation. Van Bon and Uit De Haag's study targeted CCVCC words. The added difficulty of longer words that contained two consonant blends might have had more influence on the children's ability to segment and represent blends than homorganicity (Stahl & Murray, 1994). In addition, van Bon and Uit De Haag assessed pseudowords, whereas Treiman (1993) and the present study assessed real words. Treiman's study included children who were quite proficient at blend segmentation and representation, whereas blend segmentation and representation of the children reported here was captured earlier in development. Perhaps homorganicity exerts an influence on children's ability to segment and represent consonant blends early in emergence of the skill. However, recall that final nasal blends were particularly difficult for all children to segment and represent. Because all final nasal blends are homorganic, we followed up our initial analysis with an examination of homorganicity of only initial blends and final blends without final nasal blends. When only initial blends or final blends without final nasal blends were considered, homorganicity did not appear to be an important factor. Thus, it appears that although homorganicity may play a role in children's segmentation and representation of blends at some points in development, differences in performance based on homorganicity may be driven by nasality rather than place of articulation. Future research should study this issue in more detail.

Final nasal blends. As previously discussed, children were much more likely to segment and represent final s-blends than final nasal blends ($d = 1.0$). In addition, children were more likely to segment and represent initial nasal blends than final nasal blends ($d = .81$). These large effects add to existing evidence (e.g., Read, 1975; Treiman, 1993; Treiman et al., 1995; van Bon & Uit De Haag, 1997) that final nasal blends present a particular challenge to children in the course of development of the segmentation and representation of consonant blends. In fact, it appears that a certain level of proficiency at segmenting and representing other types of blends may be necessary before the ability to segment and represent final nasal blends advances beyond a minimal level of proficiency.

Several factors may play a role in children's particular difficulty with segmenting and representing final nasal blends. First, Ohde, Haley, and Barnes (2006) reported that perceptual cues to place of articulation for nasal consonants were diminished in VC (e.g., /an/) contexts as compared to CV (e.g., /na/) contexts. They also found that child productions of nasal syllables contained less prominent perceptual cues than adult productions. Thus, it appears that perceptual cues for postconsonantal nasals are not as strong as for preconsonantal nasals. In addition, children's self-rehearsals of words with final blends likely contain less prominent perceptual cues, which may lead to incomplete segmentation and representation of final nasal blends. Second, Treiman et al. (1995) suggested that children's phonemic representations may differ from the conventional writing system. Thus, children may attribute the nasal quality to the preceding vowel until experience with written language teaches them conventional spelling of final nasal blends. There is minimal nasality on vowels when preceded by nasal consonants, so omission of the nasal consonant is much less frequent in initial nasal blends.

Implications for Educational Practice

The order of development of segmentation and representation of consonant blends has implications for educational programs for young children with respect to phonemic awareness and spelling. Explicit phonemic awareness instruction has proven effective for children who struggle to learn early literacy skills (e.g., Ball & Blachman, 1988). However, Al Otaiba and Fuchs (2002) reported that a majority of children who are unresponsive to early literacy instruction continue to have substantial deficits in phonemic awareness. In addition, deficits in orthographic knowledge are associated with treatment nonresponsiveness (Al Otaiba & Fuchs, 2002). Thus, it appears that the current broad phonemic awareness and orthographic knowledge interventions are not sufficiently effective for the lowest performing students. There is a need for a more incremental study of early literacy skills, including phonemic awareness and orthographic knowledge, so that educators can be more successful at teaching such skills to children who struggle with early literacy despite best efforts to teach them.

It is important to consider factors that affect development of the ability to segment and represent consonant blends when choosing words for teaching segmentation and representation. For example, *jump* is not an appropriate word for a student with little segmentation and representation skill because final nasal blends are particularly difficult. Instead, the results of this study suggest that beginning instruction with final s-blends would be more developmentally appropriate. In fact, we propose the following order of instruction:

1. Final s-blends
2. Initial l-blends
3. Nonhomorganic initial s-blends
4. Initial r-blends and homorganic initial s-blends
5. Final nasal blends

This study identifies an area in early reading and spelling instruction in which SLPs can collaborate with classroom teachers. Many teachers may lack specific knowledge of speech sounds and mapping speech to print that should influence word choice in early reading and spelling tasks (Moats, 1994). For example, SLPs' knowledge exceeded teachers' knowledge on a paper and pencil task of explicit phonemic awareness, and teachers were less able than SLPs to ignore their orthographic knowledge in analyzing the sounds of words (Spencer, Schuele, Guillot, & Lee, 2008). Additionally, SLPs can assist teachers in understanding how the range of kindergartners' spellings provides valuable insight into children's phonemic awareness and orthographic knowledge.

