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Orthographic learning in Spanish children: influence of previous semantic and phonological knowledge

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Orthographic learning is one of the steps needed to achieve reading fluency. There are different variables that could influence the formation of orthographic representations. The aim of this study was to investigate the role of the previous semantic and phonological knowledge on the formation of orthographic representations. We used a decrease of the length effect as the measure of orthographic learning. We made a reading aloud task that utilised new words with Spanish children from third grade under three different conditions: with prior semantic and phonological training, with prior phonological training and without training. Results showed that knowing the meaning and the phonological form of the words facilitated the formation of orthographic representations, as the length effect was significantly lower than in the other conditions, and it also improved the children's reading performance.

Keywords: orthographic learning, semantics, phonology, Spanish children

Highlights

What is already known about this topic

- Spanish children from primary education form orthographic representations after approximately six exposures to new words.
- Phonological previous knowledge facilitates the formation of orthographic representations in children and adults from a transparent or an opaque language.
- Semantic previous knowledge of words seems to only facilitate the orthographic learning in adults from a transparent language.

What this paper adds

- Semantic and phonological prior training and only phonological prior training increase reading speed.
- Semantic and phonological previous knowledge makes easier to form orthographic representations in Spanish children, with a transparent orthographic system.

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Implications for theory, policy or practice

- More knowledge about how children from a transparent language form orthographic representations of new words.
- Relevance of oral vocabulary (i.e., meaning and phonological form of words) in reading performance.
- Importance of this previous knowledge on the orthographic learning.

It is known that one of the steps needed to achieve fluent reading is the formation of orthographic representations (Ehri, 1987; Perfetti, 1992; Share, 1995; Stanovich & West, 1989). Following self-teaching theory (Share, 1995, 1999), orthographic representations are formed from the repeated and correct decoding of written words, which are then stored in the visual lexicon. These orthographic representations allow the reading of new words as a whole, rather than letter by letter, which permits faster and more fluent reading.

Several studies have focused on how orthographic representations of new words are formed and assessed questions relating to how many exposures are needed to form them or which variables influence them. Regarding the first question, it seems that four to six exposures are sufficient for English populations, children and adults, to form orthographic representations of new words (Bowey & Muller, 2005; Kwok & Ellis, 2014; Maloney, Risko, O'Malley, & Besner, 2009). A Spanish study also showed that after six repeated exposures to new words, presented either in isolation or within a context, children from second to sixth grades had formed orthographic representations (Suárez-Coalla, Álvarez-Cañizo, & Cuetos, 2016).

Concerning the second question, there are several variables, such as syllabic structure, orthographic consistency and the presence of context-dependent graphemes, which seem to influence the formation of orthographic representations (Álvarez-Cañizo, Suárez-Coalla, & Cuetos, 2018; Wang, Castles, & Nickels, 2012; Wang, Nickels, Nation, & Castles, 2013). In addition, some authors have focused on the role of phonological and semantic knowledge of new words before facing the orthographic form.

It should be highlighted that several authors have found a relationship between oral vocabulary and reading performance (Bowey, 1995; Ricketts, Nation, & Bishop, 2007; Walley, Metsala, & Garlock, 2003). In terms of knowing the word's orthographic form, understanding of the phonology and meaning contribute to forming a high-quality representation, allowing the reader to grasp the printed word exactly (Perfetti & Hart, 2001, 2002). It is clear that knowledge of the phonological form of words has considerable advantages for reading performance as children can sound new written words out and match the output with words in their spoken vocabularies, facilitating more successful reading (Share, 1995). In addition, children are very sensitive to the phonological forms of words and their connection to the orthographic forms from a very early stage (Ehri, 1992; Ehri & Wilce, 1985; Rack, Hulme, Snowling, & Wightman, 1994).

With regard to semantics, Berends and Reitsma (2006) observed in their study that semantic understanding improved reading speed and reading accuracy in poor readers in Dutch, a transparent language. In contrast, in languages with an opaque orthographic system, such as English, semantics have been found only to improve reading performance of irregular words, while phonology also plays a role in reading regular words (McKay, Davis, Savage, & Castles, 2008), as well as facilitating the ability of English children to remember the spelling of new words (Laing & Hulme, 1999). Nevertheless, some studies

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in English have not found any improvement in reading performance when the semantics of new words are known (Hogaboam & Perfetti, 1978; McKague, Pratt, & Johnston, 2001; Nation & Cocksey, 2009; Nation, Angell, & Castles, 2007). This discrepancy in the results might be due to the different methodologies used for including semantics and assessing reading performance, or to the different languages and populations.

