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Spanish children spelling in English as a foreign language: Central and peripheral processes

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Background: Spelling acquisition requires the assimilation of the regularities of the writing system, but these regularities may differ between the native and a foreign language. English spelling acquisition is a challenge for Spanish-speaking children due to differences in the orthographic systems. The aim of this study was to examine to what extent Spanish-speaking children use sub-lexical and lexical information when spelling in English as a foreign language (EFL), and whether this varies across grades.
Methods: To achieve this, we administered a spelling-to-dictation task of monosyllabic words to children 9 to 11 years old. Spelling accuracy, written latencies, and writing durations were analysed as a function of phonology-to-orthography consistency, lexical frequency, word length, and the semantic knowledge that the children have of the words.
Results: Results showed differences between grades, with word length only influencing younger children. Lexical frequency, consistency, and semantic knowledge facilitated performance in older children. The cumulative exposure to English may lead to an improvement in spelling due to vocabulary growth and increased sensitivity to new spelling patterns and regularities. Such development occurs despite differences between the orthographies of the native and foreign language and even in the absence of explicit instruction in EFL spelling.
Conclusions: Semantic information about words helps spelling retrieval during writing in EFL. Spanish-speaking children develop sensitivity to English orthography and spelling patterns, evident in the older group of children.

Keywords: spelling, foreign language, central and peripheral processes, Spanish-speaking children

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Highlights

What is already known about this topic

- Different linguistic variables, namely, lexical frequency, orthographic consistency, and word length, have an impact on spelling development.
- English spelling acquisition is a challenge for Spanish-speaking children.
- Central and peripheral processes interact during handwriting.

What this paper adds

- Having semantic information about words facilitates spelling retrieval during writing in English as a foreign language.
- Spanish-speaking children develop sensitivity to English spelling patterns, evident in older children.
- Nucleus and coda are the most demanding sub-syllabic elements for Spanish-speaking children when spelling in English.
- The effect of central (linguistic) processes on handwriting performance varies with age.

Implications for theory, policy, or practice

- English teachers should encourage English lexical–semantic development in Spanish-speaking children from the earliest grades of exposure to English as a foreign language.
- Receiving instruction in the use of grain size units larger than phoneme–grapheme would be very helpful in learning to spell in a foreign language.
- Teachers should consider a systematic and explicit approach to teaching English orthographic regularities, by including this objective in their lessons.
- Interactions between linguistic and motor aspects of writing need to be considered during teaching and assessment of the written products of children writing in English as an additional language.

Cognitive processes involved in writing can be categorised into central and peripheral processes (Purcell et al., 2011). Central processes deal with abstract units of processing and include higher-order processes associated with the formulation and maintenance of the message to be communicated, as well as with the linguistic processes conducing to the activation of the specific sequence of letters to be produced. These processes are referred to as central as they are thought to be involved in writing regardless of the modality in which one is producing the response (e.g., handwriting, typing, and oral spelling). Peripheral processes are motor processes associated with the response execution and vary greatly

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depending on the response modality. Although spelling is a central process, referring to the retrieval and maintenance of the orthographic representation to be produced (Van Galen, 1991), accumulating evidence shows that it might affect peripheral aspects of the response, such as handwriting speed (Lambert et al., 2011; Sausset et al., 2012). Thus, spelling is considered in most theoretical models a crucial aspect of writing production (Chenoweth & Hayes, 2001; Van Galen, 1991).

Spelling acquisition requires several years of instruction and practice, especially in deep orthographic systems (Ehri, 1992, 2001). Many studies have tried to understand and describe how and when spelling ability develops (Ehri, 1992, 2001; Frith, 1980; Share, 1995). However, spelling acquisition and strategies may be different when dealing with a foreign language (FL), as it involves learning a new code with its peculiarities. The present study addresses the English spelling performance of Spanish-speaking children. This study aims to contribute both to practice and theory, considering the importance of English language in today's society, and the remarkable differences between the English and Spanish orthographic systems (opaque vs. transparent). Most studies about this topic to date have been carried out in the United States as there are a considerable number of Spanish speakers in the American education system (Hussar et al., 2020). By contrast, few studies have been performed in Spain, where children are usually only exposed to English only in the school context (Hevia-Tuero et al., 2022; Lahuerta, 2015, 2018). Moreover, studies on FL spelling have generally focused on the number and type of errors produced, although several studies have shown that spelling processes modulate handwriting movements (Lambert et al., 2011; Sausset et al., 2012). Therefore, the current study analyses spelling accuracy and several measures of the speed of motor aspects of the response (viz., written latencies and writing durations) during a spelling-to-dictation task performed in EFL by Spanish-speaking children.

Spelling Development and English Orthography

In general, at the beginning of spelling acquisition, progressively develop an understanding of the phonology-to-orthography (P–O) conversion rules of the language. Regular and reliable P–O conversion rules are very useful, as it allows for the spelling of unknown words; however, it does not guarantee the correct spelling of inconsistent words. It is only after years of exposure to spelling that learners can develop word-level orthographic representations for known words, providing a lexical strategy for spelling (Ehri, 1992; Frith, 1980; Rittle-Johnson & Siegler, 1999; Share, 1995). Thus, young children's spelling is mainly determined by word length (i.e., accuracy depends on the number of phoneme-to-grapheme conversions to be made), indicating a sub-lexical strategy (Goswami et al., 1998; Sprenger-Charolles et al., 2003). As orthographic knowledge increases, due to the formation of word-level orthographic representations, the word length will cease to be a determining variable, and other variables, such as lexical frequency, will become more influential (Bonin & Fayol, 2002; Share, 1995). High-frequency words, for example, are assumed to have strong orthographic representations, facilitating spelling accuracy (Bonin et al., 2016). The effect of lexical frequency has been observed in several languages and populations (French: Martinet et al., 2004; Spanish: Suárez-Coalla et al., 2016; and English: Caravolas et al., 2005). Nevertheless, spelling performance seems to be strongly determined by the characteristics of the writing system. One of the main characteristics that distinguish alphabetic writing systems from each other is their level of orthographic

