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The effect of orthographic complexity on Spanish spelling in Grades 1–3

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Abstract This study was designed to identify a continuum of orthographic features that characterize Spanish spelling development in Grades 1–3. Two research questions guided this work: (1) Is there a hierarchy of orthographic features that affect students' spelling accuracy in Spanish over and above other school-level, student-level, and word-level factors? and (2) If there is such a hierarchy, do students master these orthographic features in a knowledge-based continuum that supersedes grade placement? The authors used logistic regression modeling to demonstrate that the orthographic features tested in this study represent a developmental hierarchy, moving from sound-based features to context-dependent pattern-based features and finally to meaning-based, or morphological, features. Results showed that the probability of correctly representing specific spelling features decreases as a student moves along the continuum of orthographic knowledge, regardless of the student's spelling ability, although the probability of spelling any given feature correctly is greater for students with higher levels of overall spelling development. The authors controlled for school-, student- and word-level factors other than orthographic features that might affect students' spelling in Spanish (i.e., school placement, student grade level, student gender, word frequency, and word length).

Keywords Spanish spelling · Orthographic feature inventory · Spelling inventory · Developmental spelling

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Research on spelling in alphabetic orthographies has consistently revealed that children internalize orthographic features in a hierarchical, developmental progression (Bear, Templeton, Helman, & Baren, 2003; Ferreiro, 1991; Hachén, 2002; Henderson & Beers, 1980). As they move through this progression, children gradually develop a more and more sophisticated understanding of the relationship between spoken words and their representations in print, with the result that they tend to master specific spelling features in a predictable order. The progression begins with spelling features that simply require an understanding of sound-symbol correspondences (e.g., beginning and ending consonants, digraphs, blends), followed by those that require an understanding of word patterns (e.g., silent letters that influence the sound of other letters), and finally those that require an understanding of morphological units (e.g., affixes and roots). Of course, students can and do use morphological knowledge throughout their development; however, they typically do not harness the full generative power of roots and affixes until they become aware of spelling-meaning connections in derivationally related words.

Much of the research on developmental spelling has been done in English; however, existing research has demonstrated the existence of a developmental progression in Spanish as well, even though Spanish has a shallow orthography as compared with the deeper orthography of English. For example, Defior and Serrano (2005) analyzed the spelling of Spanish children in the first 2 years of Kindergarten (ages 4 and 5) and the first year of Primary School (age 6) and identified seven distinct categories of spelling, ranging from linear scribbles to conventional spelling. These categories represent movement from a pre-phonetic approach to spelling (i.e., spelling that does not associate letters with sounds) to an alphabetic approach in which children's spelling is based entirely upon their attempts to represent the sounds they hear in words, and finally to a broader orthographic approach in which children use their knowledge of word patterns to spell words that may have inconsistent or contextually constrained spellings. Defior and Serrano suggested that this progression is very similar to the progression identified by researchers in English spelling, and they concluded that the development of spelling in Spanish is not qualitatively different from the development of spelling in English and other opaque orthographies, with the exception of the time it takes for mastery. Due to the transparency of the Spanish orthography, the rate of spelling acquisition in Spanish is much shorter than in English.

In a later study with Spanish children in Grades 1–4, Defior, Jiménez-Fernández, and Serrano (2009) found that by the end of second grade, children typically achieve a high level of proficiency in spelling words that require only an understanding of phonological rules. Proficiency was much slower to develop for words that require an understanding of orthographic contingencies related to silent letters or inconsistent phoneme-grapheme mapping. Although children demonstrated gradual progress in spelling these words from grade to grade, they had not reached mastery by fourth grade. These findings are consistent with the findings from a 1980 study conducted by Carbonell de Grompone, Tuana, Moratorio, Pintos, and Mandracho that identified three distinct stages in native Spanish speakers' spelling development. In the first stage, children were found to rely solely upon phoneme-grapheme mappings in their spelling. In the second phase, they were able to represent

phonemes that were governed by rules associated with the context in which the phonemes appeared (e.g., /g/ is spelled *g* before *a*, *o*, or *u*, but *gu* before *e* and *i*). In the third and final stage, children were able to spell phonemes that had more than one graphical representation (e.g., /b/ can be spelled as b or v) that can not be predicted by relying on a rule.

Jiménez et al. (2008) examined the spelling of children in Grades 2–6 (ages 7–12) on the Spanish island of Tenerife, looking specifically at when children learned to spell words that include a silent h or phonemes that can be represented by more than one grapheme (i.e., */b/* by *b* or *v*; */x/* by *j* or *g*; */r/* by *r* or *rr*; */k/* by *c*, *qu*, or *k*; */g/* by *g* or *gu*; */s/* by *c*, *s*, *z*, or *x*; */λ/* by *y* or *ll*). They found a grade-level effect for mastery of these spelling patterns. That is, children in higher grades were more likely to spell these phonemes correctly than children in lower grades. By fourth grade, most of the children in their study had mastered all of the patterns except those governed by specific context-related rules (e.g., */k/* is spelled *c* before *a*, *o*, or *u*, but *qu* before *e* or *i*). The spelling of these rule-governed orthographic features was generally not mastered until fifth grade. Jiménez et al. noted that in general, students relied primarily on their knowledge of phoneme-grapheme correspondences in spelling until third grade, but by fourth grade they began to use contextually constrained orthographic information (i.e., knowledge of word patterns) as well.