Bearing in mind that both phonological understanding and semantics could have an influence on reading performance, we wondered if these aspects would influence the formation of orthographic representations. Cunningham (2006) performed a study with English children using real words known orally within a story context and in scrambled passages that eliminated the semantic information, assessing the formation of orthographic representations through a choice task and a spelling task. The results did not show significant differences between the two conditions, with orthographic learning found in both. These results could be due to the use of real words, which were already known to the participants; the semantic representation might have been activated when they read the words independently if meanings were provided. Nevertheless, similar results were found in a study conducted by Chalmers and Burt (2008) with English adults in which the stimuli consisted of pseudowords in a reading task and orthographic learning was assessed with a spelling task. This showed that semantic or phonological information improved orthographic learning, but there was no greater benefit when both semantic and phonological cues were provided together (Chalmers & Burt, 2008). The authors suggested that semantics may have provided a scaffold for new orthographic representations, as well as perhaps making the training more interesting and encouraging participants to attend. Studies conducted with English children have also demonstrated that semantic information does not affect orthographic learning in reading tasks in which the meaning of pseudowords is provided through a story context or a picture (Nation et al., 2007) or in spelling tasks with semantic information provided beforehand through definitions and drawings (Ouellette & Fraser, 2009), albeit the latter study found a semantic influence on the recognition of new words when performing a choice task.

Contrary to these findings, a study conducted with English adults showed that previous word knowledge, phonological and semantic, or only phonological, influenced orthographic learning and generalisation, with the semantic information having a stronger influence (Taylor, Plunkett, & Nation, 2011). In this study, adults were trained using semantic and phonological information, or only phonological information, for some new words before seeing their orthographic form. Orthographic learning was tested using an old-new decision task. The results showed a semantic benefit for the items containing low-frequency inconsistent vowels, whereas the benefit of phonological familiarity was observed across item types. Ouellette (2010) also found that semantic information improved the orthographic learning and spelling of English children. He created a task with new words, providing semantic information for half in a reading or a spelling training session. Dictation of these new words was used to assess their learning, confirming the benefit of semantic training. These differences with regard to the benefits of prior provision of semantic information in orthographic learning probably result from the methodologies used to assess the formation of the orthographic learning of new words (e.g., spelling recognition, dictation, orthographic choice task) as some can be considered a measure of episodic memory rather than orthographic learning. Moreover, such studies also used different ways of including the meanings of words (e.g., stimuli embedded in a story, images).

What is more, these studies were undertaken with English populations. English has an opaque orthographic system, so other variables might influence reading, such as the

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regularity or inconsistency of the words. In addition, the lack of a direct correspondence between grapheme and phoneme makes it necessary to know the phonological form of words in order to read them accurately, which could highlight the importance of phonology as opposed to semantics. In contrast, Spanish is a transparent language in which there are clear grapheme-phoneme correspondences that allow students to achieve reading accuracy very early (Cuetos & Suárez-Coalla, 2009). This may result in different contributions of semantic and phonological understanding to the formation of orthographic representations of new words. This connection was studied with Spanish adults (Suárez-Coalla & Cuetos, 2017), who performed three reading aloud tasks in order to compare the influences of prior semantic and phonological training, phonological training alone and no training on orthographic learning. The results showed that semantic information favoured the formation of orthographic representations. Moreover, this facilitation also continued 1 month later, when the reading times for the task in the follow-up session were found to be shorter for the participants who had previous semantic and phonological training. However, these results are not in line with those found in a study of Spanish children (Suárez-Coalla et al., 2016) who had to read new words in isolation and within a context. In this study, it was found that no semantic influence was required to form orthographic representations as these were similar for both tasks, regardless of whether semantic information was provided or not. Reading within a context requires that children make an extra effort to learn the orthographic form while also extracting the semantic form of the new words. While the context may provide children with the opportunity to access the meaning of the target word, it does not ensure that they can understand the meaning. In this regard, when there is specific semantic training, the meaning of the target word is accessible without needing textual comprehension.