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consistency. There is considerable evidence that literacy acquisition is faster in transparent than in opaque orthographies (Bruck et al., 1996; Caravolas, 2004; Caravolas & Bruck, 1993; Goswami et al., 1998; Marinelli et al., 2015; Oney & Durgunoglu, 1997; Spencer, 2007; Thorstad, 1991; Wimmer et al., 1991; Wimmer & Hummer, 1990; Wimmer & Landerl, 1997) and that it is more demanding to spell inconsistent than consistent words (Caravolas et al., 2005; Lété et al., 2008; Planton et al., 2019; Weekes et al., 2016).

The English orthography is characterised by its inconsistency, with a major impact on the rate of acquisition and spelling strategies (Caravolas, 2004). Orthographic consistency is a complex concept. From a traditional point of view, consistency has been understood as the correspondence between spelling and sound, identified as *feedforward consistency*; thus, a word is consistent when its pronunciation matches that of words of similar spelling. For instance, 'cake' is consistent because its pronunciation, /e.iscp;k/, matches that of 'take', 'make', and 'fake'. In contrast, 'cough' is inconsistent because its pronunciation (/kɒf/) conflicts with that of similarly spelled words, such as 'dough' (/dəʊ/), 'tough' (/tʌf/) and 'through' (/θruː/) (Glushko, 1979). In addition, the inverse relationship has been proposed, between sound and spelling, has been referred to as *feedback consistency* (see Chee et al., 2020, for an extended explication). For example, 'roar' is feedback inconsistent because several other words that have the same pronunciation, /.oop;r/ (e.g., 'core', 'more', 'bore') are spelled '-ore', instead of '-oar'. On the other hand, the degree of orthographic consistency can be considered to occur on a continuum as it depends on the number of friends and enemies that a word has. Words that include the same spelling and pronunciation are considered friends, while those that do not follow this relationship are considered enemies. A widely accepted way to calculate the degree of orthographic consistency of a word is to divide the number of friends by the total number of friends and enemies, producing a value between 0 and 1 (Chee et al., 2020).

Furthermore, it is necessary to take into consideration the sub-syllabic elements (onset, nucleus, coda, rime). Consistency can be computed at different sub-syllabic grain sizes (Chee et al., 2020), even when many studies have focused on consistency at the level of rime (De Cara & Goswami, 2002; Lacruz & Folk, 2004). From a linguistic perspective, a syllable consists of several elements: the onset (any consonants that precede the vowel), the nucleus (the vowel), and the coda (the consonants that follow the vowel). Higher-order units such as the rime (the vowel and the coda forming a higher-order unit), and the oncleus (the onset and nucleus), can also be identified (Vennemann, 1988). For example, in the word 'crab', 'cr-' is the onset, '-a-'is the nucleus, '-b' is the coda, 'cra-' is the oncleus, and '-ab' is the rime. These sub-syllabic elements are particularly relevant for dealing with English orthography inconsistencies. According to the *psycholinguistic grain size theory* (Ziegler & Goswami, 2005), English spellers need to develop intermediate representations between grapheme and the whole word (i.e., syllables, rimes, and morphemes) to reduce the level of inconsistency.

To this, the role of semantics in spelling development must be added. Semantic representations, phonology, and orthography constitute the three main components of word identity (Perfetti, 2007). Substantial evidence has now been provided on the relationship between vocabulary and reading (Nation & Cocksey, 2009; NICHD Early Child Care Research Network, 2005; Ouellette & Beers, 2010), but some studies have also found support for the role of semantics on the development of spelling abilities (Hilte & Reitsma, 2011; Ouellette, 2010; Tainturier & Rapp, 2001; Van Rijthoven et al., 2021). Indeed, Hilte and Reitsma (2011), in a study conducted with Dutch 2nd graders, showed that the activation of semantic information of a word supports the acquisition of phonology–orthography

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connections and leads to a well-specified lexical–orthographic representation that can facilitate retrieval. In the same vein, Ouellette (2010) suggested that semantics is an important factor in learning to spell, demonstrating benefits for spelling when words are presented along with semantic information in 2nd graders.

Interaction Between Central and Peripheral Processes

While studies on the number and type of errors have offered important insights into writing processing, studies on kinematic measures (e.g., written latencies -WLs- or writing durations -WDs) have begun to provide data on the interaction between central (linguistic) and peripheral (motor) processes (Afonso, Álvarez, & Kandel, 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Delattre et al., 2006; Kandel et al., 2006, 2014; Kandel & Perret, 2015; Kandel & Valdois, 2005; Lambert et al., 2011). In this line of research, the impact of several variables (e.g., lexical frequency, orthographic consistency,- or word length) on handwriting movements has been studied. Results suggested that the central processing of some words does not end when motor execution begins, operating in a cascaded fashion (Bonin et al., 2012). However, the scope of the interaction seems to vary with age or level of spelling ability (Olive & Kellogg, 2002; Sausset et al., 2012).

