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Article

Syllabic length effect in Spanish: evidence from adult readers

Efecto de longitud silábica en español: evidencia en lectores adultos

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Abstract

Dual route theories of reading assume the existence of two paths: the lexical route, which operates with complete words and allows direct access from spelling to semantics and speech; and, the sublexic route, which operates in an analytical way converting, by correspondence rules, graphemes into phonemes. Numerous research reported that the length effect is an important aspect for the study of the processes that underlie word recognition. The objective of the present study is to examine the length effect in reaction times of participants without alterations of reading. A group of 84 university students were evaluated with a task of word and nonword reading aloud. We carried out analysis per subject (F1) and per stimulus (F2) that showed statistically significant length effect and, in addition, a significant interaction with the type of stimulus was observed. These findings constitute convergent evidence with the assumption of the existence of two reading mechanisms in transparent spelling languages such as Spanish.

Resumen

Los modelos cognitivos de doble ruta de lectura apoyan la existencia de dos vías: la léxica que opera con palabras completas y permite el acceso directo desde la ortografía a la semántica y a la pronunciación; y la subléxica que funciona de manera analítica convirtiendo, mediante reglas de correspondencia, cada uno de los grafemas en el fonema correspondiente. Numerosas investigaciones concluyen que el efecto de longitud constituye un índice de gran utilidad para el estudio de los mecanismos que subyacen a la lectura. El objetivo del presente trabajo es estudiar el efecto de longitud a partir del análisis de los tiempos de reacción. Para esto, se evaluaron 84 estudiantes universitarios con una tarea de lectura en voz alta de palabras y no-palabras de distinta longitud. Se llevó a cabo un análisis por sujeto (F_1) y un análisis por estímulo (F_2) que arrojaron efecto de longitud estadísticamente significativo y, además, se observó una interacción significativa con el tipo de estímulo. Estos hallazgos constituyen evidencias convergentes con la asunción de la existencia de dos procedimientos de lectura en lenguas de ortografía transparente como el español.

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Introduction

Studies of the lexical and sublexical effects observed during the reading aloud of isolated words have led to the recognition of at least two processing mechanisms in much of the research (Coltheart, Rastle, Perry, Langdon and Ziegler, 2001; Coslett, 2003; Ellis and Young, 1988; Protopapas et al., 2016; Schurz et al., 2010). In the first of these mechanisms (the lexical route), orthographic representations are connected with semantic and phonological representations, while the second (the sublexical route) acts through the application of rules that convert graphemes into phonemes. How much each of these paths contributes to the reading process depends on various factors. These include the level of "transparency" or "opacity" of the language in question, that is, whether grapheme-phoneme correspondence is high or low (Kwok, Cuetos, Avdyli, and Ellis, 2017). Another factor is the stimulus type: whether these are existing words in the language or sequences of letters that are pronounceable but are not part of the lexicon (nonwords) such as "beráfolo," in Spanish, or "beraph," in English.

As a result, to study the functioning and interaction of the two routes during reading aloud tasks, different variables are manipulated in the process of preparing and selecting stimuli. The length effect is one of the most useful indices for studying the mechanisms involved in reading (Barton, Hanif, Eklinder Björnström, and Hills, 2014) among both participants without reading disorders and those who present acquired reading deficits as a result of a brain lesion (Harris, Olson, and Humphreys, 2013; Reinhart, Schaadt, Adams, Leonhardt, and Kerkhoff, 2013; Sheldon, Abegg, Sekunova, and Barton, 2012; Woodhead et al., 2013). Broadly speaking, the length effect is the correlation reported in psycholinguistic and neurolinguistic studies between the number of letters in stimuli and the visual processing of these. In other words, the longer the stimulus, the harder it is to process. One of the first studies to have reported the length effect in participants without reading disorders was McGinnies, Comer, and Lacey (1952).