Therefore, it has been noted that phonological understanding consistently plays an important role in the formation of orthographic representations, in both opaque and transparent languages. However, the influence of semantic knowledge on orthographic learning is unclear, there being differences between the results of studies with English participants and those with Spanish adults and children. Nonetheless, it should be considered that discrepancies in the findings for Spanish children and adults could be due to the different methodologies used in the studies.

The aim of our study was to determine the role of semantic and phonological knowledge in forming orthographic representations of new words among Spanish children using a task with previous training providing specific access to the meaning of the words (word-level semantics), in addition to its phonological form. To address this objective, we set up a reading aloud task under three different conditions with children from the third grade. The first condition consisted of semantic and phonological training of obscure words prior to the reading aloud task. In the second condition, only phonological training was carried out before the reading aloud task. The third condition consisted only of the reading aloud task, without prior training. We selected children in the third grade as this stage has commonly been used in studies, being an important grade for the learning-to-read process (Cunningham & Stanovich, 1990; Kyte & Johnson, 2006) in which children start to acquire the reading skills needed for fluency.

The formation of orthographic representations was measured by the reduction of the length effect in the reading aloud task. The length effect can be described as the difference between short and long stimuli, with long stimuli having longer reading times and also less accuracy than short stimuli (Just & Carpenter, 1980). Following the dual-route model (Coltheart, 1978; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), a sub-lexical route was used to read unknown words, which implies more time and greater differences

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between short and long stimuli. When a word was already known, lexical reading was used, which tends to be faster and reduces differences in length. This method for checking the formation of orthographic representations has been used by other authors (Kwok & Ellis, 2014; Suárez-Coalla et al., 2016; Suárez-Coalla, Avdyli, & Cuetos, 2014; Suárez-Coalla, Ramos, Álvarez-Cañizo, & Cuetos, 2014).

Method

Participants

The study was conducted with a group of 75 third-grade children (M = 8.46 years, SD = 0.29) from three public schools, with a medium socioeconomic status: 25 children participated in the first condition (17 girls and 8 boys), 25 in the second condition (17 girls and 8 boys) and 25 in the third condition (13 girls and 12 boys). The participants were selected for the experiment based on the results obtained on the PROLEC-R test of reading words and non-words (Cuetos, Rodríguez, Ruano, & Arribas, 2007). Only those with an appropriate score for their age (see Table 1) were included, following the battery scales. PROLEC-R is a standardised battery for the assessment of reading in Spanish children between 6 and 12 years old. None of the children had any known cognitive impairment, visual or motor disorders, and all were native Spanish speakers. The children selected for each condition were counterbalanced, meaning that the three conditions were applied for all children from the three schools.

The study was approved by the Ethics Committee of the Psychology Department of the University of Oviedo. Before starting the experimental tasks, the families of the participants received pertinent information about the purpose of the study, the types of tasks and their duration. Written informed consent was obtained from them, authorising the children to take part in the experiments.

Materials

Eight obscure words were used (lexical frequency = 0; Martínez & García, 2004), which were unknown even to the adults, thus functioning as pseudowords; half were short (four letters and two syllables, e.g., *daza*) and half long (seven letters and three syllables, e.g., *panique*). Each word was accompanied by an image that showed the word's meaning (see example in Figure 1). In addition, eight pseudowords were created to be used as fillers with the same length, number of syllables, syllabic frequency (Alameda & Cuetos, 1995) and syllabic structure as the obscure words.

Table 1. Main results of PROLEC-R.

	Reading words		Reading pseudowords	
	Accuracy (out of 40) *M* (*SD*)	Speed (s) *M* (*SD*)	Accuracy (out of 40) *M* (*SD*)	Speed (s) *M* (*SD*)
Condition 1	39.1 (0.9)	43.8 (9.1)	36.8 (1.5)	67 (12.5)
Condition 2	39.2 (0.9)	42.1 (9.5)	36.7 (1.8)	67.1 (19.1)
Condition 3	38.7 (1.2)	47.4 (11.3)	37 (1.7)	74.3 (15.4)

