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On the role of syllabic neighbourhood density in the syllable structure effect in European Portuguese

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Abstract

Previous lexical decision masked priming studies have shown that the advantage of syllable-congruent primes over syllable-incongruent primes is observed for CV (e.g., JU.ROS [interests]), but not for CVC first-syllable words (e.g., TUR.BO [turbo]), giving rise to the so-called *syllable structure effect* (e.g., ju.ral-JU.ROS < jur.ga-JU.ROS; tur.ta-TU R.BO = tu.res-TUR.BO). This effect is puzzling since it is not accounted for either by the distributional frequencies of CV and CVC syllables in European Portuguese (EP) or by syllable complexity. Here we examine whether the number of words of the same syllabic length sharing the same (first) syllable in the same (first) position, a measure taken as an index of syllabic neighbourhood density, may account for the syllable structure effect. To that purpose, 36 EP skilled readers performed a lexical decision masked priming task in which 48 CV and 48 CVC words matched in the number of syllabic neighbours, amongst other variables, were preceded by syllable-congruent (e.g., ju.ral-JU.ROS and tur.ta-TURBO), syllable-incongruent (e.g., jur-ga-JU.ROS and tu.res-TUR.BO), and unrelated primes (e.g., pu.cas- JU.ROS and binva-TURBO). Syllable priming effects were still observed only for CV words, even though CVC words with a CV phonological structure (e.g., PEN.TE[comb] - /pˈẽtɨ/) tended to behave similarly to CV words, suggesting that EP syllable effects may be driven by phonological factors.

Keywords: Syllable effects; Syllable structure effect; Syllabic neighbourhood; Masked priming; Visual word recognition

1. INTRODUCTION

The role of the syllable as a sublexical unit in visual word recognition has been well established in several languages such as Spanish (e.g., Álvarez et al. 1998, 2000, 2001, 2004; Carreiras et al., 1993; Carreiras & Perea, 2002; Conrad et al., 2008; Perea & Carreiras, 1998), French (e.g., Chetail & Mathey, 2009; Conrad et al., 2007; Mathey et al., 2013; Mathey & Zagar, 2002), German (e.g., Conrad & Jacobs, 2004; Conrad et al., 2006; Hutzler et al., 2004; Stenneken et al., 2007), Korean (e.g., Kwon et al., 2011), and European Portuguese (EP; e.g., Campos et al., 2018, 2020). Nonetheless, most lexical decision masked priming studies where the syllable congruency between primes and targets was manipulated, only observed reliable syllable effects for words with a CV first-syllable structure as JU.ROS [inter-

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ests] - note that C stands for consonant and V for vowel; and not for words with a CVC first-syllable structure as TUR.BO [turbo]) casting serious doubts on the role of the syllable as a relevant sublexical unit for lexical access at early stages of visual word recognition.

This syllable structure effect was first observed in the pioneering study of Álvarez et al. (2004), where CV and CVC words were presented to participants preceded by brief 64 ms primes that could be syllable congruent, sharing the first three letters and the same syllable boundary with the target (e.g., ju.nas-JU.NIO [june] - dots are only used here to ease comprehension) or syllable incongruent, sharing the same three letters with the target but a different syllable boundary (e.g., jun.tu-JUN.IO). Note that, since primes could share, or not, the syllable boundary with the targets, Álvarez et al. (2004) opted to include words with a CVC first syllable and not only words with a CV first syllable following the same manipulation (i.e., syllable-congruent - e.g., mon.di-MON.JA [nun]; and syllable-incongruent condition – e.g., mo.nis-MON.JA) as a control measure. As expected, participants were faster at recognizing targets preceded by syllable-congruent than syllable-incongruent primes, which could not be explained by the orthographic overlap between primes and targets. However, the advantage of the syllable-congruent condition over the syllable-incongruent condition was only observed for CV words, giving rise to the so-called *syllable structure effect*, later observed in other studies conducted in other languages such as French (Chetail & Mathey, 2009) and EP (Campos et al., 2018, 2020).