Diuk, Borzone, Sánchez Abchi, and Ferroni (2009) had similar findings in a study with Argentinian children in Grades 1–3. They found that words that could be spelled using phoneme-grapheme knowledge alone were easier for children to spell than words with rule-governed orthographic features and words with inconsistent phoneme-grapheme correspondences that were not rule-governed (e.g., b/v). They also found that children's spelling performance improved with grade level. Among the words that were more difficult to spell, those with non-rule-governed inconsistent correspondences that used the most prevalent spelling of the inconsistent phoneme (e.g., */b/* represented by *b*, as in *banco*) were easier to spell than words with rule-governed features. The most difficult of all were words with non-rule-governed inconsistent correspondences that used the less prevalent spelling of the inconsistent phoneme (e.g., */b/* represented by *v*, as in *nave*). It may be that these findings related to the prevalence of competing spellings for phonemes with inconsistent representations are associated with bigram frequency. In a study with Spanish children in Grades 2–6, Carrillo and Alegría (2013) found that students' choice of *b* or *v* to spell the phoneme */b/* was related to the frequency of the bigram in which the phoneme appeared. For example, in the initial position in Spanish, the bigram *vi* occurs more frequently than *bi*, but *bu* occurs more frequently than *vu*. Carrillo and Alegría found that students in their study were more likely to use the more common bigram in spelling both real words and pseudowords.

Defior, Alegría, Titos, and Martos (2008) extended the exploration of Spanish spelling beyond phoneme-grapheme and broader orthographic cues by examining the role of morphosyntactic information in spelling. Participants in their study were children in Grades 1–3 from Andalucía, a region in southern Spain in which the final *s* in words is typically not pronounced. The researchers designed a spelling task in which children were asked to write high- and low-frequency plural nouns that ended

in *s* and high- and low-frequency second-person singular verbs that ended in *s*. As a control, the task also included nouns that ended in an *s* that was not morphologically motivated (e.g., *lunes*/Monday, *dosis*/dose), which the researchers referred to as lexical nouns. The words in the spelling task were presented in sentence format in two different modalities: a written mode in which the target word was replaced by a blank and an oral mode in which the sentence was recorded on tape by a speaker whose dialect systematically omitted final *s* sounds. Students' responses were counted correct if they included the final *s* in the spelling, even if the rest of the word was not spelled correctly. The researchers found that for high frequency words, students' scores were higher for lexical nouns than for verbs and plural nouns. However, for low frequency words, for which students were less likely to be able to draw on orthographic information stored in the internal lexicon, scores were higher for verbs and plural nouns than for lexical nouns. These findings suggest that morphological knowledge does contribute to spelling in Spanish. The results also demonstrated an effect for grade level, with a progressive increase in correct spellings as the number of years in school increased, indicating that exposure to morphosyntactic rules over time may enhance spelling performance.

Developmental spelling inventories

Developmental spelling inventories measure children's growing understandings about written language by assessing their ability to spell words representing a range of spelling features that span multiple developmental phases. Because spelling and reading develop in synchrony (Ehri, 1997; Henderson & Beers, 1980), analyzing children's performance on a spelling inventory can provide useful information, not only about their spelling, but also about their overall literacy development, providing teachers with valuable information for planning and individualizing literacy instruction. For example, students struggling to represent phoneme-grapheme correspondences can be expected to struggle with decoding words in even the simplest of books. Knowledge of what their students understand about the orthographic code can help teachers plan the kind of phonics and spelling instruction that will also boost their decoding and word recognition.

Ferroli and Krajenta (1990) were among the first researchers to create a developmental spelling assessment in Spanish. They based their test on existing research on spelling development in English, as well as some early research on children's invented spelling in Spanish (e.g., Hudelson, 1981–82; Temple, 1979). The Ferroli and Krajenta assessment was designed to identify the spelling stage (i.e., preliterate, semi-phonetic, phonetic, or transitional) of children in kindergarten through second grade, using a scoring system based, with some adaptations, on criteria developed by Morris and Perney (1984) for evaluating English spelling. In their analyses, Ferroli and Krajenta found statistically significant correlations between scores on their developmental spelling test and measures of word reading in Grades K-2 and reading comprehension in Grade 3, making the assessment a useful indicator of reading achievement. The test is less useful, however, as an

indicator of children's specific strengths and needs in spelling as it does not systematically assess a range of spelling features at varying levels of difficulty.

In 2002, Estes and Richards created a spelling inventory (the Test of Spanish Word Features, or TSWF) that tested students' mastery of 12 unique graphophonemic features in Spanish. The TSWF was an adaptation of the Word Features Spelling List (WFSL), an English spelling inventory created by Viise in 1994. The 12 features on the TSWF were derived from an initial list of 20 features identified by the researchers through interviews with a group of bilingual teachers. The researchers administered the TSWF to 200 children in Grades 1–5 and used Guttman scaling to estimate the extent to which the spelling features formed a unidimensional continuum that was cumulative, meaning that students who spelled a particular feature correctly could be expected to spell all less difficult features correctly as well. Estes and Richards found that, although the spelling features on their assessment demonstrated internal consistency, the Guttman scale that they produced was only marginally cumulative. They concluded that Spanish orthographic features vary less than English orthographic features in complexity and that there is less evidence that children master those features in a particular order, thus casting doubt on the usefulness of a developmental framework.