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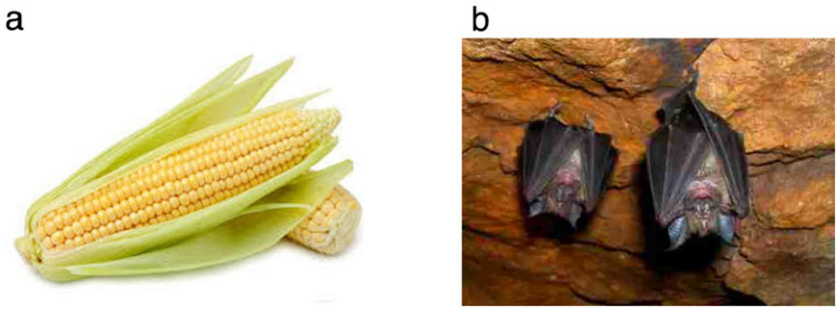

Figure 1. Examples of pictures and meanings of stimuli. a: Daza: a kind of corn. b: Panique: large size bat from Oceania. [Colour figure can be viewed at wileyonlinelibrary.com]

Procedure

We prepared a task with three different conditions for the selected stimuli (i.e., semantic + phonology training condition, phonology training condition and no training condition). The first condition comprised two parts: in the first, children were required to listen to and repeat the eight obscure words, one at a time in random order, when the images related to each word appeared on the laptop screen along six blocks using DMDX software (Forster & Forster, 2003). All the children received the same oral and written instructions: 'This is a repetition task. You will see a picture and hear its name. You have to repeat it aloud. Press SPACEBAR to start'. In this stage, the children had not been provided with the orthographic forms of the words. The second part consisted of a reading aloud task in which the obscure words and the pseudowords were presented individually and in random order on a computer screen using DMDX software to record the answers. Each child was given a verbal explanation of the task and written instructions also appeared on the screen: 'This is a reading task. Words will appear on the computer screen. You have to read FAST, but DO NOT MAKE MISTAKES. When you are ready, press SPACEBAR to start'. Each block of obscure words and pseudowords was repeated six times.

The second condition was similar to the first, but in this instance the children only received phonological training before the reading aloud task. In the third condition, the children did not receive any training prior to the reading aloud task. The children's responses to the reading aloud tasks in all three conditions were recorded and saved in.wav files and subsequently analysed using the CheckVocal program (Protopapas, 2007) to determine the reaction times and the number of mistakes. The tasks were carried out in school rooms free of noise and distractions.

Results

To analyse the data from the children, we only used those from the obscure words, rejecting the data from the pseudowords that served as fillers.

From the total responses, 4.1% had errors and were therefore not included in the analysis. The outliers (1.5 standard deviations, SDs, above or below the mean), which amounted to 1.6%, were also not included. In the following analysis, only the reaction times (RTs) that involved correct responses to the obscure words were used (see Table 2 for the main means and SDs by condition, block and length).

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Table 2. Mean and SDs of RTs by condition and length in blocks 1 and 6.

	Block 1		Block 6	
	Short *M* (*SE*)	Long *M* (*SE*)	Short *M* (*SE*)	Long *M* (*SE*)
Condition 1	694.9 (37.6)	853.8 (37.9)	663.9 (37.7)	726.7 (37.9)
Condition 2	756.6 (37.8)	951.1 (37.9)	703.8 (37.9)	783.4 (37.8)
Condition 3	794.3 (37.9)	1010.3 (38.2)	736.7 (37.9)	832 (38.3)

Our study had a repeated measures design, with the same items presented to different participants (between-subject design), requiring the use of mixed-effects modelling in order to estimate both fixed effects, that is, condition (semantic + phonology, phonology, without training), block (one to six) and length (short and long words) and random effects, that is, unexplained effects due to random variation between items or participants (Baayen, 2008; Baayen, Davidson, & Bates, 2008). In this case, the RTs were the dependent variables, whereas the condition, block and length were independent variables.

From the data, and using the linear mixed-effects model fit by REML (R Core Team, 2017), we found as the best model (lowest AIC): RT ~ Condition * Block × Length + (1| Subject) + (1|Item). We used the lme4 (Bates, Mächler, Bolker, & Walker, 2015) and the lmerTest (Kuznetsova, Brockhoff, & Christensen, 2015) packages of R in order to conduct these analyses. The ANOVA of this model showed a statistically significant effect for condition ($p = .003$), as the condition with both semantic and phonological previous training ($M = 720.7$, $SE = 28.4$) had RTs significantly smaller than the condition without training ($M = 820.1$, $SE = 28.4$); block ($p < .001$), since the reading times decreased along the blocks; and length effect ($p = .03$), as short words had lower latencies ($M = 717.8$, $SE = 31$) than long ones ($M = 830.9$, $SE = 31$). We also found significant interactions between block and length ($p < .001$) and condition and length ($p = .001$).

