Title: On the role of the written accent mark in visual word recognition in Spanish

Running head: Accent mark and visual word recognition

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Acknowledgments: This study was partially funded through the project PSI2011-29155 of the Spanish Ministry of Science and Innovation.

ABSTRACT

Background: Previous research has shown that syllables are important units in visual word recognition in Spanish. If they are treated as real phonological units, then other related phonological features such as lexical stress (syllable prominence) may also play a role in this process. At times, lexical stress is the only difference between minimal pairs in Spanish (e.g., *sábana* 'sheet' vs. *sabana* 'savannah'). These words are usually distinguished by an accent mark. This research examines whether lexical stress is used in visual word recognition, and the role of the written accent mark in this process.

Methods: In a lexical decision task, words with an irregular stress pattern according to generative phonological rules (e.g., *túnel* 'tunnel' or *mitin* 'meeting') were compared to regular words (e.g., *melón* 'melon' or *grifo* 'faucet').

Results: Irregular words without an accent mark (*mitin*) were particularly difficult to recognize. However, irregulars that carried an accent mark were identified significantly more quickly and accurately.

Conclusions: These findings are discussed as evidence that lexical stress may be an important cue in visual word recognition in Spanish, as suggested by previous research in the psycholinguistic and educational fields, and that models of visual word recognition should consider the impact of the accent mark in languages such as Spanish.

Keywords: Spanish, lexical stress, accent mark, visual word recognition

HIGHLIGHTS

What is already known about this topic

- The syllable is an important unit in visual word recognition in languages like Spanish.
- Lexical stress is the prominence of a given syllable in a word, and there are regularities in the phonology that predict its placement in Spanish words.
- The written accent mark is used to identify the stressed syllable in Spanish.

What this paper adds

- The written accent mark facilitates the reading of words with irregular stress patterns.

Implications for theory, policy or practice

- A word's full phonological representation appears to include lexical stress.
- The role of the written accent mark should be considered in psycholinguistic models of visual word recognition in Spanish.
- Future research may explore whether encouraging children to pay attention to the accent mark may facilitate the learning of new words.

INTRODUCTION

Syllables are important units for visual word recognition in Spanish (Carreiras, Álvarez, & de Vega, 1993). The syllabic level of phonological processing has been shown to influence lexical activation (Álvarez, Carreiras, & Perea, 2004), suggesting that phonological information plays a significant role when reading words in Spanish. Previous research has focused mainly on the level of the syllable, but if syllables are processed as phonological units, then other phonological features, such as prosody, may also be relevant. This paper examines the role of phonology in visual word recognition in Spanish, focusing on syllable prominence. More specifically, we explore lexical stress, the prominence of a given syllable in a word, as it is an underexplored phonological element that may potentially form an important cue in lexical processing.

Previous research has shown that reading in Spanish is affected by lexical and sublexical information, since variables such as lexical frequency, familiarity, or length affect word naming (Davies, Barbon, & Cuetos, 2013); and lexical frequency, age of acquisition, imaginability, orthographic neighborhood, and length affect lexical decision (Gonzalez-Nosti et al., 2014). Furthermore, research has shown that sublexical processing is based on phonological syllables (Álvarez et al., 2004). However, the impact of syllabic information has not been fully explored, as syllables are closely related to lexical stress. The present study contributes new evidence showing an interaction between syllable structure and lexical stress on visual word recognition.

There are several reasons to believe lexical stress may affect lexical access. First, there are models of visual word recognition and reading, such as Frost (1998), that maintain that lexical access must include the processing of a word’s complete phonological form (see also Van Orden, 1987, and Stone, Vanhoy, and Van Orden, 1997, on the importance of phonology and phonological feedback in visual word identification). In languages such as Spanish, the syllable has been established as a significant level in a word's phonological representation. For example, it has been observed that words with high-frequency first syllables are recognized more slowly than comparable words with lower-frequency beginning syllables. This is arguably the case because they have more competitors that share the first syllable (Carreiras, Álvarez, & de Vega, 1993). Similarly, priming experiments have shown that syllables are treated as phonological units, evidenced by a priming effect when pseudoword primes and word targets share either their first orthographic syllable (*vi.rel-VI.RUS*) or their first phonological syllable (*bi.rel-VI.RUS*), as compared to a control condition (Álvarez, Carreiras, & Perea, 2004).