Estes and Richards' findings, however, were generated by the particular spelling features that they chose to include in their inventory, and it is likely that a different list of features would have added more variance in complexity to the TSWF. For example, the TSWF omitted some features that later research (e.g., Defior et al., 2009; Diuk et al., 2009) would identify as integral to orthographic development in Spanish, such as context-dependent, or rule-governed consonants, substituting instead other features that are more characteristic of English spelling than Spanish (e.g., root constancy, which refers to consistency in spelling word roots across all words derived from that root). Root constancy is an important consideration in English spelling because of the significant role that morphology plays. The emphasis on the spelling-meaning connection in English can be seen in the tendency of derived forms to retain the original spelling of the base word or root from which they are formed, even if their pronunciation is different. For example, the schwa sound /ə/ is spelled with *o* in the word *composition* but with *a* in the word *relative* in order to retain the spellings of the base words *compose* and *relate*. In Spanish, on the other hand, morphology plays a less important role, and the emphasis is on the spelling-sound connection. In fact, the spelling of word roots in Spanish is frequently altered in order to maintain the sound-symbol correspondence. In the verb *buscar*, for example, the *c* is changed to *qu* when it precedes the letter *e* in order to represent the /k/ sound phonetically (e.g., *busco/I look for*, but *busqué/I looked for*).

In 2005, Arteagoitia et al. created a spelling inventory (the Spanish Developmental Contrastive Spelling Test) designed to assess Spanish/English bilingual students' spelling, not only from an intra-linguistic developmental perspective, but also from a contrastive perspective, that is, looking at spelling features that might cause difficulty for students as a result of cross-linguistic interference from English to Spanish. Three categories of spelling features were included in the assessment: (a) words with regular spelling patterns that include phonemes that can be

represented by more than one grapheme (e.g., /b/ represented by b or v), (b) words whose spelling depends upon knowledge of specific context-dependent rules (e.g., silent *u* sometimes needed after the letter *g* to spell /g/), and (c) words with features that might prompt cross-linguistic interference (e.g., words with the letter ñ). The researchers conducted a pilot study with 196 children in Grades 2–5 enrolled in two-way immersion programs in which they received instruction in both Spanish and English. Some of the children were native Spanish speakers, and some were native English speakers. Results from the pilot study revealed that the words that were most difficult for children to spell were those that required attention to context-dependent rules, which mirrors the findings of Jiménez et al. (2008). Interestingly, the words with features that were expected to cause cross-linguistic interference were among the easiest to spell for pilot participants. The researchers concluded that this outcome may have been influenced by their study sample, which included native English speakers as well as native speakers of Spanish.

In 2015, Helman, Delbridge, Parker, Arnal, and Jara Mödinger (2015) tested the reliability of a spelling inventory called the Spanish Developmental Spelling Inventory (SDSI) in a study with students enrolled in Grades 1–5 in public, subsidized, and private schools in a large metropolitan area in Chile. The inventory, which was originally published in 2004 (Helman, 2004), was divided into five groups of words representing five expected levels of difficulty for spellers, and it included a feature guide demonstrating how to evaluate students' spelling development by examining the specific orthographic features they could spell correctly. The assessed skills ranged from the ability to represent the most salient vowels and consonants in words to the ability to use morphological cues in spelling words that could not be spelled using phonological or contextual information alone. The results of the 2015 study demonstrated a progression of development from first grade though fifth grades and showed that the SDSI could be used to categorize individual students' performance into five distinct phases of development, ranging from representing only the most salient sounds in words (e.g., writing bebé as B) to using knowledge of morphological units to guide spelling (e.g. recognizing that *juventud* is spelled with v because it derives from *joven*). The researchers found, however, that a large number of students were clustered in what they referred to as the pattern phase of development, which includes rule-governed and non-rule-governed inconsistent phoneme-grapheme correspondences. They concluded that this "could point to a leap in understanding that is needed [to move to the next stage of development], or it could indicate a need for more sensitivity in the SDSI as students advance through complexities in the orthographic system" (p. 21). The current study increases the sensitivity of Spanish developmental spelling inventories by adding more orthographic patterns and by using a more rigorous analytic strategy controlling for school, student and word-level factors that might also influence students' spelling development.

The current study

The current study was designed to extend previous research in Spanish developmental spelling by using more rigorous analytic strategies that tested multiple hypotheses simultaneously within a single multilevel model in which the variables included also acted as controls for all the other factors tested. For example, some children may know how to spell the word *cuadro* because of their particular school's curriculum, because of their grade placement, because of their gender, or because the word is frequently occurring. By controlling for these factors simultaneously, we sought to establish a hierarchy of orthographic features that are associated with students' accuracy in Spanish over and above other school-, student-, and word-level factors.

The inventory was developed as part of the Phonological Awareness Literacy Screening in Spanish for Grades 1–3 (PALS español) (Ford & Invernizzi, 2014a), which also includes measures of oral reading (accuracy, fluency, and comprehension), automatic word recognition, alphabet knowledge, and phonemic awareness. In creating the orthographic feature inventory, we focused specifically on Spanish/English bilingual children who were receiving literacy instruction in Spanish in US schools. Spanish speakers in the US are not a homogeneous group, and their language can vary significantly, based on their family's country of origin and even the area of the US in which they live. To ensure that the items we included on the inventory did not advantage one group over another, we consulted a panel of native Spanish speakers representing different regions of Latin America, and we conducted multiple rounds of piloting with children from different regions of the US. Our goal was to identify a continuum of orthographic features that characterize Spanish spelling development in Grades 1–3 and create a spelling inventory that would help teachers across the US design appropriate word study instruction for their Spanish speaking students.