We conducted a post hoc analysis of the two significant interactions in order to explain them using the lsmeans package (Lenth, 2016). Firstly, regarding the block × length interaction (Figure 2), we found that the length effect decreased significantly from the first block (*Estimate* = 189.8, $SE = 42.4$, $p = .045$) to the last one (*Estimate* = 79.3, $SE = 42.5$, $p = .75$). Finally, the condition × length significant interaction (Figure 3) means that the length effect was significantly lower in the condition with prior semantic and phonological training >(*Estimate* = 90.2, $SE = 41.4$, $p = .358$) compared to the other two conditions

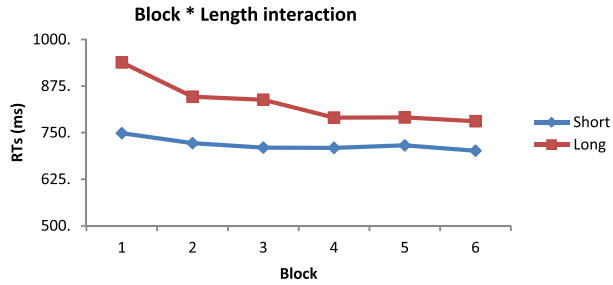

Figure 2. Significant interaction block × length in reaction times. [Colour figure can be viewed at wileyonlinelibrary.com]

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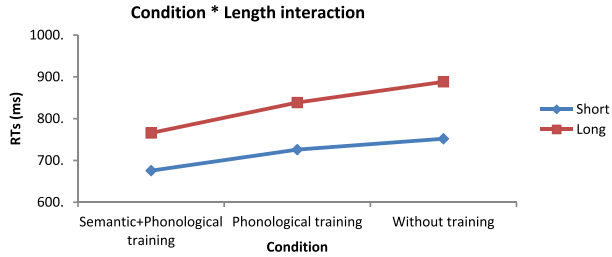

Figure 3. Significant interaction condition × length in reaction times. [Colour figure can be viewed at wileyonlinelibrary.com]

($Estimate_{Condition\ 2}$ = 112.8, SE = 41.5, p = .194; $Estimate_{Condition\ 3}$ = 136.2, SE = 41.5, p = .101).

Discussion

The aim of this study was to determine whether previous semantic and phonological knowledge affected the formation of orthographic representations of new words among Spanish children. To meet this objective, we conducted an experiment that involved giving the children a task of repeatedly reading aloud unknown words under three different conditions: with prior semantic and phonological training (i.e., hearing and repeating the pronunciation while seeing a picture corresponding to the meaning), with only prior phonological training (i.e., only repeating the phonological form) and without training. Orthographic learning was measured using the reduction in the length effect of RTs after six times of repeated reading, a methodology successfully used in previous studies (Kwok & Ellis, 2014; Suárez-Coalla et al., 2016; Suárez-Coalla, Avdyli, & Cuetos, 2014; Suárez-Coalla & Cuetos, 2017; Suárez-Coalla, Ramos, et al., 2014).

Our results show that children's reading speed benefited from receiving training prior to the task, both semantic and phonological and only phonological, as we found lower RTs in these two conditions compared to that without training, indicated by the significant effect of Condition. This partially agrees with previous studies conducted in other languages in which a clear benefit was found from reading with prior phonological knowledge (Chalmers & Burt, 2008; Duff & Hulme, 2012; Nation & Cocksey, 2009), but there was no extra benefit from having prior semantic information. In addition, it seems that children started to form orthographic representations after the six orthographic exposure as the length effect in RTs decreased significantly along the blocks, indicating that they started to use lexical reading. This confirms the results of previous studies finding that only few exposures to new words are needed in order to form orthographic representations (Bowey & Muller, 2005; Maloney et al., 2009; Share, 1999, 2004; Suárez-Coalla et al., 2016).