Measuring reaction times is one of the most frequently used techniques in recognition tasks (Ferrand et al., 2010; New, Ferrand, Pallier, and Brysbaert, 2006) and reading aloud tasks (Balota, Cortese, Sergent-Marshall, Spieler and Yap, 2004; Weekes, 1997; Ziegler, Perry, Jacobs and Braun, 2001; Zoccolotti et al., 2005). In both these types of tasks, the reaction times for stimuli containing more letters are longer than those for shorter stimuli because the former are harder to process. Other studies have discussed and verified whether similar results are obtained regarding the length effect when using a recognition task such as visual lexical decision and in reading aloud. Balota et al. (2004) contrasted the findings obtained for the two tasks and observed a more marked length effect in reading aloud than in lexical decision tasks.

For many years, psycholinguistic research focused on monosyllabic stimuli, and huge progress has been made in that field. However, the number of letters in a word is not the only criterion used to study the length effect. More recent studies have taken the syllable as the unit of measurement (Bijeljac-Babic, Millogo, Farioli, and Grainger, 2004; Chetail, 2014; Ferrand, 2000; Muncer and Knight, 2012; Yap and Balota, 2009, among others). In fact, at present, the syllable is considered to be a functional unit in the processing of written words not just in Spanish (Carreiras, Álvarez, and de Vega, 1993), but also in other languages (Chetail and Mathey, 2009; Conrad, Stenneken, and Jacobs, 2006).

According to dual-route reading models, the length effect that is observed when measuring reaction times for reading aloud tasks reflects the serial processing of the sublexical route. The fact that length is observed to have a strong effect on the reading of nonwords (Ferrand, 2000; Ferrand and New, 2003) is evidence that supports this assumption. On the other hand, smaller length effects have been observed in the reading aloud of words than of nonwords. These findings were explained as being the result of the interaction between the parallel processing of the lexical path and the serial processing of the sublexical route in word reading (Perry, Ziegler, and Zorzi, 2007).

The length effect has also been studied through the contrast between different languages. For example, one study reported that reaction times on a reading aloud task using stimuli of different lengths were longer in German than in English (Ziegler et al., 2001). These differences were explained by the sublexical route contributing more in German due to the high correspondence between graphemes and phonemes for reading in this language, considered to be "transparent" (Perry and Ziegler, 2002).

Evidence from studying the length effect would make an extremely interesting contribution to the debate over how applicable the dual-route reading model is to languages like Spanish, which has a "transparent" orthographic system (Ardila and Cuetos, 2016). If graphemes and phonemes are converted via a single mechanism during the reading of all stimulus types, we should not observe significant differences in the reading of words and nonwords, nor should the length variable interact with lexical variables such as stimulus type, frequency, imaginability, and the number of orthographic neighbors, among other factors. In Italian, evidence supporting the contribution of the lexical path has been provided by research on reading words aloud in which lexical variables have been observed to have different effects in children (De Luca, Barca, Burani and Zoccolotti, 2008; Spinelli et al., 2005; Zoccolotti et al., 2005) and adults (Barca, Burani, and Arduino, 2002; Bates, Burani, D'Amico, and Barca, 2001).

In Spanish, Cuetos and Barbón (2006) studied reaction times for reading words aloud among a group of university students. One of their objectives was to study which variable was the greatest determinant of reading speed. The results indicate that the variable that correlated most strongly with reading times was length, measured both in terms of the number of letters and number of syllables, followed by acquisition age and frequency. These findings were replicated by Davies, Rodríguez-Ferreiro, Suárez, and Cuetos (2013) in a study conducted using an extensive list of words (over 2000 stimuli). Although both studies provide evidence as to the relevance of the length effect in word reading, neither of them addresses this variable in reading nonwords or in comparisons of the two types of stimulus.

Consequently, the objective of this study was to analyze the effect of syllable length on the reading aloud of words and nonwords among Spanish-speaking adult readers. The hypotheses were, first, that reaction times would be significantly longer for nonwords than for words. Second, that reaction times would be shorter for shorter stimuli than for longer ones in the case of both words and nonwords. Finally, a significant interaction between length and stimulus type was expected.

Method

Participants

84 students (63 women and 21 men) in the first year of the psychology undergraduate program at the University of Buenos Aires participated in the study. All were native Spanish speakers and reported having normal vision or compensating for this by using eyeglasses. The average age was 23.4 years (SD=7.4), with a range of 18 to 58 years. The average schooling was 14.8 years (SD=1.8).