This unexpected result was accounted for by Álvarez et al. (2004) in Spanish and Chetail and Mathey (2009) in French based on the fact that that words with a CV syllable are much more common than words with a CVC syllable in these languages (see Álvarez et al., 2004 and Colé et al., 1999 for estimates). This unbalanced distribution was taken as potentially creating a bias in the visual recognition system that would make CV syllables to be more easily activated even when a CVC syllable is presented instead - note that, in most CVC first-syllable words, a CV permissible syllable is also embedded, which can account for the absence of significant differences between the syllable-congruent and syllable-incongruent conditions since both structures would receive activation (see Álvarez et al., 2004; Chetail & Mathey, 2009; Mathey et al., 2006). This proposal was further supported in a lexical decision study conducted by Conrad and Jacobs (2004) in German, a language in which there is a greater diversity of syllable structures, less than 30% of the words have a CV or a CVC first-syllable structure, and where syllable effects were observed for words with different syllable structures (see Conrad & Jacobs, 2004 for details).

This hypothesis, however, has recently been challenged by the results observed in a masked priming lexical decision study conducted in EP by Campos et al. (2018), following the same paradigm employed by Álvarez et al. (2004), but using a 50 ms prime duration and adding an extra unrelated condition to ascertain whether syllable effects were facilitative. While an advantage of the syllable-congruent condition over the syllable-incongruent and the unrelated conditions were observed, indicating that syllable effects in EP were, indeed, of facilitation, the authors only found signs of reliable syllable priming effects for CV first-syllable words; for CVC first-syllable structure words, no differences were observed between the three conditions, replicating the same syllable structure effect observed in other languages (Álvarez et al., 2004; Chetail & Mathey, 2009). Nonetheless, unlike Spanish and French, in EP while CV words still constitute the majority of words in the lexicon, the difference between CV and CVC words are far less pronounced - according to the Procura-PALavras lexical database (P-PAL; Soares et al., 2018; Soares et al., 2014), 38% of the EP words present a CV first-syllable structure and 30.2% present a CVC first-syllable structure – making it unlikely that this frequency-based account might fully explain why in EP syllable effects during visual word recognition are still restricted to CV words.

Furthermore, the syllable structure effect observed at early stages of visual word recognition becomes even more intriguing when we consider that previous studies investigating syllable effects in speech recognition and production in the same languages have found syllable effects both for CV and CVC words (Spanish: Sebastián-Gallés et al., 1992; French: Cholin et al., 2006; Mehler et al., 1981; EP: Morais et al., 1989). For instance, Morais et al. (1989), in a pioneering study investigating if the syllable emerged as a unit of lexical access during speech recognition, asked literate and illiterate EP readers to detect as soon and accurately as possible if CV (e.g., /ga/) or CVC syllables (e.g., /gar/) were embedded in words (e.g., *garagem* [garage] and *garganta* [throat]) presented into short sentences. The authors observed that participants were faster at detecting the target segments when they corresponded to the first syllable of the word than when they only shared the same first three letters but a different syllable boundary (i.e., faster at detecting /ga/ in *garagem* than in *garganta* and /gar/ in *garganta* than in *garagem*), hence showing that, in speech, syllable effects are observed both for CV and CVC structures.

To account for the syllable structure effect observed at the early stages of visual word recognition in EP, (Campos et al., 2020) recently proposed syllable complexity as a potential source of the effect. Since CVC syllables present an additional syllable unit when compared to CV syllables, the coda, which was proven to be one of the hardest syllable components to be processed (see Content et al., 2001; Treiman & Danis, 1988), it is reasonable to anticipate that 50 ms of prime duration, as used by Campos et al. (2018), might not suffice to allow CVC syllables to be fully activated. Note that, when a CV prime is presented, readers only have to process the stimulus until the third letter position for the syllable segment to be extracted. However, for CVC syllables, readers must process the CVC prime until, at least, the fourth letter position for syllable parsing to occur. To directly test this hypothesis, (Campos et al., 2020) replicated the study previously conducted by Campos et al. (2018) with the same materials but increasing prime durations from 50 ms to 67 ms and 82 ms to allow more time for processing. Although (Campos et al., 2020) observed similar facilitation effects for CV and CVC words alike, as participants were faster at recognizing CV and CVC words preceded by syllable-congruent (and also syllable-incongruent primes) when compared to the unrelated primes, differences between syllable-congruent and syllable-incongruent primes (indicative of a genuine syllable effect) were only observed for CV words. The absence of statistical differences between the syllable-congruent and syllable-incongruent conditions for CVC words, suggests that the facilitative effects observed in both conditions were likely due to the orthographic overlap between primes and targets and not due to a syllable activation *per se*.