There is also evidence from various languages to suggest that stress and syllable structure are highly linked. For example, Ashby and Clifton (2005) found in English that syllable prominence forms part of phonological processing during silent reading. In their study, words with more stressed syllables elicited longer reading times, suggesting that readers construct a prosodic contour during silent reading in which stress placement plays an important role. In more recent work on Greek, Protopapas, Panagaki, Andrikopoulou, Gutiérrez-Palma, and Arvaniti (2016) found that priming effects were obtained only when words matched in both segmental structure and stress placement, never just in stress placement alone. This finding is consistent with the view that the encoding of syllables, both their prominence in the form of stress and the specification of the segments within them, is inherent in the lexical representation of a word.

There are also language-specific data that highlight the importance of lexical stress in visual word recognition. In the case of Spanish, lexical stress is variable, unlike the fixed stress system of other languages such as French or Hungarian. For example, in minimal pairs such as *sábana* 'sheet' vs. *sabana* 'savannah', meaning may only be differentiated by stress. At other times, stress is a cue to grammatical category (e.g., *jugo* 'juice' [noun] vs. *jugó* 'played' [verb]) or to verbal forms (e.g., *mato* 'I kill' [present] vs. *mató* 's/he killed' [preterite]). Thus, stress in Spanish is a crucial element in deriving both lexical and morphosyntactic meaning.

Lexical stress assignment in Spanish

Lexical stress in Spanish may be derived through both orthographic and phonological cues. In the case of reading, the clearest cue is the accent mark, a diacritic placed on the vowel of the stressed syllable, used to draw the reader's attention to an unexpected stress pattern (e.g., *<u>á</u>rbol*). The presence or absence of this mark is rule-based and allows for the identification of lexical stress in any Spanish word. The specific orthographic convention is as follows: words in Spanish that end in a consonant, except *n* or *s*, are normally assigned final stress, and words that end in a vowel, *n*, or *s* receive penultimate stress. Any word that violates either of these two rules carries an accent mark to indicate its stressed syllable.

Phonologically speaking, Spanish has been argued by many to be a quantity-sensitive language (Harris, 1983; Núñez Cedeño, 1986; Shelton, Gerfen, & Gutiérrez Palma, 2012; Fuchs, 2018). This means that stress assignment in Spanish is modulated by subsyllabic structure. Based on its internal makeup, any given syllable in the language is considered to be either heavy or light. Light syllables are those that end in a single vowel, while syllables that contain a diphthong or a postvocalic consonant are heavy. In languages that are sensitive to syllable weight (i.e., quantity-sensitive), heavy syllables tend to attract stress. In Spanish, lexical stress is computed from the right edge leftward and is only permitted on one of the last three syllables (compound words may provide exceptions). Thus when stress is assigned to two-syllable words, final light syllables are usually passed over, and stress is placed on the first syllable. As examples, words like *ca.sa* 'house' and *pi.so* 'floor' are stressed penultimately, because the final syllable ends in a single vowel and is therefore light and skipped. Words such as *re.loj* 'watch' and *fi.nal* 'ending' receive final stress, because their final syllable ends in a consonant, which makes it heavy and attract stress.

Words that do not follow the general stress rules are considered irregular. As these words are typically accented (e.g., *tú.nel* 'tunnel' or *so.fá* 'couch'), it may appear that the Spanish accent mark points out exceptions to the generative phonological rules. While generally true, this is not always the case. Words such as *cajón* 'drawer' and *compás* 'rhythm' also carry accent marks on their final syllables, even though traditional phonological theory would already predict final stress, given that they end in *n* and *s*, which renders the final syllable heavy. Even though these words are phonologically regular, the accent mark is a useful cue in these cases, because Spanish words that end in *n* or *s* are usually stressed on the penultimate syllable. This is due to the high frequency of penultimately-stressed words ending in the plural *-s* and verbal forms that end in both *n* and *s* (Hualde, 2014). Therefore, there is a mismatch between the generative linguistic rules on stress placement and the orthographic rules used in Spanish spelling.