Limitations and Future Directions

The use of a developmental spelling measure rather than oral segmentation is a limitation of the study. The efficiency of a developmental spelling as a measure of phonemic awareness over oral segmentation allowed for inclusion of a greater number of participants; however, it is possible that the conclusions we have drawn about phonemic awareness development would have differed had we used an oral segmentation task. It is possible that children could have orally segmented blends but be unable to represent them in writing. In this first step study, we did not address this possibility directly. We attempted to control for the possibility by examining responses for misrepresentations of phonemes, but future research should directly compare performance on developmental spelling and oral segmentation.

In addition, the evaluation of each blend at each time was based on only one exemplar of each blend. It is possible that for some words, children had a stored MGR of the written form. We attempted to control for this possibility by examining children's full word spellings (and found that very few responses were conventionally spelled), but it is possible that children had partial MGRs for some words. We were not able to address this possibility. Future studies could evaluate children's representations of nonwords with blends. Another possible limitation is that we administered the items on the developmental spelling task in the absence of sentence contexts. We did this to limit the sources of other types of linguistic information (e.g., semantics, syntax, coarticulation) to the greatest extent possible so as to better ensure that children's spellings were based mainly on phonology. However, it is possible that children misperceived the target words without the semantic context that a sentence would provide. A future evaluation comparing the two modes of administration would better inform spelling testing procedures.

Another possible limitation is our use of a nonstandardized word reading measure. We chose the WIF curriculum-based reading measure because it allowed us to administer a different word list at each time and avoided the floor effects and reduced variability of many norm-referenced word recognition measures. However, the word reading measure did not allow us to assign a grade level or percentile to children's reading performance. Such a measure might have aided readers in generalizing our findings.

Finally, one of our words contained a morphological blend (*rocks*). We selected this word due to a limited field of exemplars (*fox, box*). Thus, it was possible that children's representation of the final /ks/ blend in "rocks" could be affected by morphological knowledge. However, follow-up analysis indicated that there was no difference across words at any time for final /ks/ representation.

The results of this study suggest that, at least in children with typical development, success with segmentation and representation of consonant blends depends somewhat on properties of the phonemes that comprise the blends. A clear developmental sequence emerged. Future research should investigate the effectiveness of intervention that follows this developmental sequence as compared to general blend segmentation instruction. In addition, future research should explore the differential success of children with language impairments and children who are struggling readers, including those with language impairments, with segmentation and representation of consonant blends and effectiveness of blend segmentation and representation training for children who have difficulty acquiring the skill of segmenting and representing blends.

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APPENDIX A. DEVELOPMENTAL SPELLING WORD LISTS

	List 1	*List 2*	*List 3*
Initial blends			
/sp/	spot	spin	spoon
/st/	step	stick	stove
/sk/	skip	skin	skate
/sl/	sleep	slide	slip
/sm/	smell	smoke	small
/sn/	snake	snail	snack
/pl/	play	plum	plane
/pr/	price	prize	press
/bl/	blow	block	blue
/br/	broom	brown	bread
/tr/	truck	train	treat
/dr/	drum	drive	dress
/kl/	clap	cloud	clock
/kr/	crop	crown	crib
/gl/	glass	globe	glove
/gr/	green	grape	grass
/fl/	flag	floor	flame
/fr/	fruit	frog	free
Final blends			
/ft/	soft	gift	lift
/sk/	mask	ask	desk
/sp/	wasp	lisp	gasp
/st/	fast	last	list
/ks/	box	fox	rocks
/nt/	ant	want	hunt
/nd/	hand	sand	find
/mp/	camp	jump	lamp

APPENDIX B. BLENDS IN EACH VARIABLE

Initial blends
/sp/ /st/ /sk/ /sl/ /sm/ /sn/ /pl/ /pr/ /bl/ /br/ /tr/ /dr/ /kl/ /kr/ /gl/ /gr/ /fl/ /fr/
Final blends
/ft/ /sk/ /sp/ /st/ /nt/ /mp/ /nd/ /ks/

Initial l-blends
/sl/ /pl/ /fl/ /bl/ /kl/ /gl/
Initial r-blends
/pr/ /br/ /tr/ /dr/ /kr/ /gr/ /fr/
Initial s-blends
/sp/ /st/ /sk/ /sl/ /sm/ /sn/

Final s-blends
/sk/ /sp/ /st/ /ks/
Final nasal blends
/nt/ /mp/ /nd/

Homorganic blends
/st/ /sl/ /sn/ /mp/ /nd/ /nt/
Nonhomorganic blends
/sp/ /sk/ /sm/ /pl/ /pr/ /bl/ /br/ /tr/ /dr/ /kl/ /kr/ /gl/ /gr/ /fl/ /fr/ /ft/ /ks/

Initial nasal blends
/sm/ /sn/
Final nasal blends
/nt/ /mp/ /nd/