Here, we tested another hypothesis to account for the syllable structure effect: the number of words with the same number of syllables sharing the same (first) syllable with the target, i.e., an analogous of the *N* orthographic neighbourhood density measure proposed by Coltheart et al. (1977) to the syllabic domain. The rationale behind this proposal is the following: because CV words tend to occur more frequently than CVC words (even in EP, although, as mentioned before, the difference is much less pronounced than what is observed in other languages), CV syllables tend to present a higher number of syllabic neighbours (i.e., words with the same number of syllables sharing the same first syllable) than CVC syllables. We can hypothesize that since CV words tend to present a higher number of syllabic neighbours than CVC words, it is possible that the larger syllabic neighbourhood of CV words might speed up their recognition as the higher number of syllabic neighbours might make CV words present lower levels of activation, thereby needing less input for a ‘yes’ response to be produced during a lexical decision task. This account also agrees with the ‘fast-guess’ mechanism proposed within the Dual-Route Cascaded model (DRC - Coltheart et al., 2001) or the Multiple Read-Out model (MROM - Grainger & Jacobs, 1996) and its recent MROM-S extension (Conrad et al., 2010), which implements a syllabic layer to explain the syllable inhibitory frequency effect observed in the Spanish language. Within the MROM-S model, it is claimed that although, initially, words with high-frequent syllables would spread activation to a large number of words sharing the same syllable boosting syllable activation, later, this high number of lexical candidates would compete with the target for activation via lateral-inhibition, hence explaining the syllable inhibitory frequency effect. This inhibition would be particularly prominent when lexical candidates had a higher frequency of occurrence than the target word. Nevertheless, due to the fact that in masked priming lexical decision studies the primes are typically pseudowords, which do not have a lexical representation (see Mathey et al., 2013 for more details), they are not expected to compete with word targets for recognition (see, however, Dominguez et al., 1997; Mathey et al., 2013 for a detailed account of how pseudoword primes might, in certain cases, hinder word recognition). Therefore, syllabic neighbourhood effects in lexical decision masked priming studies using a syllable congruency paradigm are expected to be facilitative.

Although the MROM-S was not designed to account for the syllable structure effect observed in syllable congruency masked priming studies, we can nevertheless hypothesize that when a CV syllable-congruent pseudoword prime is presented (e.g., jural) it might be syllabified in a syllabic layer (e.g., ju.ral), as the MROM-S model claims (Conrad et al., 2010). This activation would then spread out to all the words in the lexicon that present the same CV syllable in the same position (e.g., JU.LHO [july], JU.IZ [judge], JU.NHO [june], etc.), hence making that, when a CV target word is subsequently presented (e.g., JU.ROS), less activation is needed to recognize it as a word. However, because CVC words tend to come from sparser syllabic neighbourhoods, the level of activation generated from the previous presentation of CVC congruent pseudoword primes might lag clearly behind the one generated from CV congruent pseudoword primes, hence explaining the syllable structure effect observed in EP as well as in other languages such as Spanish and French. It is also worth noting that although (Campos et al., 2018, 2020) have matched the CV and CVC words used in their experiments in a high number of psycholinguistics variables known to affect word processing (see (Soares et al., 2015, Soares et al., 2019a,b) for evidence in the EP language), such as the frequency of the word as a whole, the number of letters, several orthographic neighbourhood measures, as the *N* (Coltheart et al., 1977), the Orthographic Levenshtein Distance (OLD_{20}) measure (see Yarkoni et al., 2008), obtained from the P-PAL EP lexical database (Soares et al., 2018; Soares et al., 2014) and also in the summed frequency of the words with the same number of syllables sharing the same first syllable with the targets (i.e., in the token frequency of the CV and CVC syllabic neighbours), a post-analysis of their stimuli revealed that the CV words used in the studies of (Campos et al., 2018, 2020) effectively presented a higher number of words sharing the same syllable in the same position than CVC words (i.e., type frequency of the CV and CVC syllabic neighbours), which might have accounted for their results.