As for orthographic consistency or regularity, it was reported that orthographic inconsistencies systematically increase both WLs (Bonin et al., 2015; Delattre et al., 2006) and WDs (Afonso, Álvarez, & Kandel, 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Lambert et al., 2011; Roux et al., 2013). Kandel and Perret (2015), in a study with French children (8–10 years old), found that WLs were influenced by orthographic regularity, but only in 8–9 years old children. However, orthographic regularity had an impact on handwriting movements at all ages. Moreover, in Spanish, orthographic inconsistency increased the duration of the first letter in a spelling-to-dictation task around the age of 8 years (Suárez-Coalla et al., 2018). Regarding lexical frequency, it has been found to have a clear impact on WLs (Afonso et al., 2018; Bonin & Fayol, 2002; Delattre et al., 2006); however, results about the impact on motor execution have not been as consistent (Afonso et al., 2018; González-Martín et al., 2017; Kandel & Perret, 2015; Søvik et al., 1994). Kandel and Perret (2015) found a similar effect at all ages, meanwhile, Afonso et al. (2018) concluded that the impact only appeared in young children, and Søvik et al. (1994) found that lexical frequency affected only long words.

In sum, existing evidence supports that spelling processes cascade to affect handwriting movements. Thus, the effect of linguistic variables on WLs and WDs, in addition to effects on spelling accuracy, may inform about the spelling strategy used by the writer.

Spelling in English as a Foreign Language

Spelling acquisition differs across orthographies. Moreover, spelling processing in a FL or second language (L2) is not comparable to that of the native language (L1) (Lemhöfer et al., 2008). In the framework of the *linguistic interdependence hypothesis* (Cummins, 1991), several studies using diverse methodologies addressed the potential influence of the L1, or transfer, on English FL spelling. The influence will depend on the characteristics of the language, and transfer can occur in different situations and lead to different effects. If the two languages share linguistic features, then the transfer will be

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positive; on the contrary, if specific orthographic knowledge of English is required and has not yet been acquired, the use of L1 strategies may be counterproductive (Figueredo, 2006; Sammour-Shehadeh et al., 2022). In this context, differences in terms of orthographic depth between the L1 and English seem to be critical for spelling (Geva et al., 1993; Katz & Frost, 1992; Sammour-Shehadeh et al., 2022). English learners whose L1 has a transparent orthography, such as Spanish-speaking people, may struggle to learn the English phoneme–grapheme correspondences and may use different grain size units, leading them to use the correspondences of their native language to spell in English (Dixon et al., 2010; Sammour-Shehadeh et al., 2022). On top of that, the English orthography includes several multi-letter correspondences, digraphs, and clusters (Schmalz et al., 2015), which learners may not be familiar with. But the reliance on the L1 seems to disappear as learners improve their English language skills, increasing their reliance on English spelling rules and strategies, like orthographic context and bigger grain size units (Wang & Geva, 2003).

Many of the mentioned studies on spelling development in Spanish speakers have been conducted in the United States, where most children speak Spanish at home, but receive instruction in English or in both Spanish and English languages. Thus, explicit instruction in English might considerably reduce the number of transfer errors (Rolla San Francisco et al., 2006). The situation is very different in Spain, where children do not receive explicit literacy instruction in English, and where exposure to the English language outside school is low. It may have important repercussions on spelling development (Sammour-Shehadeh et al., 2022). A recent study addressed the different sources of knowledge (phonology, orthography and morphology) used by Spanish-speaking children to spell in English, a less consistent orthographic system than that of their native language (Spanish), (Hevia-Tuero et al., 2022). It was found that Spanish-speaking children (4th–6th grades) made more orthographic errors than phonological and morphological, a finding that had also been reported by Bahr et al. (2015). This is considered a consequence of the reliance on phonology besides an incomplete knowledge of English orthography, leading to a misapplication of phoneme–grapheme conversion rules. However, errors of this kind were grade dependent, diminishing in older students. Considering phonological errors, the results confirmed that Spanish-speaking children rely more on phonology, with a large number of phonological errors made in novel phonemes, strongly supporting the *linguistic affiliation hypothesis* (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2010). The presence of novel phonemes and the absence of familiarity with them constitute a challenge for EFL learners (Dixon et al., 2010; Raynolds et al., 2013; Rolla San Francisco et al., 2006; Russak, 2022; Russak & Saiegh-Haddad, 2011; Wang & Geva, 2003). This leads to the application of the phoneme–grapheme correspondences of the native language (Fashola et al., 1996; Howard et al., 2012; Lindner et al., 2022).

These studies highlight the importance of orthographic characteristics and differences between writing systems when it comes to learning to spell in a FL, even more so when the FL's orthography is as complex as it is in English. Surprisingly, as far as we know, no study has collected measures of handwriting movements to investigate the spelling strategies used by children writing in EFL.

Our Study

The aim of this study was to examine the English spelling performance of Spanish-speaking children. We adopted a developmental perspective and tested children

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attending 4th to 6th grade, after a few years of exposure to the English language in a Spanish school context. Specifically, we aimed to answer different research questions, which we include below, along with hypotheses based on previous literature:

1 Do Spanish-speaking children rely on lexical or sub-lexical strategies when spelling in English as a foreign language? Does the pattern of spelling strategies change across grades?
Hypothesis: The impact of word length will decrease on the collected measures across grades, while lexical frequency will gain importance, suggesting a change in spelling strategies.
2 Is lexical–semantic knowledge a determinant of English spelling accuracy and speed in this population?
Hypothesis. Semantic knowledge will facilitate spelling accuracy and handwriting execution.
3 Are they sensitive to English spelling consistency (onset, nucleus, coda, and rime) with an effect on accuracy and handwriting execution? Does it depend on the grade?
Hypothesis. Orthographic consistency effects on spelling accuracy and handwriting will be limited, due to the limited exposure to English and scarce instruction regarding English spelling rules. This effect could be more evident in older children.
4 Does the number of errors in each of the sub-lexical units of the word (onset, nucleus, and coda) depend on spelling consistency?
Hypothesis. Regarding sub-lexical units (onset, nucleus and coda), there will be more errors in the nucleus and coda than in the onset of the syllable, due to the greater inconsistency of these parts.