Confirming a developmental continuum of feature complexity in a language with a transparent orthography such as Spanish would have implications for teaching that go beyond just spelling instruction. Typically, the teaching of word-level skills in reading and spelling in Spanish focuses primarily on phoneme-grapheme correspondences (e.g., memorizing the pronunciation of syllables that form words), without much attention to contextual constraints such as silent letters or to the morphological aspects of spelling-meaning connections, both of which have the potential to increase vocabulary and reading comprehension. Understanding word derivations and knowing why particular spelling patterns occur in specific contexts can help children develop a deeper understanding of Spanish vocabulary, which supports reading fluency and comprehension as children move into more challenging text. August, Carlo, Dressler, and Snow (2005), Kieffer, Biancarosa, and Mancilla-Martinez (2013), Kieffer and Lesaux (2012), and Townsend, Filippini, Collins, and Biancarosa (2012) and others have all called for more attention to vocabulary, particularly the morphological aspects of written words, in both instruction and intervention as a way of improving reading comprehension for English learners in the US.

Method

The spelling features included in our feature analysis were chosen and ordered according to difficulty based on previous research on the relative challenge that certain word patterns and syllable structures pose for monolingual Spanish-speaking children learning to read and write in Spanish (Defior et al., 2009; Defior & Serrano, 2005; Ferreiro, 1991; Hachén, 2002; Helman et al., 2015). To represent the features, we culled age-appropriate words for children in Grades 1–3 from two basal reading series in Spanish written for children in the US (Acosta et al., 2005; Blanco et al., 2000) and from a word frequency dictionary of children's vocabulary in Spanish (Martínez & García, 2004). From our corpus of possible words, we selected words with specific orthographic features that represented the previously documented progression of difficulty from sound-based features to context-dependent pattern-based features and finally to meaning-based, or morphological, features. In some cases, we used the specific features that had been used in previous research (e.g., rule-based and inconsistent consonants). In other cases, we split previously identified categories into specific features for greater specificity (e.g., separating nasals from other consonant blends because they represent a different level of difficulty for early spellers).

Prior to the current study, we tested our choice of features and their order of difficulty in a preliminary study (Ford & Invernizzi, 2014b) in 12 schools across the US In that study, 321 children in Grades 1–3 were administered a 45-word spelling inventory, with five words representing each of the nine spelling features our research suggested would be integral to Spanish spelling development. These features include open syllables, closed syllables, blends, nasals, diphthongs, inconsistent consonants (i.e., non-rule-based consonants), silent H, rule-based consonants, and affixes/roots (see Table 1 for descriptions). We calculated the percentage of correct spellings of each feature across all opportunities to spell that feature (i.e., 5 examples $\times$ 321 children $=$ 1605 opportunities). The findings of this preliminary study supported our hypothesis that the difficulty of the features would be associated with the type of knowledge students must draw upon in order to spell words correctly. Orthographic features that can be spelled using letter-sound correspondences alone were the easiest to spell, followed by features that required an understanding of contextual clues in the orthography, and finally by features that required a knowledge of word derivations. The findings also supported our ordering of the nine orthographic features we tested, with one exception. We had anticipated that inconsistent (non-rule-governed) consonants would pose a greater challenge for students than rule-governed consonants, simply because the latter have rules that provide a clear guide for spelling. Our data, however, showed that the rule-based consonants were more challenging (38% correct out of 1605 attempts, as compared with 59% for inconsistent consonants).

The current study was designed to further explore this developmental continuum of orthographic features using logistic regression modeling and controlling for other factors that might affect students' spelling in Spanish. We explored the following research questions: (1) Is there a hierarchy of orthographic features that affect

Table 1 Spelling inventory words by feature

Features	Spelling words
SET A (sound-based)	
Open syllables[a]	**ni**ño, pla**to**, glo**bo**, ar**co**
Closed syllables[b]	**al**to, **is**la, es**tas**, on**das**
Blends	**cl**ase, **fl**ores, **fr**esco, cua**dr**o
Nasals[c]	tron**c**o, cam**p**o, tam**b**or, e**n**tra
Diphthongs	t**ie**mpo, nad**ie**,, **oi**go, **ai**re
SET B (pattern-based)	
Inconsistent consonants[d]	corre**g**ir, ori**g**inal, cora**z**ón, bri**ll**an
Silent H	**h**ormiga, **h**ambre, **h**ermoso, **h**orrible
Rule-based consonants[e]	ve**c**es, tran**qu**ilo, se**gu**ir, bilin**gü**e
SET C (meaning-based)	
Affixes/roots	**ju**ventud, **geo**grafía, **in**menso, actri**z**

Bold print and underlining identify the targeted spelling feature in each word

[a]CV syllable pattern, [b]VC or CVC syllable pattern, [c]Letter m or n before another consonant, [d]Consonants with inconsistent sound-letter mapping, [e]Sound-letter mapping based on prescribed, context-dependent rules

students' spelling accuracy in Spanish over and above other school-level, student-level, and word-level factors? and (2) If there is such a hierarchy, do students master these orthographic features in a knowledge-based continuum that supersedes grade placement? To address these questions, we nested responses within students and controlled for various school, student, and word characteristics, such as word frequency and word length, which have been associated with difficulty level in reading and spelling (Alvarez, Carreiras, & Taft, 2001; Cuetos & Suárez-Coalla, 2009; Diana & Reder, 2006).