Furthermore, it is also important to emphasize that, despite the fact that previous studies have examined the role that syllabic neighbourhood plays on syllabic processing, in particular in the syllable inhibitory frequency effect above mentioned (e.g., Álvarez et al., 2000, 2001; Carreiras et al., 1993; Conrad et al., 2006, 2007, 2008; Mathey & Zagar, 2002; Perea & Carreiras, 1998; Stenneken et al., 2007), all these studies lack a clear definition of what syllabic neighbours are, which might explain the inconsistency of the results observed (see Chetail & Mathey, 2011 for a review). Indeed, while in some studies syllabic neighbourhood is defined as the number of words sharing the same syllable (not necessarily the first) with the target, regardless of word length (e.g., Álvarez et al., 2000; Carreiras et al., 1993; Conrad & Jacobs, 2004; Perea & Carreiras, 1998), others adopted a more strict definition, describing it as the number of words with the same length (i.e., number of syllables) sharing the same (first) syllable in the same position (e.g., Chetail & Mathey, 2011; Conrad et al., 2007, 2008; Mathey et al., 2006; Mathey & Zagar, 2002). As Chetail and Mathey (2011) noted, the definition of syllabic neighbours is critical towards a clear understanding of how the syllable comes into play. In fact, a broader definition of syllabic neighbours might very well translate into a higher set of competitors with higher summed frequencies, when compared to a measure that only considers those lexical entries with the same number of syllables. Moreover, in some studies, the measures of type (number of words of the same syllabic length sharing the same syllable in the same positions) and token (summed frequency of the words with the same number of syllables sharing the same syllable with the targets) syllabic neighbourhood are often used indistinctively. Despite being highly correlated (e.g., Álvarez et al., 2001; Chetail & Mathey, 2011), it is important to highlight that they are not the same and, some studies have even demonstrated that they produce opposite effects. For instance, Conrad et al. (2008), contrasting effects of type and token syllable frequency during the visual word recognition of Spanish words, showed that while high syllable type frequency produced facilitative effects in the standard lexical decision task even when the number of higher frequency syllabic neighbours was controlled for, high syllable token frequency produced an inhibitory effect. These results seem to be consistent with the vast number of studies conducted on the role of orthographic neighbours in visual word recognition, showing that words from denser neighbourhoods were recognized faster/more accurately than words coming from sparser neighbourhoods, when the number and the frequency of high-frequent orthographic neighbours were controlled for (e.g., Andrews, 1989, 1997; Grainger et al., 1989; see also Perea, 2015, for a review). The absence of lexical databases providing reliable syllabic measures (e.g., type and token syllabic positional and non-positional frequencies, number of more frequent syllabic neighbours, frequency of more frequent syllabic neighbours) certainly contributed to this state of affairs. To the best of our knowledge, the only exceptions are the InfoSyll for French (Chetail & Mathey, 2010) or the Syllabarium for the Basque language (Duñabeitia et al., 2010). Even in EP, the number of syllable measures provided by the P-PAL database is quite restrictive (see Soares et al., 2018; Soares et al., 2014).