In order to test our research questions, we tested Spanish-speaking children in 4th, 5th and 6th grade on a spelling-to-dictation task of English monosyllabic words. Several variables were considered in selecting the words: P–O consistency, lexical frequency and word length. In addition, an English to Spanish translation task, using the same words as the dictation task, was created to assess the children's semantic knowledge of these words. Word spelling accuracy, sub-lexical accuracy (i.e., accuracy for each of the syllable units: onset, nucleus and coda), WLs and WDs were collected.

Method

Participants

A total of 89 Spanish-speaking children, in fourth (29 students; M_{age} = 9 years, 4 months; SD = 6 months), fifth (28 students, M_{age} = 10years, 2 months; SD = 5 months), and sixth grade (32 students; M_{age} = 11 years, 3 months; SD = 5 months), participated in this study.

All of them were native Spanish speakers and attended a primary school in the north of Spain. They started schooling at the age of 3 years (age at which they start kindergarten, which lasts for 3 years). These children, when they start the first year of primary school (6 years old), already know the alphabetic code of the Spanish language. In Spain, children with certain cognitive difficulties that hinder their academic performance, are assessed by the school counsellor or psychologist. All the participants have been in school for a minimum of 7 years and had not been identified as having learning difficulties during this time. In addition, teachers confirmed that the participants in this study showed typical literacy

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development in their native language, without the need for any academic support or grade retaking throughout the years of schooling. Children with cognitive, motor, learning, or behavioural impairments were not included in the study. Moreover, children speaking a second language at home were also excluded. The school is in an area of medium socio-economic status.

In this school, children are introduced to English in kindergarten, learning basic vocabulary on different topics (e.g., colours, numbers, or animals). Fourth and fifth graders receive English classes during 5 h a week, while sixth graders attend 6 h. of English classes per week. The English teaching in most Spanish schools includes relatively little explicit spelling instruction. In the case of the participants in this study, although a phonics approach is increasingly being considered in the participating school, pupils were generally expected to learn the meaning, the pronunciation, and the spelling of words at the same time.

The procedure of the experiment was approved by the Ethics Committee of Research of the Principality of Asturias, Spain, and it has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Parental written consent was collected for all participants, and children agreed to participate in the study.

Materials

A total of 58 English monosyllabic and morphologically simple nouns (M_{letters} = 4.25; SD = 0.78) were selected to be included in the two tasks: a spelling-to-dictation task and an English-to-Spanish translation task. The words were obtained from an unpublished database created in our laboratory. This database includes the words contained in the two most widely used English textbooks in Spanish primary education. To create this database, schools (a total of 224 primary schools) in the north of Spain were asked to provide the textbook used to teach English in their school, as well as the number of pupils in their school. Two publishers were the most used, with 84% of the schools using one of these two publishers. With these predominant results, these two publishers were taken as a reference and the words (from first to sixth grade) were obtained from them. The textbooks from both publishers were digitised, and all words were dumped into an editable document. After cleaning, 3682 different word types were obtained for a total of 184,655 tokens. The number of times that each word appears in these textbooks was considered to calculate lexical frequency in the database. Based on this, we obtained the total number of occurrences of the word, as well as the frequency by grade and by textbook publisher. One of the publishers considered was used in the school attended by the participants in this study, so this publisher's frequency of occurrence was used when selecting the stimuli. The stimuli were selected, so all of them had at least one consonant in both onset and coda (e.g., cat or desk). In addition, we considered the occurrence of the words in textbooks for Grade 4 and below, to ensure words to which the children had already been exposed were included. For these words, we considered the following variables: word length (3 to 6 letters, M_{letters} = 4.26; SD = 0.78); lexical frequency according to the English textbook used in the school (1 to 73 occurrences, M = 20.91, SD = 16.30); feedback consistency scores of the onset (range: 1–0.0617188 = 0.938281; M = 0.94, SD = 0.15), the nucleus (range: 0.9951112–0.0033207 = 0.9917905; M = 0.48, SD = 0.33), the coda (range: 1–0.0223089 = 0.9776911; M = 0.63, SD = 0.33), and the rime (range:

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1–0.0305344 = 0.9694656; $M = 0.63$, $SD = 0.29$) according to Chee et al.'s consistency norms for 37,677 English words (2020). Examples of the words selected are *beach*, *cheese*, *clock*, *dog*, *glove* or *horse*. The full list of words used, and their individual characteristics can be found in the Data S1.

The auditory stimuli (words) for the spelling-to-dictation task, were recorded by a bilingual (Spanish/English) speech therapist. She used a ZOOM H4n voice recorder with a microphone Ht2-P Audix and edited using Praat software (Boersma & Weenink, 2022).

Apparatus

Stimulus presentation and digital recording of the responses were controlled by Ductus, a software package for the study of handwriting production (Guinet & Kandel, 2010). The experiment was run on an HP Mini laptop. A WACOM Intuos 5 graphic tablet connected to the computer and an Intuos Inking Pen were used to register the participants' responses.

Procedure

Participants were tested individually at school, in a quiet space free of distracting elements. All children first completed the spelling-to-dictation task, and then the English-to-Spanish translation task. Regarding the spelling-to-dictation task, participants were required to write the stimuli as quickly as they could in lowercase letters, trying to avoid errors. Each trial started with an auditory signal and a fixation point on the screen, with a duration of 500 ms. Subsequently, the auditory stimulus was presented, and participants had to start writing with the inking pen on a lined paper – one line per word – placed on the graphic tablet. When they finished writing the word, they should hover the pen over the next line without touching it, to get ready for the next word. Then, the experimenter presented a new stimulus using the mouse. Two different lists were created to randomise the order of presentation of the stimuli.