We anticipated that, after controlling for other factors, the probability of correctly representing specific orthographic features would decrease as students moved along an orthographic knowledge continuum from features that simply require an understanding of sound-symbol correspondences to those that require an understanding of orthographic patterns and rule-based contingencies and finally to those that require an understanding of morphological units. We also hypothesized that even the more proficient spellers would be challenged by features that require an understanding of Spanish orthography beyond the simple phoneme-grapheme correspondences that form the basis for most reading and writing instruction in Spanish in the first three grades.

Procedure

Children in Grades 1–3 were administered a 36-word spelling inventory representing the developmental spelling features we proposed as integral to Spanish spelling (i.e., open syllables, closed syllables, blends, nasals, diphthongs, inconsistent consonants, silent H, rule-based consonants, and affixes/roots). There were four words representing each spelling feature (see Table 1). The assessment was administered in a group format, either by the students' classroom teacher or by an assessor trained by the researchers. The person administering the inventory monitored the group during administration to ensure that children were focused on

their own papers. The administrator said the word once, followed by a sentence using that word (provided as part of the inventory). The word was then repeated. Students were told that the inventory was not a graded test but was designed to help their teacher understand how they spell. They were told that some words would be easy and some would be more difficult, but they were asked to write every word as best they could.

The inventory was organized into three sets (see Table 1) based on the characteristics of the spelling features and their expected level of difficulty (i.e., Set A = sound-based features/easiest, Set B = pattern-based features/more challenging, Set C = meaning-based features/most challenging). Based on the findings of our preliminary study with 321 students (Ford & Invernizzi, 2014b), we administered Sets B and C only to students whose performance on previous sets indicated that they would demonstrate at least minimum competency. Findings from the earlier study demonstrated that students who scored less than 50% correct on Set A words had a mean score of < 1 on Set B words, suggesting that students who have not mastered features that can be spelled using knowledge of letter-sound correspondences only are not likely to be successful in spelling features that require an understanding of context-dependent patterns. Our earlier findings also showed that students who scored less than 50% correct on Set B words had a mean score of < 1 on Set C words, suggesting that students who have not mastered features based on context-dependent word patterns are not likely to be successful in spelling words that require an understanding of morphological derivations. For that reason, in the current study, all students were administered Set A, students who scored at least 50% correct on Set A were administered Set B, and students who scored at least 50% correct on Set B were administered Set C. In this discussion, students who took Set A but did not score high enough to move on to Set B will be referred to as Level 1 spellers, students who took Sets A and B but did not score high enough to move on to Set C will be referred to as Level 2 spellers, and students who took Sets A, B, and C will be referred to as Level 3 spellers.

Participants

Participants were 864 first- ($n = 541$), second- ($n = 160$), and third-grade ($n = 163$) students (50% female) from 30 schools in seven US states (i.e., Wisconsin, Virginia, Pennsylvania, Minnesota, California, Missouri, North Carolina) and the District of Columbia. All students were in dual language, transitional bilingual, or Spanish immersion programs in which they were receiving literacy instruction in Spanish. Although the home language of these students was not available, all were sufficiently proficient to be administered a comprehensive literacy assessment entirely in Spanish. Of these students, 462 (53%) were administered Set A words only, 298 (34.5%) were administered Sets A and B, and 104 (12%) were administered Sets A, B, and C.

Data analysis

To test our hypothesis of increasing spelling feature difficulty, we used a multilevel logistic regression model with responses nested within students. Alternatively, this has been referred to as an explanatory item response theory model or a linear logistic test model (LLTM; see Justice, Bowles, & Skibbe, 2006 for an example). As with a logistic regression model, coefficients can be expressed as odds ratios (ORs) that show a change in odds with a one-unit increase in the predictor.

The outcome of our model was whether a child spelled the targeted spelling feature in each of the 36 words correctly (1) or incorrectly (0). These targeted features are underlined and in bold print in Table 1. As our main variable of interest, we included dummy-coded variables to represent the spelling features, with the most difficult feature in each set of words (i.e., Set A, Set B, and Set C) serving as the reference group for that set. An advantage of running a regression model is that we could include several controls simultaneously. At the student level, we included student grade level and gender. At the word/response level, we included word length (i.e., number of letters in the word; $M = 5.81$, $SD = 1.51$, Range = 4–10) and word frequency ($M = 57.94$, $SD = 6.63$, Range = 43.65–72.80). Our measure of word frequency was the standard frequency index ($\underline{\text{SFI}} = 10 * [\log_{10}(\underline{\text{U}}) + 4]$), calculated using word frequency data from the *Corpus del español* (Davies, 2002), a 100 million-word corpus of Spanish words gathered from a variety of fiction and nonfiction sources. In addition, we included school dummy-codes (i.e., fixed effects), which accounted for any and all variability resulting from students nested within schools (Huang, 2016). School nesting was important to control for as the variability resulting from the school level was not ignorable; we computed a preliminary unconditional model per spelling level (i.e., $ICC_{1st} = 0.21$; $ICC_{2nd} = 0.15$; $ICC_{3rd} = 0.28$).