Stimuli

The reading aloud task used was from the Batería Transpruebas (China and Ferreres, 2017), which contains 45 words and 45 nonwords. The words are all concrete drawable nouns containing two syllables (15 words), three syllables (15 words), and four syllables (15 words). The frequency of the stimuli from each of the three groups is controlled (each contains six high-frequency words and nine low-frequency words). Based on the *Diccionario de frecuencias de las unidades lingüísticas del castellano* (Alameda and Cuetos, 1995), the Batería Transpruebas considers words that occur at a rate is higher than 95/2,000,000 to be high-frequency and those occurring at a rate lower than 15/2,000,000 to be infrequent.

The nonwords were constructed by mixing words syllables within each length group, respecting the position of the syllable and whether it is stressed or unstressed in the base word. Length, phoneme frequency, and syllable frequency were thus kept balanced between words and nonwords.

Procedure

The test was given to participants individually in a quiet room during a session that lasted approximately 10 minutes. The stimuli were presented one at a time on a laptop screen in an Arial 30-point font. Participants were asked to read the stimuli allowed as quickly and accurately as possible.

Each stimulus was preceded by a fixation point that remained on the screen for 1000 milliseconds, after which the word or nonword appeared and remained on the screen until the participant gave their answer. This was followed by an interstimulus interval of 500 milliseconds. Reaction times were recorded in milliseconds using SuperLab software (Beringer, 1995). The researcher recorded all reading errors on a spreadsheet and a digital recorder was also used to confirm this manual record.

Data analysis

Before the data was analyzed to test the hypothesis, the reaction times were analyzed to exclude any outliers. To this end, 540 values (7.1% of the total) were eliminated because they were either wrong answers or due to technical failures. Secondly, the percentiles for the remaining reaction times were grouped according to stimulus type and those equal to or higher than the 98th percentile were discarded, proceeding separately for each type of stimulus (words and nonwords). As a result, 210 values (3%) corresponding to reaction times that were very long or very short in comparison with the overall performance were excluded from the analysis in each case (< 436 ms and > 1361 ms for words; < 525 ms and > 1709 ms for nonwords).

To test the hypothesis, first, descriptive statistics were calculated for the reaction times for each stimulus type. To analyze the effects of lexicality and length, two analyses were carried out focusing on the subjects (F_1) and the items (F_2), respectively. In the F1 analysis, the mean reaction times were calculated for each participant for each length group among both words and nonwords. Using this data, an ANOVA was carried out for repeated measurements using stimulus type and length as intrasubject factors and the corresponding pairwise comparison to analyze the specific differences between each of the variables. Second, for the F_2 analysis, the means of the reaction times were calculated for each of the items and a factorial ANOVA of 2 x 3 (stimulus type by length) was carried out, as were the corresponding post hoc analyses using Tukey's HSD. All these analyses were implemented using SPSS 23 statistical software.

Results

Table 1 shows the descriptive statistical data for the reaction times for words and nonwords for which higher average reaction times were observed depending on stimulus length.

The overall ANOVA result showed significant statistical differences for reaction times ($F_2(5)$ = 81 711, $p < .001$, $\eta_p^2 = .829$). In both the analyses focusing on the subjects (F_1) and the items (F_2), stimulus type was observed to have a major effect ($F_1(1)$ = 224 960, $p < .001$, $\eta_p^2 = .730$; $F_2(1)$ = 266 351, $p < .001$, $\eta_p^2 = .760$) in that reaction times for words were shorter (*M* = 733.1, *DE* = 38.7) than those for nonwords (*M* = 891.4, *DE* = 96.9). The effect size of the influence of this variable was large for both analyses (F_1 and F_2).

As table 1 shows, reaction times for stimuli with fewer syllables were shorter than for those with more. Length was observed to have a principal effect ($F_1(2)$ = 159 823, $p < .001$, $\eta_p^2 = .658$; $F_2(2)$ = 49 259, $p < .001$, $\eta_p^2 = .540$) and the analysis of effect size showed that this had a significant influence on variance for both the F_1 and F_2 analyses. The *post hoc* analysis and the pairwise comparisons revealed that the length effect was present in the F_1 analysis (difference of averages $_{\text{2syll vs 3syll}}$ = -57 301, $p < .001$; $_{\text{3syll vs 4syll}}$ = -64 806, $p < .001$; $_{\text{2syll vs 4syll}}$ = -122 107, $p < .001$) and in the F_2 analysis (difference of averages $_{\text{2syll vs 3syll}}$ = -54 138, $p < .001$; $_{\text{3syll vs 4syll}}$ = -63 655, $p < .001$; $_{\text{2syll vs 4syll}}$ = -117 792, $p < .001$).