After the spelling-to-dictation task, children performed the English-to-Spanish translation task. For this purpose, a piece of paper including the 58 words was handed to the participants. They were asked to write the Spanish translation of all the words they knew. The aim of this last task was to assess if children knew the meaning of the words included in the experimental task. The score was considered an index of semantic knowledge. The total duration of the two tasks was approximately 15–20 min, although younger children were generally slower than their older counterparts.

Data Analysis

In this study, we investigated central and peripheral processes during English spelling in Spanish-speaking children, 4th to 6th grade. We collected a total of 5162 items or responses (4th = 1682; 5th = 1624; 6th = 1856). We measured spelling accuracy (scored as 0 when the word was misspelled and 1 when it was correctly spelled), sub-lexical units' accuracy (onset, nucleus, and coda accuracy, considering 0 when the sub-lexical unit was misspelled and 1 when it was correctly spelled), and both written latencies (WLs) and writing duration (WDs) for correct responses. WLs were measured as the time between the presentation of the stimulus and the onset of the response. Latencies are thought to mainly reflect central processes associated with spelling retrieval (in addition to processes

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associated with the stimulus identification and the preparation of the production of the first letter). WDs refer to the time between the first pen down produced in a word and the last pen lift in the same word. This measure captures differences in the motor aspects of the response, but they have also been observed to be sensitive to the linguistic properties of the stimuli, especially to sub-lexical spelling processes (Afonso & Álvarez, 2019). Statistical analyses were carried out using the R software version 4.1.3 (RDevelopment Core Team, 2022), *lme4* (Bates et al., 2015), *lmerTest* (Kuznetsova et al., 2017), and *broom.mixed* (Bolker & Robinson, 2022) packages.

Regarding the word spelling accuracy analysis, a generalised mixed effects modelling (GLMM), using the binomial family and the Laplace approximation for the likelihood, was performed. Generalised mixed models were used due to the dichotomous nature of the outcome variable and the existence of fixed and random effect factors, hence also the use of the binomial family and the Laplace likelihood approximation for coefficient estimation. The aim was to estimate the odds ratios that a response would be accurate given a set of predictors. Random effects of both participants and items were considered while grade, word length, translation accuracy or semantic knowledge, English lexical frequency, onset consistency, nucleus consistency, coda consistency, and rime consistency were considered fixed effects. When estimating a multivariate regression model, the absence of collinearity between predictor variables must be checked. In this case, the absence of collinearity was checked with the variance inflation factors and by calculating the intraclass correlation coefficient (ICC). The ICC is calculated by dividing the between-group variance (random variance) by the total variance (random and residual variance) and can be interpreted as 'the proportion of the variance explained by the grouping structure in the population' (Hox, 2002, p. 15). An ICC of .403 was obtained. The significance level used was .05.

Moreover, different univariate linear mixed models were constructed to predict WLs and WDs. We considered the different predictor variables or factors as fixed effects (grade, word length, semantic knowledge, English lexical frequency, onset consistency, nucleus consistency, coda consistency, and rime consistency) and the interaction of each factor with grade. Participants and stimulus were included as random effects. The variables with a significance less than or equal to .20 in the univariate models were selected and included in the multivariate model as there might be interactions between variables that are not significant in a univariate model. Those variables were included as predictors in the multivariate model. The absence of collinearity was checked with the variance inflation factors and by calculating the ICC. The formula for the specification of the linear mixed-effects models will have the following form: '$y \sim fixed_1 + fixed_2 + \ldots + (1|random) + \ldots$', where '$y$' is the outcome or response variable, meanwhile *fixed* refers to predictor or factor variables and *random* to those variables that may have unknown or uncontrollable values, but they are expected to contribute to the variability of the outcome variable (e.g., participants or stimuli variables that we did not control).

Results

Word Spelling Accuracy

In the analysis of the spelling accuracy of the words, we included all the responses given by the children, which amounts to a total of 2227 (43.14%) correctly spelled words and 2935

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errors (56.86%). As for the translation task, we found a total of 2883 correct answers, indicating that participants knew the meaning of 55.85% of the given words while they did not translate or did not correctly translate a total of 2279 (44.15%) words. See Table 1 for details.

Starting from a maximal model that included all interactions with the grade, and given the existence of non-significant coefficients, we opted to apply a backward algorithm to simplify the model. The mixed effects logistic regression analysis showed a semantic knowledge effect, $\chi^2_{(1)} = 118.140$, $p < .001$, where known words were more likely to be spelled correctly than words whose meaning was unknown to the children, odds ratio (*OR*) = 6.03, *SE* = 0.242, confidence interval (*CI*) = 0.011–2.67. A nucleus consistency effect was also significant, $\chi^2_{(1)} = 4.8382$, $p = .027$, as words with more consistent nucleus were more likely to be spelled correctly than less consistent ones, *OR* = 4.93, *SE* = 3.58, *CI* = 1.19–20.5. In addition, we found an interaction between grade and semantic knowledge, $\chi^2_{(2)} = 25.6464$, $p < .001$, revealing that the effect of semantic knowledge is grade-dependent, as 6th graders benefit from word knowledge more than fourth and fifth graders, $p < .001$, *OR* = 0.368, *SE* = 0.07, *CI* = 0.246–0.551. The interaction between grade and word length was also significant, $\chi^2_{(2)} = 6.1273$, $p = .046$, as the effect of word length was higher in 4th grade than in 5th, $p < .001$, *OR* = 1.33, *SE* = 0.17, *CI* = 1.03–1.72, and 6th grade, $p < .001$, *OR* = 1.32, *SE* = 1.65, *CI* = 1.03–1.69. There was a significant interaction between grade and lexical frequency, $\chi^2_{(2)} = 11.3839$, $p = .003$, with a higher probability of correctly spelling frequent words in 6th grade than in the 4th and 5th grades, $p < .001$, *OR* = 1.02, *SE* = 0.006, *CI* = 1.01–1.03.