The present study was specifically designed to investigate if syllabic neighbourhood density, defined as the number of words with the same number of syllables sharing the same (first) syllable with other words in the lexicon, can account for the syllable structure effect observed in EP. Additionally, we also sought to analyse if, with a new set of stimuli, syllable effects could also be observed for EP pseudowords, as observed in other languages (e.g., Álvarez et al., 2000; Carreiras et al., 1993) since in a previous study (Campos et al., 2018) have failed to obtain any sign of syllable effects for pseudoword targets. To this purpose, EP skilled readers performed a lexical decision masked priming task, in which CV and CVC EP word targets controlled on several variables known to affect word processing, including several type and token syllabic neighbourhood measures, were preceded by brief 50 ms pseudoword primes in three different prime condition (congruent, incongruent and unrelated) as in (Campos et al., 2018, 2020).

Although a more direct way to test the role that syllabic neighbourhood density might play on the syllable structure effect would involve the manipulation, rather than the control of the syllabic neighbourhood density measures, it is worth noting that because in EP, as well as in other languages, CV syllables tend to come from denser syllabic neighbourhoods, we were not able to find enough CV words with a sufficiently low number of syllabic neighbours, or enough CVC words with a sufficiently high number of syllabic neighbours with the high strict control imposed to the stimuli to allow its manipulation. Thus, the only viable option was to control for the CV and CVC syllabic neighbourhood measures. Therefore, we hypothesized that if the syllabic neighbourhood density was the driving force of the syllable structure effect observed in EP, and possibly in other languages, when CV and CVC words were matched on all the relevant psycholinguistics variables known to affect word processing, including type and token syllabic neighbourhood measures, facilitative syllable priming effects should be observed for CV and CVC words alike.

2. METHOD

2.1. Participants

Thirty-six undergraduate students (M_{age} = 21.2, SD_{age} = 2.7; 27 women) took part in the experiment in exchange for course credits. Sample size was estimated with G*Power software (Faul et al., 2009) showing that 33 participants would provide adequate power ($1-\beta = 0.80$; $\alpha = 0.05$) for an effect size of f(U) = 0.4 ($\eta_p^2 = .14$). All the participants had normal or corrected-to-normal vision and were native speakers of EP with no history of learning or reading-related disabilities. Prior to the experiment, written informed consent was obtained from all the participants. The study was approved by the local Ethics Committee.

Table 1
Psycholinguistic Variables in Which CV and CVC Words Were Matched as Obtained From the P-PAL Database (Soares et al., 2018) and measures of familiarity (i.e., measured by subjective frequency), imaginability and concreteness as obtained from the Minho Word Pool Database (Soares et al., 2017).

Psycholinguistic variables	CV words *M* (*SD*)	CVC words *M* (*SD*)	*p-value*
Word length (number of letters)	5.08 (0.27)	5.17 (0.38)	.221
Word length (number of phonemes)	4.88 (0.44)	4.83 (50.59)	.698
Word frequency (per million)	6.09 (7.84)	7.37 (10.83)	.508
Orthographic neighbourhood Size (O*N*)	5.06 (4.04)	5.77 (3.35)	.352
Phonologic neighbourhood Size (P*N*)	5.21 (4.26)	5.96 (3.82)	.366
Mean frequency of the orthographic neighbours	20.75 (67.05)	25.93 (52.92)	.676
Number of higher frequency orthographic neighbours	1.46 (1.65)	1.94 (1.85)	.184
Number of higher frequency phonologic neighbours	1.35 (1.85)	2.02 (1.92)	.090
Mean frequency of higher frequency orthographic neighbours	42.72 (138.09)	63.85 (114.29)	.416
Orthographic Levensthein Distance (OLD_{20})	1.67 (0.27)	1.60 (0.23)	.162
Number of orthographic syllable neighbours sharing the first syllable	44.77 (13.69)	41.50 (13.45)	.241
Summed orthographic frequency of the syllabic neighbours	678.41 (659.32)	620.28 (657.29)	.666
Summed phonological frequency of the syllabic neighbours	793.97 (841.34)	491.78 (701.79)	.059
Number of higher frequency orthographic syllable neighbours	11.48 (9.04)	10.02 (6.66)	.371
Mean frequency of higher frequency orthographic syllable neighbours	74.94 (80.23)	64.67 (81.20)	.535
Frequency of the most frequent orthographic syllable neighbour	352.18 (385.37)	257.66 (321.51)	.195
Number of words sharing bigrams with the target	346.02 (211.96)	390.60 (190.40)	.281
Mean number of words sharing bigrams with the target	83.71 (48.10)	91.59 (35.22)	.362
Summed frequency (log10) of words sharing bigrams with the target	4576.87 (2483.65)	5316.59 (2667.71)	.163
Mean frequency of words sharing bigrams with the target	14.78 (8.94)	14.79 (7.59)	.996
Subjective frequency (1-7)	3.79 (1.26)	4.05 (1.32)	.655
Imageability (1-7)	5.04 (1.75)	5.07 (1.70)	.493
Concreteness (1-7)	5.28 (1.46)	5.27 (1.32)	.194