Finally, an interaction effect was recorded between stimulus type and length for both analyses ($F_1(2)$ = 133 479, $p < .001$, $\eta_p^2 = .617$; $F_2(2)$ = 21 844, $p < .001$, $\eta_p^2 = .342$). In both cases, the interaction effect showed the same pattern: the syllable number variable was more influential for nonwords than for words. Figure 1 contains a comparison of the two stimuli types and shows the interaction pattern between these and length.

Table 1

Descriptive statistics for reaction times in milliseconds for two-, three-, and four-syllable words and nonwords

Stimulus type	Length	Mean (SD)
Words	Two syllables	716.9 (25.6)
	Three syllables	725.9 (33.1)
	Four syllables	756.5 (45)
	Total	733.1 (38.7)
Nonwords	Two syllables	793 (33.6)
	Three syllables	892.3 (51.2)
	Four syllables	989 (72)
	Total	891.4 (97)
Total	Two syllables	754.9 (48.7)
	Three syllables	809.1 (94.6)
	Four syllables	872.7 (132.1)
	Total	812.3 (108.2)

SD=standard deviation

The stimuli for which reaction times were longest were three low-frequency, three-syllable words: “caparazón” [shell] (M=829.9), “pandereta” [tambourine] (M=813.1), and “regadera” [watering can] (M=812.6). The three nonwords that prompted the longest reaction times were “teparrita” (M=1142), “pogamizón” (M=1082.7), and “cidepora” (M=1077.3). Conversely, the stimuli that triggered the shortest reaction times were “foca” [seal] (M=688.2), “pala” [shovel] (M=686.1), and “botella” [bottle] (M=685.6), in the case of words, and “pinca” (M=753.8), “brato” (M=752.3), and “perzo” (M=743.9), for the nonwords.

Discussion

In this study, we set out to analyze the effect of syllable length on the reaction times for reading aloud words and nonwords among a sample of Spanish-speaking participants. We found this effect to be present in both the subject analysis (F_1) and the stimulus analysis (F_2): shorter

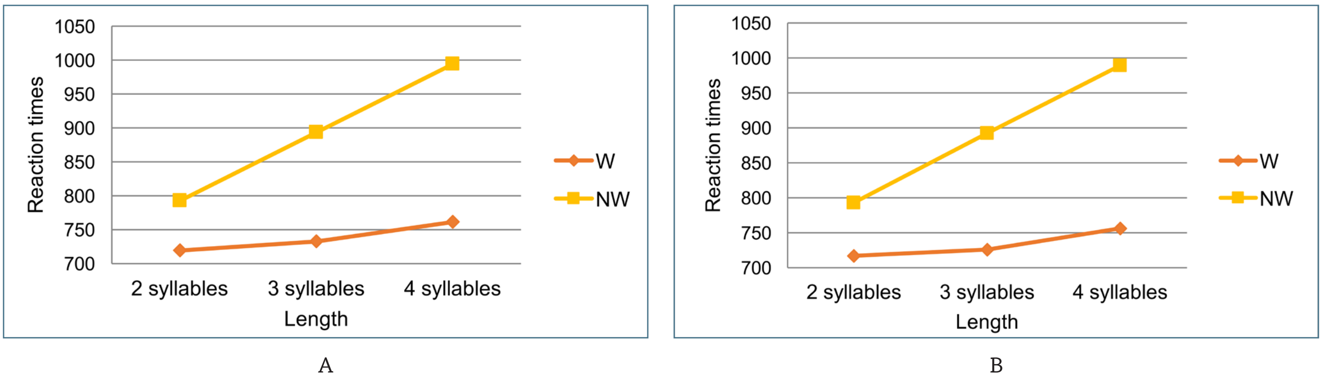

Figure 1. Graphs of interaction profiles between stimulus types (W: words; NW: nonwords) and of length on reaction times (ms) for the F_1 analysis (A) and the F_2 analysis (B).

stimuli were read more quickly than longer ones. Furthermore, our results found a significant interaction between length and stimulus type. In other words, the number of syllables turned out to be a more influential variable when the stimulus is a nonword than when it is a word. We also observed significant differences between the reading of words and nonwords.