In addition to these orthographic and phonological rules, there are other sources of information on stress assignment in Spanish. For example, most words in Spanish (about

64%) have stress on the penultimate syllable (Morales-Front, 2014). However, this percentage depends on the word's ending. When words end in a vowel, 88% have penultimate stress, while only 2% of words that end in a consonant do (Morales-Front, 2014). Verb tenses are also closely associated with certain stress patterns. For example, most present tense forms have penultimate stress (e.g., *juego* "I play"), and the future tense almost always carries final stress (e.g., *jugaré* 'I will play'). In this paper, we refer mainly to the visual word recognition of nouns and adjectives, of which 95% follow the unmarked pattern of final stress for words ending in a consonant and penultimate stress for words ending in a vowel (Hualde, 2014).

Empirical evidence

Evidence from Spanish suggests that both orthographic and phonological stress cues are used in visual word recognition. Gutiérrez-Palma and Palma-Reyes (2008), for example, found in a lexical decision task that words that had been primed by items with a different stress pattern (e.g., *teclá*/*tecla* 'key') were more difficult to classify than words with a stress-congruent prime (e.g., *técla*/*tecla*). This suggests that the accent mark serves as an orthographic cue to stress placement. The same authors also identified similar patterns among children in which participants committed fewer errors when naming words whose stress followed regular phonological stress patterns (as predicted by syllable structure) than those that did not (Gutiérrez-Palma & Palma-Reyes, 2004). Moreover, very recently, Domínguez and Cuetos (2018) discovered that the Spanish accent mark may, in fact, play an earlier role in lexical access than previously ascribed. Using masked priming, they found facilitation when the previous and the target words matched in stress (e.g., penultimate stress, as in *persa* 'Persian'/*rasgo* 'feature') compared to a non-matching pair (e.g., final and penultimate stress, as in *dormí* 'I slept'/*rasgo* 'feature'). In this experiment, the accent mark again clearly plays an important role as an indicator of stress placement when processing stress congruency.

Further evidence that stress cues are used when reading comes from languages other than Spanish. For example, in an early study on lexical stress in English, Kelly, Morris, and Verrekia (1998) found that disyllabic words whose spelling is consistent with expected stress patterns were distinguished more quickly and accurately in lexical decision tasks. Equivalent results also surfaced in a naming task. Similarly, Rastle and Colheart (2000), examining disyllables formed with prefixes, showed that words with irregular stress patterns elicited longer naming latencies, particularly for low-frequency words. When testing a dyslexic population, Ktori et al. (2015) observed that patients with surface dyslexia committed stress regularization errors when reading irregular words. In addition to these studies, other work in English has argued that lexical stress affects both early and late stages of lexical access when reading. For example, Ashby and Clifton (2005) examined eye movements during silent reading and found that assigning stress may be the final phase of lexical access, and lexical stress has the potential to have an effect even when phonological activation is not strictly necessary. Focusing on earlier stages, Arciuli and Cupples (2006) claimed that lexical stress might facilitate lexical processing when word endings (final syllables' rimes) cue the typical stress pattern for a particular grammatical category (e.g., trochaic for nouns and iambic for verbs). A similar interaction has been found in Italian for reading aloud pseudowords presented in a grammatical context; Spinelli et al. (2016) showed that the grammatical context in which a pseudoword appears may determine the selection of the stress neighbors (i.e., words sharing the pseudoword's rhyme and stress) used to assign stress to it. However, stress neighborhood only affects reading aloud; in lexical decision tasks, the relevant factor is the most frequent stress pattern (Colombo & Sulpizio, 2015). As a whole, these findings substantiate the view that lexical stress is a significant factor in lexical access in multiple languages, including English, Italian, and Spanish.

From another point of view, research on reading acquisition has shown that the awareness of lexical stress accounts for unique variance in reading and spelling tasks in children from 3rd to 6th grades (Defior, Gutiérrez-Palma, & Cano-Marín, 2012; Gutiérrez-Palma et al., 2016). These results have been interpreted as evidence that stress awareness may help readers learn how to use the accent mark, regardless of their phonological awareness. In addition to this hypothesis, it could be argued that stress awareness facilitates the acquisition of rich phonological representations, including lexical stress, which may be used in visual word recognition.