2.2. Materials

A total of 96 disyllabic EP words, all between five and six letters long, were selected as targets from the P-PAL lexical database (Soares et al., 2018; Soares et al., 2014). From these, 48 words have a CV first syllable (e.g., JU.ROS [interests]) while the other 48 have a CVC first syllable (e.g., TUR.BO [turbo]). The CV and CVC words were matched (all *p*'s > 0.162) on several orthographic syllable measures, including the number of syllabic neighbours sharing the first syllable (i.e., type frequency), their summed frequency (i.e., token frequency), and the number and frequency of higher frequency syllabic neighbours, as computed from the P-PAL lexical database (Soares et al., 2018). Besides, CV and CVC words were also matched on several variables known to affect word processing, such as the frequency of the word as a whole, number of letters, and several orthographic neighbourhood measures, as *N* and OLD_{20} (see Soares et al., 2015, Soares et al., 2019a,b for recent evidence in EP). Table 1 displays the mean and standard deviations (in brackets) of the psycholinguistic variables in which the CV and CVC words used in the experiment were controlled for.

Concreteness (M_{CV} = 5.28 and M_{CVC} = 5.27; p = .194), imaginability (M_{CV} = 5.04 and M_{CVC} = 5.07; p = .493), and familiarity (operationalized as subjective frequency, M_{CV} = 3.79 and M_{CVC} = 4.05; p = .655), measures were also controlled for, though they were only available for 22 of the CV and 26 of the CVC words used in the experiment as obtained from the Minho Word Pool (MWP) EP database (see Soares et al., 2017). Furthermore, it is also worth noting that CV and CVC words were also controlled for in the number of phonemes (M_{CV} = 4.88 and M_{CVC} = 4.83; p = .689), number of phonological neighbours (M_{CV} = 5.21 and M_{CVC} = 5.96; p = .366) and number of higher frequency phonological neighbours (M_{CV} = 1.35 and M_{CVC} = 2.02; p = .090). The opacity of the EP language makes the simultaneous control of the orthographic and phonological measures particularly hard to achieve; thus, although CV and CVC words were matched on the type and token orthographic syllable neighbourhood measures displayed in Table 1, CV words present, nevertheless, a higher number of phonological syllable neighbours than CVC words (M_{CV} = 55.21 and M_{CVC} = 32.85; p < .001), as well as a tendency for the words that constitute their syllabic neighbours to present a higher frequency of occurrence as well (M_{CV} = 793.97 and M_{CVC} = 491.78; p = .059). Because of these factors, and also due to the fact that the task was presented in the visual domain, we opted to control for the orthographic syllable neighbourhood measures as they were assumed to be more relevant for visual word processing.