In addition to presenting ORs and reporting statistical significance (see Table 2), we also report a more easily interpretable predicted probability per word feature (see Fig. 1). As each higher-order feature was expected to be more difficult, descending ORs and probability levels were expected, showing increasing feature difficulty.

Results

The first research question that guided our study was: Is there a hierarchy of orthographic features that affect students' spelling accuracy in Spanish over and above other school-level, student-level, and word-level factors? We anticipated that this would, indeed, be the case because each successive feature represented a more sophisticated orthographic construct, and our findings supported this hypothesis.

For Level 1 spellers, the Set A word features all showed an increasing level of difficulty (see Table 2). All the spelling features were easier than the reference group (i.e., diphthongs, the most difficult feature in Set A) and progressively became more difficult as evidenced by the lower odds ratios. For example, the odds of correctly spelling an open syllable word compared to a word with a diphthong

Table 2 Multilevel logistic regression results by maximum level reached (Levels 1, 2, and 3)

Variable	Level 1 (n = 462 students)		Level 2 (n = 298 students)		Level 3 (n = 104 students)	
	OR	95% CI	OR	95% CI	OR	95% CI
Feature[1]						
Open syllable	**7.65**	(6.33–9.26)	**59.24**	(43.04–81.53)	**76.19**	(36.31–159.89)
Closed syllable	**4.39**	(3.64–5.29)	**67.65**	(48.19–94.98)	**139.09**	(54.00–358.27)
Blend	**2.57**	(2.16–3.06)	**40.04**	(30.36–52.80)	**69.21**	(33.65–142.36)
Nasal	**2.36**	(1.99–2.79)	**26.56**	(20.50–34.40)	**48.33**	(25.84–90.37)
Diphthong			**11.39**	(9.04–14.35)	**30.59**	(17.91–52.24)
Inconsistent			**2.20**	(1.82–2.67)	**4.86**	(3.52–6.73)
Silent h			**0.78**	(0.61–0.98)	**4.74**	(3.28–6.86)
Rule-based					**1.72**	(1.29–2.30)
Word length	**0.68**	(0.61–0.76)	0.98	(0.93–1.04)	**1.10**	(1.01–1.20)
Word frequency	**1.02**	(1.01–1.03)	**1.02**	(1.01–1.03)	1.00	(0.98–1.02)
Grade level	**2.90**	(2.16–3.90)	**1.74**	(1.48–2.05)	**1.76**	(1.30–2.39)
Female	**1.33**	(1.02–1.75)	1.04	(0.86–1.27)	1.03	(0.80–1.34)

All models account for school-level nesting

Numbers in **BOLD** are statistically significant ($p < 0.05$)

OR odds ratio

[1]Features are dummy coded. Feature reference group for Level 1 = Dipthong. Feature reference group for Level 2 = Rule-based consonant. Feature reference group for Level 3 = Affix/root

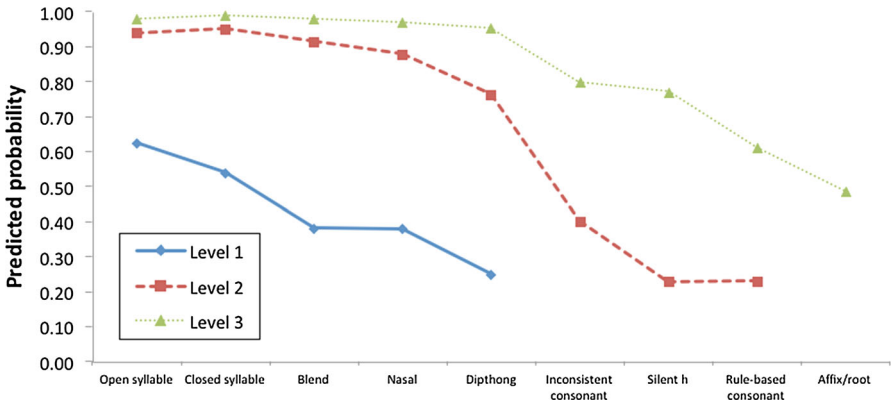

Fig. 1 Predicted probabilities of correctly identifying the word feature by spelling level

was higher by a factor of 7.65 ($p < 0.001$) while controlling for all other variables in the model. The 95% confidence intervals for the feature estimates can also be used to determine if the differences between feature difficulty are statistically significant. For example, even though blends (OR = 2.57, $p < 0.001$) and nasals (OR = 2.36,

$p < 0.001$) had a higher likelihood of being correctly spelled by Level 1 spellers compared to diphthongs, the difference in odds between blends and nasals was not statistically significant as a result of overlapping confidence intervals (i.e., blends and nasals were not that much different).

Similarly, for Level 2 spellers, the Set B words showed an increasing order of difficulty, and all the word features were easier to spell compared to the reference group (i.e., rule-based consonants, the most difficult feature in Set B). Level 3 spellers also displayed a similar progression of difficulty as all spelling features were easier compared to the reference group in Set C (i.e., affix/root, the most difficult feature in Set C). In general, there was an evident progression of difficulty as seen by the declining ORs for the different features (i.e., the odds of getting that feature correct decreased). Even though for Level 2 and 3 spellers, open syllable words looked more difficult than closed syllable words (as seen by the differences in ORs in Table 2), differences were not statistically significant as seen by the overlapping 95% confidence intervals for the ORs.