In sum, there are both theoretical and empirical reasons to consider the processing of lexical stress an essential part of lexical access. In the case of Spanish, the mismatch between phonological patterns and orthographic rules warrants an examination of the influence of the accent mark when reading. This may prove particularly informative in those cases in which the phonological and orthographic expectations differ. This comparison is the primary goal of the present paper. In particular, we expect that words without an accent mark will be more difficult to recognize when their lexical stress does not correspond to phonological expectations. This would be evidence that lexical stress exerts an influence on lexical access, and that the accent mark might be used to correct the stress mismatch in irregular words.

METHOD

Participants

Participants were 87 undergraduate students, aged 18 to 30. All of them had Spanish as their native language. Their participation was voluntary. All signed an informed consent form and were compensated with course credit.

Materials and Experimental Design

Critical stimuli consisted of 60 disyllabic Spanish words that were selected for comparisons between phonological regularity and the presence/absence of the orthographic accent mark. Phonologically regular words were those that followed generative rules for stress placement. For example, *tapiz* 'tapestry' ends in a consonant and carries final stress. Similarly, *grifo* 'faucet' ends in a vowel and is stressed penultimately. Words in the irregular category do not follow phonological expectations, such as *rubí* 'ruby', which ends in a vowel but has final stress, or *túnel* 'tunnel', ending in a consonant but with penultimate stress.

Stimuli were also selected for the presence or absence of a written accent mark. Given the orthographic conventions of written Spanish, it is possible to prepare stimuli sets in which both regular and irregular words appear both with and without accents. For example, both *túnel* 'tunnel' and *melón* 'melon' are written with accent marks, but while *túnel* does not follow phonological expectations, *melón* does. The accent mark in the latter is due to the exception in Spanish for words that end in *n.* Likewise, *mitin* 'meeting' and *tapiz* both lack accent marks, but only the latter follows traditional phonological rules.

This design allows for the comparison of four critical conditions, each containing 15 items as seen in Table 1.

[INCLUDE TABLE 1 ABOUT HERE]

Words were matched in several psycholinguistic indices, including number of letters, number of phonemes, lexical frequency, and positional frequency of the first syllable by type and token. These indices were obtained from Davis and Perea (2005). Moreover, we also considered other measures that might affect word recognition, such as contextual diversity (Adelman, Brown, & Quesada, 2006) and familiarity (Davis, Barbón, & Cuetos, 2013). Contextual diversity was obtained from the EsPal database (Duchon et al., 2013). As available databases do not offer a measure of familiarity for all words, we prepared four versions of a questionnaire that included our stimuli and filler words. A total of 128 participants responded using a scale from 1 to 7 to judge how often they encounter the words in their daily life. In order to estimate the convergent validity of our questionnaire, the scores obtained in it were correlated with the familiarity scores for the few words included in EsPal, which led us to a value of 0.67. Additionally, a divergent validity of -0.01 was estimated through the correlation with the scores of unrelated measures of EsPal such as Repeated letters. These indices (contextual diversity and familiarity) could not be matched between conditions, but they were included in the analyses as control variables. In the EsPal database, contextual diversity corresponded either to the count or to the percentages of different movies a word appears in; we analyzed the percentages.

[INCLUDE TABLE 2 ABOUT HERE]

In addition to the critical items, a list of 60 pseudowords was developed for presentation in a lexical decision task. These items were created to be as similar as possible to the critical stimuli, both in structure and in conditions. There were pseudowords with and without accent marks, presenting both regular (e.g., *larín*, *dagaz*) and irregular (e.g. *píber*, *detin*) stress patterns. As these stimuli served only as fillers and were not analyzed further, their high similarity to real words served the purpose of encouraging full lexical access during the lexical decision task. Real-word and pseudoword stimuli are included in Appendix I and Appendix II, respectively.