Two-hundred and eighty-eight pseudowords were created as primes and assigned to each of three experimental conditions: (i) syllable-congruent condition (i.e., prime and target shared the first three letters and the syllable boundary – e.g., ju.ral-JU.ROS, tur.ta-TUR.BO); (ii) syllable-incongruent condition (i.e., prime and target share the first three letters but not the syllable boundary – e.g., jur.ga-JU.ROS, tu.res-TUR.BO); and (iii) unrelated condition (i.e., prime and target do not share either the first syllable or the same letters - e.g., po.car-JU.ROS and bin.va-TUR.BO). Additionally, a set of 96 pseudowords targets and a set of 288 pseudowords primes, following the same manipulation as the word targets, were created for the purposes of the lexical decision task, by replacing one or two letters in the medial positions of words with similar characteristics to those used in the experiment (e.g., for instance, the pseudoword VERVE was created by replacing the <m > in the EP word *verme* [maggot] with a <v>) following common practices in the literature (e.g., Perea et al., 2013; Soares et al., 2018, 2019a,b, 2020; Sze et al., 2014; Yap et al., 2010; Soares et al., 2021). These stimuli were distributed across three lists to counterbalance targets across the three prime conditions. Participants were randomly assigned to a list while assuring that each list had the same number of participants (n = 12). The complete list of the prime-target pairs can be found in Appendix A.

2.3. Procedure

The experiment was run individually in a soundproof booth. Participants were asked to decide as quickly and accurately as possible whether each of the letter strings presented in uppercase at the centre of a 22'' inch computer screen was a real EP word or not by pressing two different keyboard buttons: "M" for words and "Z" for pseudowords. The DMDX software (Forster & Forster, 2003) was used for the presentation of the stimuli and recording of the responses. The task entailed 192 trials (96 words and 96 pseudowords) randomly presented to the participants. Each trial consisted of a sequence of three visual events: (i) a forward mask (######) presented for 500 ms; (ii) the prime, presented in lowercase (14-point Courier New), for 50 ms; and (iii) the target, presented in uppercase (14-point Courier New), that remained on the screen until the participants' response or 2,500 ms had elapsed. At the beginning of the experiment, 24 practice trials (12 words with a CV structure, 12 words with a CVC structure, and 12 pseudowords) were used to familiarize participants with the task. The entire session lasted approximately 15 minutes per participant.

3. RESULTS

The analyses were conducted on the latency (RTs in ms) and accuracy (% of incorrect responses) data for word and pseudoword targets using linear mixed effects (lme) models in the R software (Bates et al., 2011). The lme analyses on RTs were conducted after response times for incorrect responses (5.7% for the word data and 4.8% for pseudoword data) and response times for correct responses bellow 200 ms or below/above 2 *SD*s of the mean RTs of each participant, per experimental condition, were excluded from the dataset (4.9% for the word data and 6.2% for pseudoword data). The factors Prime type (congruent|incongruent|unrelated) and Target type (CV|CVC) were treated as repeated measures in the lme analyses with participants and items as crossed random intercept and with random slope per subject but not per item (see Barr et al., 2013; Matuschek et al., 2017). The lme analyses on accuracy data were conducted for word and pseudoword targets with logistic function and binomial variance. To contrast simple effects with differences of least squares means the lme4 R library (Bates et al, 2011) and the lmerTest R library were used. For the effects that reached statistical significance (α = 0.05), the second degree of freedom was reported based on the Satterthwaite's method (see Satterthwaite, 1941, and Khuri et al., 1998) and the p values were adjusted with Hochberg's method for multiple comparisons (see Benjamini & Hochberg, 1995, and Hochberg, 1988 for details). Because measures of effect sizes similar to the eta-squared (η^2) and omega-squared (ω^2), available in the F tests (ANOVA), are not currently available for lme analyses in R (see Bates et al., 2015; Kuznetsova et al., 2017 for discussions), we computed, as in previous

Table 2
Mean and Standard Deviations (in brakets) of Response Times (RTs) and Percentage of Errors (%E) per Prime Condition.