Figure 1 presents the predicted probability of each level of speller (i.e., Level 1, 2, or 3) correctly spelling each orthographic feature. As can be seen in the graph, the probability of spelling a feature correctly decreases as the feature gets more difficult, regardless of the student's overall spelling ability. These descending probability levels, along with the descending ORs shown in Table 2, suggest the increasing difficulty of the spelling features in our feature inventory.

Our second research question was: If there is such a hierarchy (of orthographic features), do students master these orthographic features in a knowledge-based continuum that supersedes grade placement? Our findings supported our hypothesis that even the more proficient spellers would be challenged by the more difficult features because those features require an understanding of Spanish orthography that goes beyond simple phoneme-grapheme correspondences. As can be seen in Table 2 and Fig. 1, the higher the spelling level of the student (i.e., Level 1, Level 2, or Level 3), the greater the probability of spelling any given feature correctly. Level 2 spellers spelled Set A words better than Level 1 spellers, and Level 3 spellers spelled all words better than Level 2 spellers.

We believe that these results are particularly robust in that we accounted for word frequency, word length, gender, grade-level, and school-level factors, each of which was shown to be statistically significant for one or more levels of spellers (see Table 2). All factors were statistically significant for Level 1 spellers, word frequency and grade level were statistically significant for Level 2 spellers, and word length and grade level were statistically significant for Level 3 spellers. By testing the association between word frequency, word length, gender, grade level, and school simultaneously within a single multi-level model, we controlled for all of these factors. Our findings suggest that children who know how to spell the word *cuadro* do so despite their school and grade placement, regardless of their gender, and notwithstanding the frequency or length of the word. Thus it appears a hierarchy of orthographic features is associated with students' spelling accuracy in Spanish over and above other school-, student-, and word-level factors.

Discussion

Our results demonstrate that the spelling features included in the orthographic feature inventory tested in this study do, indeed, represent a developmental hierarchy, moving from sound-based features to context-dependent orthographic patterns and finally to meaning-based, or morphological, features. Our findings also demonstrate that the probability of correctly representing specific spelling features decreases as a student moves along the continuum of orthographic knowledge, regardless of the student's spelling ability, although the probability of spelling any given feature correctly is greater for students with higher levels of overall spelling development. In other words, Level 2 spellers were more likely to spell any given feature correctly than were Level 1 spellers, and Level 3 spellers were more likely to spell any given feature correctly than Level 1 or Level 2 spellers regardless of school, grade, gender, word length or frequency.

These results are consistent with previous research on Spanish spelling demonstrating that Spanish features that can be spelled relying on sound alone (i.e., what Diuk et al. refer to as "context-independent consistent correspondences") are the easiest to spell, followed by features that require an understanding of context-dependent word patterns (Defior et al., 2005/2006, 2009; Diuk et al., 2009), and finally by features that require morphological knowledge (Defior et al., 2008; Helman et al., 2015). Our findings also add support to existing research on the relative difficulty of spelling features that represent inconsistent phoneme-grapheme mappings in Spanish. Just as with the children in studies conducted in Spain and Argentina (Diuk et al., 2009; Jiménez et al., 2008), the bilingual children in our study found it easier to spell words with inconsistent phoneme-grapheme mappings if those inconsistent mappings were not governed by context-dependent word patterns or rules (e.g., deciding whether /b/ should be spelled with *b* or *v* in a particular word was easier than remembering that a silent *u* must be added to *g* to spell the hard g sound before *e* or *i*). It may be that the additional difficulty presented by the rule-based inconsistent mappings is related to the demand placed on short-term memory by having to keep a rule in mind while considering multiple spelling alternatives. Alternatively, these results may be related to the effect of bigram frequency in Spanish spelling of inconsistent phonemes.

Some previous spelling inventories have only focused on particular parts of the developmental continuum in Spanish. For example, Ferroli and Krajenta (1990) were primarily interested in the early stages of development, from the preliterate stage, in which children cannot yet map phonemes to graphemes, through the transitional stage, in which children first begin to recognize that spelling sometimes requires more than simple phonetic mapping. Arteagoitia et al. (2005), on the other hand, focused on upper elementary level spellers in their inventory, and so they included only features that students at that level tend to find challenging (e.g., phonemes that can be represented by more than one grapheme and features that depend upon knowledge of specific context rules). Estes and Richards (2002) included a fairly wide range of features in their inventory; however, they omitted some features that later research (e.g., Defior et al., 2009; Diuk et al., 2009) has

shown to be more characteristic of and more integral to orthographic development in Spanish (e.g., rule-based consonants that require a silent letter in certain contexts), and they included others that are more characteristic of English spelling than Spanish (e.g., root constancy). The Spanish feature inventory tested through our research, however, has the potential to be particularly useful because it assesses a full range of orthographic features, from those that can be spelled using only an understanding of phoneme-grapheme correspondences to those that require an understanding of contextual and/or morphological cues to be spelled correctly. In that regard it builds upon Helman's Spanish Developmental Spelling Inventory (SDSI, 2004), which also included features representing each developmental stage in Spanish spelling. One limitation that Helman et al. (2015) noted in the validity study for the SDSI was that participants tended to cluster in the pattern stage of development. They suggested that this could indicate the need for greater sensitivity in the instrument, or it could represent the fact that a "leap in understanding" (p. 21) is needed for students to move beyond the orthographic complexities of the pattern stage. In the spelling inventory described in the current study, we aimed for pattern features that were more precise (e.g., separating inconsistent phoneme-grapheme correspondences that are rule-governed from those that are not rule-governed) to better identify students' specific spelling needs during this stage.