Procedure

Participants performed a lexical decision task. They were asked to decide whether the stimuli they saw on a computer screen were real words. Stimuli were presented using E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002), which also collected reaction time and accuracy data. Participants responded using a serial response box (Schneider et al., 2002), on which they pressed either the 1 or 5 key. The "yes" response corresponded to their dominant hand. Before starting the experimental block, participants completed 10 practice trials and were instructed to respond as quickly and accurately as possible.

Stimuli were presented in black letters and on a white background in 18-point Courier New font. Distance from the computer screen was approximately 90 cm, resulting in a word size with a 1.4 visual angle on average. In each trial, a warning signal "+" was displayed for 500 milliseconds, followed by the target stimulus, which appeared centered on the screen and remained for a maximum of 3 seconds. Participants received feedback only when a mistake was committed by means of an error display lasting 1 second. The inter-trial interval was 1 second. On average, the session lasted approximately 10 minutes.

Statistical design and data analysis

Statistical analyses were conducted using Linear Mixed-effects Models (Faraway, 2016), based on maximum likelihood methods that are now in common use in many areas of scientific research, including psycholinguistics (Baayen, Davidson, & Bates, 2008). Mixed-effects models have advantages over classical statistical strategies such as ANOVA from quasi-F ratios or multiple regression from aggregation and standard ordinary least squares (for a review see Baayen, 2008).

In particular, the optimal approach for analysing the data of the present investigation involved specifying a maximal random effects structure for reaction time, as the dependent variable, including random intercepts by-subjects and by-items, as well as random slopes by-subjects (see Barr et al., 2013). This incorporates fixed effects of regularity, accent and the interaction, as well as random intercepts by items, as well as random slopes and random intercepts by subjects, along with covariances between random slopes and intercepts.

In the case of Accuracy as a dependent variable, the maximal structure model could not be estimated (with convergence problems), so that it was simplified in successive iterations until achieving parametric stability. In particular, the optimal model for accounting for the data of accuracy was of the type Random intercepts for subject and target. Details on the justification of these models can be found in the supplementary material (see sections 1, and 3). Mixed-Models will allow us to deal with continuous (reaction time) and categorical (accuracy proportions) responses within a common framework (Generalized Linear Mixed Models).

Both latency and accuracy data were submitted to analyses. Since the exploratory analysis confirmed the strongly asymmetric distribution of the reaction times (RT), which is common in lexical decision tasks, a logarithmic transformation was used, and data were cleaned removing 2 standard deviations above and below the mean for each participant in each condition, resulting in a loss of 6.83% of the data. In the latency analyses, reaction times for pseudowords and errors were discarded. In order to provide robustness to statistical conclusions, all decisions were convergently confirmed through the application of Mixed-Effect analysis to different scenarios of omission of data (ranking from null to maximum, where all outliers were removed, see section 2 of Supplementary material for details). Furthermore, in all the analyses the robust variants Satterthwaite-Kenward-Roger's conservative adjustment strategy of degrees of freedom was chosen (see Kuznetsova, Brockhoff, & Christensen, 2017). Furthermore, the results were replicated using Generalized Linear Mixed-Effects Models (GLMM) instead of Linear Mixed-Effects Models (LMM). In this context, the optimal model for adjusting the data of RT was of the type Random intercepts for subject and target, as in the case of accuracy analysis. The GLMM approach has the advantage that it allows the original Reaction Times to be analyzed thanks to the estimation of their (asymmetric) probability distribution in the Model describing the plausible processes underlying the observed data (Lo & Andrews, 2015). Since our predictions rest on an interaction rather than on the effect of the main effects of the variables, the need for reliable data (i.e. raw RTs) has priority over the need for data for the maximal random structure. Consequently, we favor GLMM over LMM in the analysis of RT, despite the fact that the former tends to suffer more stability problems in the estimation of parameters (see section 3 of Supplementary material for details). All Mixed-Effects Model analyses were performed using GNU R software, version 4.0.2 (R Core Team, 2020) with lme4 (Bates Mächler, Bolker, & Walker, 2015), lmerTest (Kuznetsova, Brockhoff, & Christensen, 2017), MuMIn (Bartoń, 2020), r2glmm (Jaeger, 2017), ggplot2 (Wickham, 2016), emmeans (Lenth, 2020), data.table (Dowle & Srinivasan, 2020), foreach (Microsoft & Weston, 2020), doParallel (Microsoft & Weston, 2020), lattice (Sarkar, 2008), car (Fox & Weisberg, 2019), ggpubr (Kassambara, 2020), moments (Komsta & Novomestky, 2015), and rcompanion (Mangiafico, 2020) libraries. We use orthogonal contrasts before model estimation in order to properly perform the analysis of the interaction versus the main effects. In all cases, statistical significance was set at alpha .05, and the error was calculated from Standard Error of Mean (SEM). We have chosen to include the R^2 associated with each effect in the Mixed Model, as an alternative to estimating the effect size, thus avoiding errors of statistical validity (Edwards et al., 2008; Jaeger et al., 2017; Nakagawa, Johnson, & Schielzeth, 2017; Piepho, 2019).