Onset, Nucleus, and Coda Accuracy

To find out which part of the syllable is the most challenging for Spanish-speaking children and how this is affected by the grade, and the orthographic consistency, each part of the syllable (onset, nucleus, and coda) was coded as correct spelling (1), or incorrect spelling (0). After that, a GLMM, using the binomial family and the Laplace approximation for the likelihood, was performed for each part. Random effects of both participant and stimulus were included, while grade and consistency were considered fixed effects.

Children in the 4th grade made a total of 1812 errors; 1470 errors in the 5th grade; and a total of 1389 errors in the 6th grade. See Table 2 for details.

Table 1. Summary of the spelling and translation accuracy.

	Grade	Accuracy	% accuracy
Spelling accuracy	Fourth	587 (out of 1682)	34.91
	Fifth	703 (out of 1624)	43.31
	Sixth	937 (out of 1856)	50.50
Translation accuracy	Fourth	795 (out of 1682)	47.26
	Fifth	887 (out of 1624)	54.62
	Sixth	1201 (out of 1856)	64.71

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Table 2. Summary of the number of spelling errors made per grade in each part of the syllable.

	Onset			Nucleus			Coda		
Grade	Errors	*M* (*SE*)	%	Errors	*M* (*SE*)	%	Errors	*M* (*SE*)	%
Fourth	271	9.34 (15.17)	14.95	735	25.34 (16.10)	40.56	806	27.79 (14.67)	44.48
Fifth	201	7.17 (14.55)	13.67	600	24.42 (15.89)	40.81	669	23.89 (14.48)	45.51
Sixth	171	5.34 (12.56)	12.31	562	17.56 (14.72)	40.46	656	20.50 (12.96)	47.22

Onset Accuracy

For the onset analysis, we built the model *onset-accuracy ~ onset consistency * grade* + (*1*|*participant*) + (*1*|*stimulus*); however, no factor was found to be significant.

Nucleus Accuracy

For the nucleus analysis, the model was *nucleus-accuracy ~ nucleus consistency * grade + rime consistency * grade* (*1*|*participant*) + (*1*|*stimulus*). The ICC for this model was .349, and no collinearity was detected between the predictor variables, as verified through the variance inflation factors. The nucleus consistency effect was significant, $\chi^2_{(1)} = 13.9753$, $p = .000$, as the higher the value of nucleus consistency, the lower the probability of error, $p < .001$, OR = 16.3, *SE* = 12.2, *CI* = 3.78–70.7; the rime consistency by grade interaction was also significant, $\chi^2_{(2)} = 8.8194$, $p = .012$, as the effect of rime consistency on nucleus accuracy depended on the grade, with a tendency to benefit more from the rime consistency in 6th grade, $p = .07$, (*OR* = 2.44, *SE* = 1.23, *CI* = 0.908–6.56).

Coda Accuracy

For the coda analysis, *coda-accuracy ~ coda consistency * grade + rime consistency * grade* (*1*|*participant*) + (*1*|*stimulus*). However, no factor was found to be significant.

Written Latencies

Given the high error rate in some words, for the analysis of WLs and WDs, we only studied the data of the words with a minimum of 50% spelling accuracy. That involved 2136 responses (4th = 696; 5th = 672; 6th = 768) for a total of 24 words. Out of the 2136 responses, a total of 1436 were correct responses (67.22%), which were considered for the WLs and WDs analyses. Regarding the translation task, we obtained a total of 1552 correct responses, which indicates that participants know the meaning of 72.65% of words.

Following the procedure described above, the multivariate model was *WLs ~ semantic knowledge + grade + nucleus consistency + rime consistency + onset consistency * grade + length * grade* + (*1*|*participant*) + (*1*|*stimulus*). The ICC for this model was .218, and no collinearity is detected between the predictor variables as verified through the variance inflation factors.

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From the multivariate model, we found a semantic knowledge effect, $F(1, 1228.96) = 12.5539$, $p < .001$, as WLs were lower for words they do not know. The grade effect was also significant, $F(2, 1347.29) = 6.787$, $p = .001$, as 6th and 5th graders initiated the response significantly faster than 4th graders. The onset consistency effect, $F(1, 19.54) = 4.406$, $p = .049$, revealed that the higher the consistency of the onset, the lower the WLs. Finally, an onset consistency by grade interaction was found, $F(2, 1331.73) = 6.703$, $p = .001$, indicating that the onset consistency effect was higher in 6th and 5th than in 4th graders. See Table 3.

Writing Duration

As with WLs, we built the following multivariate model *WDs ~ semantic knowledge + coda consistency + lexical frequency * grade + onset consistency * grade + nucleus consistency * grade + rime consistency * grade + (1|participant) + (1|stimulus)*. The ICC for this model was .481, and no collinearity was detected between the predictor variables as verified through the variance inflation factors.