The children formed orthographic representations in all three conditions. However, the results showed that the length effect was smaller in the condition that involved prior semantic and phonological training than in the other two conditions. This could be due to the fact that the children were using lexical reading, in which the length effect does not affect reading times to such a great extent. This may mean that knowing the meaning and the phonological form of the words in advance makes it easier for children to use lexical reading, which is achieved by the formation of orthographic representations. In this vein, previous studies undertaken with English populations have found a benefit of

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semantic information for the orthographic learning of inconsistent words (Ouellette, 2010; Taylor et al., 2011).

Our results are also similar to those of a Spanish study conducted with adults (Suárez-Coalla & Cuetos, 2017), which used a similar training methodology. They also found that semantic and phonological training facilitated the formation of orthographic representations of new words among Spanish adults. In addition, this facility was still available 1 month later, as seen in a follow-up session in which the trained words presented lower RTs than those for the other two conditions. However, our results do not match those found in a study conducted with Spanish children (Suárez-Coalla et al., 2016), namely that there were no differences in the orthographic learning of children when new words were presented in isolation (i.e., without meaning) or within a context (i.e., providing meaning). This difference might be due to the different methodologies used in the two studies. However, we consider that using words in context does not ensure that children are provided with their meaning as their ability to extract the meaning of each unknown word depends on their reading comprehension level. Furthermore, in Suárez-Coalla et al.'s (2016) study, the semantic learning took place during the orthographic learning test as there was no previous training in meaning; the orthographic learning measures were taken during the text reading that included the semantic information. Moreover, children read a specific definition of the unknown word only once and on the other three occasions the word appeared in the story without a clear explanation.

In contrast, the training methodology used in this study would provide a direct link with the semantics of each word, without children needing to extract the meaning from the text. Instead, they only needed to look at the picture providing the meaning of the word heard. In addition, we included six repetitions of each word so they had more time to become familiar with them. In terms of phonological understanding, our results agree with those found in studies for other languages regarding the improvement of orthographic learning when the phonological form of the words is provided (Chalmers & Burt, 2008; Nation et al., 2007).

Therefore, our results show that having prior knowledge of words increases children's reading performance (i.e., speed and accuracy) and having a sense of the meaning and pronunciation seems to facilitate orthographic learning. The condition in which the semantic and phonological knowledge of the words is provided is the context children usually experience in their reading: when they encounter a new written word, children are used to knowing the oral form and the meaning. Indeed, some studies have been conducted on the relationship between oral vocabulary level and reading performance. Ricketts et al. (2007) found that oral vocabulary skills predicted concurrent reading competence and exception word reading. This is similar to the results found by Bowey (1995) in which the amount of receptive vocabulary in pre-readers predicted 20–27% of variance in first graders' reading. In addition, it seems that oral vocabulary is closely related to well-specified phonological representations that promote reading development (Walley et al., 2003).

A possible limitation of this study is the lack of other data on the children to serve as a baseline, such as vocabulary level, which seems to influence reading performance, or phonological skills. However, all the words used in our study were totally unknown to all participants. Moreover, although we did not have a specific phonological measure, we considered that all children had good decoding skills as they obtained similar results on the reading test in the PROLEC-R battery, in which it is necessary to undertake a correct phonological decoding in reading words and pseudowords. Based on confirmation of a good reading level with these tests, children in third grade have already acquired the skills

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needed to achieve fluent reading (Cunningham & Stanovich, 1990; Kyte & Johnson, 2006). Even so, this could be an interesting issue for further study in the future, together with examining different ways of training semantics to identify those providing greater benefit for children when forming orthographic representations.

Our study is of considerable interest and importance as it tries to resolve disagreement about the role of semantic and phonological understanding in the formation of orthographic representations of new words. With this aim in mind, in one condition we performed specific training in semantics and phonology to ensure prior learning before presentation of the orthographic form, comparing this with phonological training only and no training at all. Moreover, we used the length effect to assess the formation of orthographic representations, ensuring this measure would avoid episodic memory traces (e.g., using a recognition task). Finally, as Spanish has a transparent orthographic system, there are no other word variables that could influence reading, such as regularity or consistency.

To sum up, this study shows the importance of the role of semantics and phonology in the reading development of Spanish children based on an explicit training task conducted to ensure semantic and phonological learning. Our results have important educational implications as they highlight the relevance of oral vocabulary in reading performance. Giving children the oral form and the meaning of words prior to presenting their orthographic form will facilitate not only reading and the making of fewer errors, but also the orthographic learning of these words.

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