In the context of the debate over whether the dual-route reading model applies to languages with "transparent" orthography like Spanish, the findings reported in this study provide evidence that supports the existence of lexical effects in reading in Spanish. The results showed that reaction times for the reading of nonwords were significantly longer than the reaction times for words, which is known as the "lexical advantage." This result is incompatible with the hypothesis of a single reading path, since if the Spanish words and nonwords were read using the same mechanism, a statistically significant difference such as the one our data showed would not be present. In contrast, a lexical advantage in reaction times is compatible with the dual-route model, in that the reading of words in Spanish benefits from the fact that, in addition to the mechanism for converting graphemes into phonemes, they can also be pronounced by employing the association between previously stored orthographic, semantic, and phonological representations—in other words, through the mechanisms of the lexical path. In contrast, nonwords can only be pronounced by the slower, step-by-step mechanism of the grapheme-phoneme conversion path. These results are in line with the findings of earlier studies of reading aloud tasks in Spanish (Cuetos and Domínguez, 2002; Cuetos and Barbón, 2006; Difalcis, Ferreres, Osiadacz, and Abusamra, 2018).

Likewise, the differences observed for stimuli of different lengths are significant evidence for psycholinguistic studies of reading in Spanish. Two earlier studies that analyzed reaction times for a reading aloud task (Cuetos and Barbón, 2006; Davies, Barbón, and Cuetos, 2013) only studied the effect of length on the reading of words. Our results replicate what these studies observed regarding the reading of words while also providing evidence of the length effect on the reading of nonwords, which has already been observed in other languages such as English (Lavidor, Ellis, Shillcock, and Bland, 2001; Weekes, 1997), French (Chetail, 2014; Ferrand, 2000; Ferrand and New, 2003), and German (Stenneken, Conrad, and Jacobs, 2007).

Third, we found a significant interaction between length and stimulus type. The syllable number variable had a greater influence on the reaction times for nonwords than for words.

These results are compatible with the assumption that there is more than one reading mechanism in Spanish: the greater the length of the nonwords, the longer the reaction times, due to the serial processing aspect of the sublexical route. On the other hand, although reaction times increased the more syllables the stimuli included, this increase is lower than in the case for nonwords. This difference in reactions by stimulus type can be explained through the use of the lexical route: longitudinal studies show that reading strategies in Spanish change over the course of the process of learning to read (Acha and Perea, 2008; Cuetos and Suárez Coalla, 2009; Jiménez and Guzmán, 2003; Sanabria Díaz et al., 2009). In the early stages of this process, people's reading strategies depend fundamentally on the sublexical route to read both words and nonwords. In contrast, experienced readers use global reading strategies to read words—that is, they present a well-developed lexical route (Ardila and Cuetos, 2016).

Two factors constitute limitations to this study. On the one hand, although all the participants were first-year university students, the sample age range varies considerably. It would be interesting to address whether age, in addition to schooling, is a relevant variable in adult populations with similar education levels. Furthermore, we have not compared the results of the reading aloud task and the visual lexical decision task for the stimuli used here, which would be interesting to address in future research. In a study carried out in Spanish which analyzed different psycholinguistic variables in a visual lexical decision task, no significant overall length effect was observed (González Nosti, Barbón, Rodríguez Ferreiro, and Cuetos, 2014). The authors found that the number of syllables was influential in stimuli between seven and ten letters long but was not in those between three and six letters. This finding led the researchers to argue that Spanish-speaking readers only use the global processing mechanism when the stimulus is a short word. In Spanish, most words are polysyllabic, and the average word length is eight letters. This makes it extremely important to replicate the findings reported in this study using a recognition task like the visual lexical decision task to provide evidence that would allow the lexical and sublexical mechanisms involved in reading in Spanish to be studied in greater depth.

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