We found a semantic knowledge effect, $F(1, 1380.79) = 7.280$, $p = .007$, as WDs were lower when translation accuracy was equal to 1. Grade also produced a significant effect, $F(2, 789.15) = 7.994$, $p < .001$, as the duration of the movement depended on the grade, with lower WDs in 6th grade than in 4th and 5th grades. Regarding the onset consistency effect, $F(1, 18.25) = 4.7005$, $p = .043$, the higher the consistency of the onset, the lower the WDs. The nucleus consistency effect was also significant, $F(1, 18.30) = 17.1901$, $p < .001$, as the higher the consistency of the nucleus, the lower the WDs. Similarly, we found a coda consistency effect, $F(1, 18.13) = 7.0987$, $p = .015$, as the higher the consistency of the coda, the lower the WDs. The onset consistency by grade interaction, $F(2, 1326.04) = 3.4839$, $p = .030$), indicated that the impact of onset consistency on WDs depended on the grade, being higher in Grade 6, although the differences between grades were not significant. See Table 4.

Discussion

The aim of this study was to address the spelling performance of Spanish-speaking children (4th, 5th, and 6th) in EFL. Specifically, we were interested in the extent to which Spanish-speaking children use lexical or sub-lexical strategies when spelling in EFL and

Table 3. Summary of the final model for written latencies.

	Estimate	Standard error	*p* value
Intercept	2497.481	270.340	<.001
Semantic knowledge	−120.824	34.101	<.001
Onset consistency	−515.764	147.685	.001
5th grade	−664.492	180.616	<.001
6th grade	−392.952	172.300	.022
Onset:5th grade	447.633	124.398	<.001
Onset:6th grade	316.095	120.123	.008

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Table 4. Summary of the final model for writing durations.

	Estimate	Standard error	*p* value
Intercept	3245.570	289.804	<.001
Semantic knowledge	−94.755	35.117	.007
6th grade	−563.414	169.657	<.001
Onset consistency	−552.067	245.383	.033
Nucleus consistency	−916.629	241.270	<.001
Coda consistency	−395.471	148.43	.015
Onset: 6th grade	252.879	139.504	.070

whether the spelling pattern is grade dependent. Furthermore, we wanted to examine whether spelling accuracy, word retrieval, or motor execution while writing in English benefitted from lexical frequency or children's lexical–semantic knowledge, and whether these measures were sensitive to spelling consistency (at the levels of onset, nucleus, coda, and rime). Additionally, we were interested in whether the spelling accuracy of each of the sub-lexical units of the word (onset, nucleus, and coda) depended on their consistency.

For this purpose, a spelling-to-dictation task of monosyllabic words was designed, in which several variables were considered: word length, lexical frequency, and P–O consistency, as well as the children's semantic knowledge of these words. Different measures were collected: word spelling accuracy, sub-lexical accuracy (i.e., onset, nucleus, and coda), WLs, and WDs. From the analysis of WLs and WDs, in addition to the analysis of accuracy in the different sub-syllabic units, we tried to offer a more detailed picture of the spelling processes.

The results indicated that Spanish-speaking children have a low percentage of English spelling accuracy (4th = 34.89%; 5th = 43.2%; 6th = 50.48%). The data confirm the challenge posed by the English orthographic system, especially for Spanish-speaking children, whose native language has a transparent orthographic system (Figueredo, 2006; Sammour-Shehadeh et al., 2022). Linguistic differences between Spanish and English could motivate the high number of errors. English and Spanish are both alphabetic languages, but English has some orthographic features that make it very different from Spanish and could explain a significant number of errors (Bahr et al., 2015; Cronnell, 1985; Fashola et al., 1996; Hevia-Tuero et al., 2022; Howard et al., 2006, 2012; Lindner et al., 2022; Raynolds & Uhry, 2010; Rolla San Francisco et al., 2006; Sun-Alperin & Wang, 2008; Zutell & Allen, 1988). Another important constraint relates to the phonemic inventory, as the absence of some English phonemes in the L1 could hamper English spelling accuracy (Allaith & Joshi, 2011; Hevia-Tuero et al., 2022; Kahn-Horwitz et al., 2011; Russak & Kahn-Horwitz, 2015).

In our study, spelling accuracy appears to be determined by several factors, but these are grade dependent. Specifically, 4th graders were more affected by the word length than 5th and 6th graders, with more errors in long than in short words. In addition, 6th graders benefitted more from lexical frequency and semantic knowledge than 4th and 5th graders. This pattern suggests a change of spelling strategy, with greater reliance on a lexical strategy in the older grades, because of spelling exposure and English experience. In general, the spelling accuracy in young children depends on the P–O conversion rules, where long words are more likely to be misspelled than short words (Goswami et al., 1998;

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Sprenger-Charolles et al., 2003). It has been interpreted as the use of a sub-lexical strategy to spell. In terms of lexical frequency, more frequent words have a stronger orthographic representation than infrequent words, helping to achieve spelling accuracy. It seems to be in 6th grade when children start taking advantage of lexical frequency to spell in English. It could indicate that children have orthographic representations of those words they have encountered most frequently. However, the role of semantics should also be highlighted, as knowing the meaning of the word appears to be a determining factor in spelling (Hilte & Reitsma, 2011; Ouellette, 2010; van Rijthoven et al., 2021). These data confirm that knowing the word is fundamental for Spanish-speaking children to spell correctly in English, bearing in mind that children in Spain do not receive specific instruction in English spelling.