In the current study, we included orthographic features that span the entire range from sound-based to morpho-syntactic features, and we demonstrated that students' spelling errors tend to cluster around specific linguistic concepts, demonstrating their confusion about word features related to those concepts. These linguistic concepts can be defined in terms of conceptual layers of orthographic knowledge similar to those described in English by Bear, Invernizzi, Templeton, and Johnston (2016), and others. That is, children appear to master concepts related to how the orthography works to represent pronunciation and meaning gradually over time, moving from mastering context-independent phoneme-grapheme correspondences toward an understanding of context-dependent orthographic patterns, and finally towards harnessing morphological aspects of language to establish spelling-meaning connections in a more generative way. This developmental trajectory in learning to read and spell English has been described in terms of conceptual layers that loosely parallel students' overall literacy development, development that moves from a focus on sound, to increasing emphasis on pattern and meaning (e.g., Bear et al., 2016; Palmer & Invernizzi, 2014). Concomitantly, students move from a disfluent, sound-by-sound approach to reading texts to more fluent reading in terms of accuracy, expression, reading rate and comprehension. The current study suggests the same might be true for bilingual children being instructed in Spanish. Thus, using a feature inventory such as the one tested in this study to precisely identify students' strengths and needs in Spanish spelling development could inform the content and the emphasis of not only spelling, but also vocabulary and reading instruction. For example, emphasizing the speed of children's reading may be inappropriate for students still figuring out sound-based features. Instruction in those sound-based features, along with plenty of practice in reading accessible texts that contain at least some of those features, may be more advantageous. Likewise, time spent on teaching children sound-based features when they may be negotiating

morphological representations in spelling and vocabulary may be better spent teaching children how to spell, read and analyze the meaning of words with morphological structures such as affixes (e.g. i**n**menso) and roots (e.g. **geo**grafia). An added bonus to such an approach would be an increase in vocabulary knowledge.

Limitations and future research

The current study examined the spelling development of Spanish/English bilingual children in Grades 1–3 in the US. Although our research adequately addressed the research questions posed in this study, further research is need to explore the spelling development of bilingual children in Grades 4–12 in US schools. This avenue of research will be particularly important because the majority of students who receive literacy or content area instruction in Spanish only do so through Grade 3 or 4. Research is needed to describe the developmental continuum for students who do not receive Spanish instruction beyond the early elementary years and to determine whether early instruction in Spanish is associated with continued gains in Spanish spelling and reading, even after students transition to English-only instruction.

It would also be useful to replicate this study using a sample consisting entirely of children whose native language is Spanish. The students in the current study were representative of children being taught to read in Spanish in US schools in that they came from a variety of instructional programs (i.e., dual language, transitional bilingual, and Spanish immersion) and attended schools in multiple regions of the US. However, while all the children had a level of Spanish proficiency sufficient to be administered a comprehensive literacy assessment in Spanish, no data were available as to their home language or level of Spanish proficiency.

Future research is also needed to explore word characteristics other than those described here that might be associated with Spanish spelling development. For example, studies are needed that extend Carrillo and Alegría's (2013) research on the effect of bigram frequency on Spanish spelling to include inconsistent phonemes other than */b/*. Research is also needed to explore the effect, if any, of syllable frequency in Spanish spelling. Syllable frequency has been shown to have a facilitative effect in word reading in Spanish (Carreiras & Perea, 2004; Perea & Carreiras, 1998) but an inhibitive effect in lexical decision tasks (Perea & Carreiras, 1998). Future research might examine whether syllable frequency has an effect on spelling in Spanish that goes beyond the effect of word frequency and feature complexity.

Conclusion

In summary, this study identified a hierarchical continuum of Spanish orthographic features that children master according to a definable and predictable progression, beginning with those that simply require an understanding of sound-symbol

correspondences, followed by those that require an understanding of word patterns, and finally those that require an understanding of morphological units. These findings support a developmental theory of Spanish literacy development that can inform both spelling and reading instruction in Spanish. Such a developmental construct can provide a framework for differentiating reading and spelling instruction to meet children's individual needs, and it can also provide important information that can contribute to professional growth for teachers (Ehri & McCormick, 2004). Understanding the progression of literacy development in Spanish will allow teachers to use linguistic insight in interpreting their students' reading and spelling behaviors, allowing them to recognize that what might otherwise have been considered random errors are actually "diagnostic windows into students' understanding of how the written system works" (Palmer & Invernizzi, 2014, p. 28). Teachers can then use this information to plan spelling and reading instruction that will enhance students' understanding of the phonological, orthographic, and morpho-syntactic features of words, which can contribute to gains in overall literacy, including vocabulary, reading fluency, and reading comprehension (Perfetti, 2007).

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