RESULTS

The primary factors for comparison were phonological regularity (regular vs. irregular words) and accent mark (present vs. absent in the word). Means for reaction times and correct responses in each condition are listed in Table 3.

[INSERT TABLE 3 ABOUT HERE]

For reaction times, analyzed with the R g*lmer function for GLMM approach,* we found a significant effect for accent mark (Estimate = 24.810, t = 3.685, R^2 = 0.014, p = .0002) but not for regularity (Estimate = 14.538, t = 1.828, R^2 = 0.003, p = .068). More importantly, there was also a significant interaction of accent mark and regularity among the data (Estimate = 30.213, t = 4.392, R^2 = 0.012, p < .001). In fact, partial R^2 value associated with the interaction (0.012) approached R^2 associated with the mixed model (0.028) of which it is part. Subsequent simple effects analysis was run in order to detail this interaction. These analyses identified no differences between accented and unaccented regular words (Estimate = -4.550, t = -0.425, R^2 < 0.001, p = .671). However, there was a significant effect of accent for irregular words (Estimate = 53.984, t = 3.754, R^2 = 0.055, p < .001), in which accented irregulars were processed significantly more quickly (see Table 2: 647.10 vs 736.78 ms). All these results were confirmed through the LMM Mixed-Models approach analyzed with the R *lmer function*, the most outstanding thing is that the interaction was again significant [Estimate = 0.030, t (60.311)= 2.314, R^2 = 0.019, p = .024].

As indicated in the materials section, given the possibility that factors such as familiarity or contextual diversity could have been confused with our manipulations, an analysis based on mixed models was performed, adding such variables to the basic model. The most outstanding result is that the focal interaction between regularity and accent mark is still significant in the scenario that incorporates the familiarity as fixed term (Estimate = 17.376, t = 3.124, R^2 = 0.004, p = .002), as well as with the added contextual diversity fixed term (Estimate = 17.797, t = 2.203, R^2 = 0.003, p = .028). For further details of analysis, see section 2 of the supplementary material.

For accuracy data (correct vs. miss responses to real words), with the R glmer function for binomial model, the results were equivalent to the latency analysis, with a significant interaction between regularity and accent mark [Estimate = 0.476, t = 2.221, R2 = 0.005, p = .026]. In this case, the main effects were not significant, neither for regularity

[Estimate = 0.224, t = 1.046, R^2 = 0.001, p = .296], nor for accent mark [Estimate = 0.248, t = 1.155, R^2 = 0.002, p = .248]. Partial R^2 value associated with the interaction (0.005) approached R^2 associated with the mixed model (0.008) of which it is part. Regarding the simple effects, once again there was no significant difference between accented and unaccented regular words [Estimate = -0.209, t = -0.637, R^2 = 0.001, p = .524]. Among irregular words, by contrast, those carrying accent marks were classified significantly more accurately [Estimate = 0.724, t = 2.590, R^2 = 0.015, p = .01].