In addition, the nucleus consistency seems to be a determining factor in EFL spelling accuracy. Children were more likely to correctly spell those words that had a more consistent nucleus than those that had less consistent nucleus. Going deeper into this, and from the study of the sub-lexical units, the nucleus accuracy depends on the nucleus (vowel) and the rime consistency, from which 6th graders seem to benefit more than 4th and 5th graders. This indicates that Spanish children are developing a certain sensitivity to the regularities of the English orthographic system (nucleus and rime consistency), which increases with experience (i.e., grade). It has been described that the orthographic depth of English forces the development of the ability to use grain size units other than phoneme–grapheme correspondences (e.g., rime and morphemes) that might not be necessary in transparent orthographies (Ziegler & Goswami, 2005). Accordingly, older children seem to be sensitive to the rime consistency to spell the vowels, indicating the use of a grain-size unit larger than phoneme–grapheme.

Furthermore, we found a considerable number of errors in the coda. This does not seem to depend on its consistency, and it could be due to this being a multi-letter unit in many of the stimuli.

As for the measures of movement, we found that increases in grade and semantic knowledge make the WLs decrease. WLs were also influenced by the onset consistency, but only in 5th and 6th graders. The reduction of the WLs across grades informs that older children are faster in accessing and retrieving the spelling orthography of words, because of the accumulated spelling experience demonstrated in many studies (Kandel & Valdois, 2005; Rosenmblum et al., 2003). On the other hand, and unlike our results, literature has shown lexical frequency effects in WLs (Afonso, Álvarez, & Kandel, 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Bonin et al., 2016; Lambert et al., 2011), which it is supposed to be a lexical strategy. In our case, the effect of frequency has been probably replaced by the semantic knowledge effect, as children were faster to retrieve the spelling of known words. This highlights, once again, the importance of the semantic representation in spelling (Hilte & Reitsma, 2011; Ouellette, 2010; Van Rijthoven et al., 2021). The relevance of semantic knowledge is perhaps most meaningful in the context of Spanish-speaking children learning to spell English as FL. The children in the present study are non-native speakers of English, living in a non-English-speaking country, and receiving limited instruction on the English spelling rules at school.

Finally, WDs were determined by different variables. Both grade and semantic knowledge variables impacted WDs, indicating that older children (6th grade) showed a faster graphomotor execution of words than younger children (4th and 5th graders), and that known words were written faster than unknown words. This seems to indicate that a lexical strategy was used to spell, and it confirms that spelling processes affect the speed of

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handwriting movements. In other words, this finding adds to the existing evidence supporting the impact of central processes on peripheral processes. More interestingly, WDs were affected by the nucleus and coda consistency in all grades, indicating that orthographic retrieval does not end before the graphomotor execution starts, in line with the cascaded nature of writing processes suggested by several authors (Bonin et al., 2012). In addition, the results indicate that Spanish-speaking children have developed a certain sensitivity to English spelling consistency at this age.

In sum, this study informs us of the English spelling performance of Spanish-speaking children. This is the first study addressing this topic that includes analysis of the handwriting movement measures. We observed differences between grades. The cumulative exposure to English may lead to an improvement in spelling for many reasons. One of them is vocabulary growth, as having semantic knowledge about words facilitates their spelling. Another one is the increasing sensitivity to new spelling patterns and regularities, which older children can take advantage of. Such development occurs despite differences between the orthographies of the native and the FL. Furthermore, there is a shift from relying on purely letter-by-letter processing to using more complex strategies, adapted to the characteristics of English.

Limitations and Future Directions

Despite the interesting contributions of this study, one of the limitations could be the type of task used. Because Spanish-speaking children are not as exposed to oral English as their counterparts in the United States, the dictation task may be biased by their weak phonological knowledge. It is possible that certain words were not recognised by hearing, or they were recognised after a while, affecting both accuracy and handwriting measures. In this sense, lexical retrieval could differ depending on the input modality for these children. This issue should be clarified in future studies. We could use a written naming task, in which participants would have to write from a picture, without the need to receive an auditory stimulus. Alternatively, spelled words could be presented in the context of meaningful sentences to clarify the meaning. The use of alternative tasks would provide us with additional information about the strategies used by Spanish children when writing in EFL.

On the other hand, an analysis of the type of errors made could complement the results obtained here. A study carried out by Hevia-Tuero et al. (2022) analysed the errors made in the production of narratives, following the triple word form theory (phonology, orthography, and morphology) and the POMAS (Phonological, Orthographic, and Morphological Assessment of Spelling) system. Such an analysis would help us delve deeper into the strategies these children use when spelling, also testing possible phonetic discrimination difficulties and poor phonological knowledge of English.

Additionally, it would be interesting to collect data from older children (i.e., secondary education students) to study how English spelling abilities develop in Spanish-speaking adolescents. As we have seen in the current study, Spanish-speaking children in primary school have a low percentage of accuracy in spelling, which we assume should increase in secondary school for at least two reasons: the acquisition of a wider vocabulary and the increase of the children's knowledge of the regularities of English.

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Implications

We consider that this study provides us with interesting and useful conclusions for the improvement of EFL teaching in Spain. One of our main findings is the growing sensitivity towards the orthographic regularities of English, on which Spanish-speaking children rely to spell. Accordingly, explicit instruction, about the English orthographic regularities and the use of different grain size units, should be necessary from the first grades of exposure to English spelling. This instruction could strengthen their knowledge of the English orthographic conventions and provide Spanish-speaking children with strategies to spell.

Besides, the facilitation effect of semantic knowledge highlights the relevance of a strong vocabulary for spelling in EFL. Considering this, instructors should guarantee that children know the meaning of the words they are using in the classroom.

Conflict of Interest Disclosure

We have no known conflict of interest to disclose.

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Data Availability Statement

If the manuscript were to be published, we intend to make the experiment, the data,and the scripts to reproduce the analyses openly available at the Open Science Framework. For now, data and materials can be accessed anonymously for peer review in the following link (https://osf.io/8xhwc/?view_only=59c6f5b103f640ddadf8a66564c2ed4c).

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