As in the reaction time analysis, an analysis based on mixed models was also performed, adding familiarity and contextual diversity as fixed terms to the GLMM model of accuracy. Again, in this case the focal interaction between regularity and accent mark is still significant in the familiarity control scenario (Estimate = 0.374, t = 2.415, R^2 = 0.003, p = .016), but not for contextual diversity control, although it was close to statistical significance (Estimate = 0.346, t = 1.762, R^2 = 0.001, p = .078). In order to clarify this result, we proceeded to divide the data based on the median of contextual diversity (low vs. high). We then find that the focal interaction is maintained when contextual diversity is low (Estimate = 0.598, t = 2.191, R^2 = 0.013, p = .028), but not when contextual diversity is high (Estimate = 0.275, t = 1.264, R^2 = 0.001, p = .206). For further details of analysis, see section 2 of the supplementary material.

The data that support the findings of this study, R code, and explanations of statistical analysis are available in the supplementary material, which can be found online at http://www4.ujaen.es/~ngpalma/jrir2020/supplementary.zip

DISCUSSION

The primary goal of this study was to examine the role of lexical stress when reading words in Spanish. Additionally, this experiment explored the impact of the written accent mark when reading words that do or do not follow phonological expectations for stress assignment. The results of the present experiment reveal a significant interaction between phonological (stress) regularity and accent mark. This interaction suggests that when words are phonologically irregular, additional cues to stress can be useful. This finding supports previous evidence that lexical stress is relevant for visual word recognition, whether in Spanish (Gutiérrez-Palma & Palma-Reyes, 2008) or in English (Ashby & Clifton, 2005; Kelly et al., 1998). Moreover, the present results suggest that stress assignment is more difficult when naming words with irregular stress patterns (Rastle & Coltheart, 2000; Ktori et al., 2015), although this last prediction remains to be confirmed in Spanish.

Interestingly, unlike in English, which does not mark stress in the orthography, our results are able to speak to the interaction of orthography and phonology during silent reading. Specifically, in the current experiment, the presence or absence of the accent mark affects the speed and accuracy with which native speakers are able to access words in the lexicon. This is indicated by a significant interaction between the accent mark and regularity conditions. While there is no significant effect of the accent mark on regular words, its presence seems to benefit irregular words, i.e., when word stress is unexpected according to phonological rules. In this case, the accent mark appears to diminish the processing load associated with an irregular stress pattern, in a sense correcting the problem, and brings the accented irregular words in line with their regular counterparts. In this view, the accent mark facilitates the processing of lexical stress in irregular words.

Taken together, the present findings promote a conceptualization of phonological processing that includes stress as an important factor. In order to account for these data, models of visual word recognition need to consider lexical stress. This possibility is congruent with Frost's (1998) proposal that the full phonological representation is prepared during lexical access, and this should include lexical stress (see also Ashby and Clifton, 2005). It is also consistent with Stone and Van Orden's (1994) model of mutual feedback from the phonological to the visual layer. Following this model, it could be argued that, if stress rules are implicit in the connections between visual and phonological units, words with irregular stress would need more cycles of mutual feedback to be recognized. The accent mark would reduce the number of cycles, as it explicitly indicates the word's primary stress.

The present findings are also congruent with previous studies that affirm an essential role for the syllable in processing words in Spanish (Álvarez et al., 2004; Carreiras et al., 1993), and lexical stress, as a form of syllable prominence, is integral to this process. In other words, the syllable and stress are intimately linked. The phonological structure of the syllable has been shown to modulate lexical stress assignment, and this in turn has a clear influence on visual word recognition.

From a modeling perspective, the role of stress can be easily implemented in cognitive models of reading and lexical access. One model that includes specific stress nodes as part of sublexical processing is the CDP++ (Perry, Ziegler, & Zorzi, 2010). However, as it is based primarily on English, the place of the accent mark in the model is not clear. It could possibly be as easy as incorporating the mark into the letter or grapheme level of processing. However, we leave the exploration of these details for future work.

The present findings strengthen other research in Spanish that has demonstrated that lexical stress is consequential for reading among both adults (Domínguez & Cuetos, 2018; Gutiérrez-Palma & Palma-Reyes, 2008) and children (Gutiérrez-Palma & Palma-Reyes, 2004). From a linguistics perspective, the results of the current study also corroborate theoretical and experimental work in the linguistics literature that formulates stress assignment rules based on sensitivity to syllable weight (e.g., Harris, 1983; Núñez Cedeño, 1986; Shelton et al., 2012; Fuchs, 2018).

Furthermore, these results can be linked to recent research in Spanish that compares phonological vs. stress awareness as predictors in reading and spelling tasks, and that shows that stress awareness is a unique significant predictor in both reading (Defior et al., 2012; Gutiérrez-Palma et al., 2016) and spelling (Defior et al., 2012). It could be argued that stress awareness facilitates the learning of the accent mark, but it is also possible that readers with higher stress awareness skills have richer phonological representations, including lexical stress. If the latter is the case, and lexical stress is used in visual word recognition, then these readers should recognize written words better. This is a hypothesis that remains to be tested, and it represents an interesting link between psycholinguistic and educational research.

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Appendix I: *Real words* (60)

With an accent mark		Without an accent mark	
Regular	Irregular	Regular	Irregular
belén	bambú	ancla	atlas
betún	cáliz	cebra	bilis
bidón	chándal	chicle	cactus
botín	cómic	coral	campus
buzón	corsé	feroz	canon
compás	cráter	fugaz	cutis
diván	lápiz	golfo	dermis
filón	menú	grifo	mantis
galán	móvil	lepra	mitin
halcón	puré	licor	polen
jabón	rubí	matiz	pubis
limón	símil	nasal	semen
melón	sofá	sidra	tenis
pezón	tabú	tapiz	tifus
vagón	túnel	tigre	venus

Note. All read-word stimuli were nouns or adjectives, 31 with penultimate stress, 29 with final stress.

Appendix II: *Pseudowords* (60)

With an accent mark		Without an accent mark	
Regular	Irregular	Regular	Irregular
bodén	cániz	bora	anvas
cindón	cufá	cafar	boben
derón	cúmer	conar	detin
dortén	endá	cone	iclas
envás	lápar	dagaz	lofus
farrín	míndor	fatre	lusen
gosín	necá	glaca	menzas
larín	pabé	guco	mosan
pazún	petú	junil	naron
pubón	píber	mafa	nolas
ratén	rífur	potiz	pildun
sirtán	ríper	tasal	punin
tilsón	tánar	tigor	rasten
tivén	tóliz	tona	sazas
toján	zurú	zanar	sonten

Table 1. Experimental conditions

Regularity	Accent mark	
	Yes	No
Irregular	rubí, túnel	mitin
Regular	melón	tapiz, grifo

Table 2. Psycholinguistic indices in each condition, mean and (range)

	With an accent mark		Without an accent mark	
	Regular	Irregular	Regular	Irregular
Number of letters	5.13 (5.00-6.00)	4.87 (4.00-7.00)	5.07 (5.00-6.00)	5.27 (5.00-6.00)
Number of phonemes	5.07 (5.00-6.00)	4.80 (4.00-6.00)	5.00 (5.00-5.00)	5.27 (5.00-6.00)
Lexical Frequency	5.43 (0.89-11.25)	5.19 (0.71-17.68)	5.94 (0.89-13.39)	4.11 (0.18-14.46)
1st syllable type frequency	34.60 (6.00-76.00)	32.93 (1.00-90.00)	31.27 (3.00-65.00)	38.27 (1.00-117.00)
1st syllable token frequency	975.18 (67.50-4250.71)	1177.86 (2.68-5534.46)	900.12 (81.07-5534.46)	1172.56 (1.61-5856.96)
Contextual diversity	1.66 (0.27-4.48)	2.74 (0.1-9.99)	1.75 (0.38-4.82)	1.01 (0.09-4.12)
Familiarity	3.37 (1.53-6.02)	3.88 (1.73-6.79)	3.26 (1.73-5.7)	2.92 (1.23-4.52)

Table 3. Means, Standard Errors for Reaction Time (ms), and Accuracy (proportions) as a function of a 2 (Phonological Regularity) x 2(Accent Mark) design

	Accent mark					
	Yes			No		
Regularity	*M*	*SEM*	*Accuracy*	*M*	*SEM*	*Accuracy*
Irregular	678.25	6.28	0.969	770.03	8.13	0.865
Regular	691.60	7.09	0.911	707.77	6.67	0.966

Note. *M* and *SEM* represent mean and standard error of mean, respectively. Accuracy has been calculated as the proportion of correct responses.