Target type		Prime type					
		Congruent		Incongruent		Unrelated	
		RT	%E	RT	%E	RT	%E
Words	CV	697 (68)	7.3 (26)	723 (187)	6.5 (25)	737 (192)	6.5 (25)
	CVC	730 (181)	3.0 (17)	738 (205)	4.5 (21)	717 (159)	3.8 (19)
Nonwords	CV	874 (250)	4.3 (20)	873 (246)	5.9 (24)	883 (264)	5.2 (22)
	CVC	851 (227)	4.0 (20)	862 (251)	4.6 (21)	881 (258)	5.1 (22)

studies (see Soares et al., 2019a,b for an example), the Cohen's delta (*d*) statistic (Cohen, 1988) by dividing the mean adjusted for each of the factors in the model (estimated mean) by the residual of the estimated model (unexplained variance). Hence, *d* values are reported for main effects involving a two-level factor (Target type: CV|CVC), as well as for each of the post-hoc comparisons that reached statistical significance both in main effects with more than two levels (Prime type: congruent|incongruent|unrelated) and in interaction effects (Target type*Prime type effects) that reached statistical significance. Table 2 presents the means and standard deviations (in brackets) of the RTs (in ms) as well as the percentage of errors (%E) committed by participants for CV and CVC words and pseudowords in each of the three prime conditions (i.e., congruent, incongruent, and unrelated).

3.1. Word data

The results conducted on the latency data showed a main effect of the prime type, $F(2, 2982.54) = 3.2858$, $p = .038$, indicating that participants were significantly faster responding to words preceded by syllable-congruent primes than by unrelated primes ($p = .038$, $d = 0.11$). The difference between syllable-congruent and syllable-incongruent primes ($p = .144$), as well as the difference between syllable-incongruent and unrelated primes ($p = .496$), failed to reach statistical significance. The main effect of target was not significant ($p = .508$). However, the twofold prime type*target type interaction was statistically significant, $F(2, 2982.50) = 5.0723$, $p = .006$. This effect revealed that participants were significantly faster at recognizing CV words preceded by syllable-congruent than by unrelated primes (40 ms, $p < .001$, $d = 0.25$) and, also, to CV words preceded by syllable-congruent than syllable incongruent-primes (26 ms, $p = .037$, $d = 0.15$), thus revealing a genuine syllable priming effect for this type of EP words. The difference between syllable-incongruent and unrelated conditions was not statistically significant ($p = .106$), hence indicating that syllable-incongruent and unrelated primes produced virtually the same amount of priming. For CVC words, however, neither the difference between syllable-congruent and unrelated primes ($p = .866$), the difference between the syllable-incongruent and unrelated primes ($p = .866$) nor the difference between syllable-congruent and syllable-incongruent primes ($p = .866$) reached statistical significance, hence failing to show any sign of syllable priming effects.

On the accuracy data, none of the effects (prime type, $p = .372$; target type, $p = .070$) nor the interaction effect ($p = .381$) approached statistical significance.

3.2. Pseudoword data

The lme analyses revealed that in latency data neither the main effect of prime ($p = .194$), the main effect of target ($p = .447$), nor the two-fold interaction ($p = .555$) reached statistical significance. In the accuracy data, the results also failed to show any significant main (prime type, $p = .362$; target type, $p = .763$), or interaction effect ($p = .741$), thus revealing the absence of any syllable effects in pseudoword data.

4. DISCUSSION

Although syllable effects have been widely studied in different languages, the syllable structure effect - i.e., the fact that reliable syllable priming effects were only observed for CV and not for CVC first-syllable structure words in studies using the syllable congruency masked priming paradigm, remains largely overlooked. Though different explanations have been put forward, with some authors suggesting that the syllable structure effect is rooted on the difference between the number of times CV and CVC words occur in a given language (e.g., Álvarez et al., 2004; Chetail & Mathey, 2009), and others claiming that it could arise from syllable complexity (e.g., Campos et al., 2018), both hypotheses have been recently challenged. (Campos et al., 2018) showed that, in languages such as EP, where the difference between the number of times CV and CVC words occur is much less pronounced than what is observed in Spanish or French, reliable syllable priming effects were still observed only for CV words. In addition, (Campos et al., 2020), in a recent study aimed to test if syllable complexity could account for the syllable structure effect by increasing prime durations, also failed to show reliable syllable effects for CVC words.

The goal of the present study was to investigate if the syllabic neighbourhood density, operationalized as the number of words with the same number of syllables that share the same first syllable at the first position, could account for the syllable structure effect observed in EP as well as in other languages. To this purpose, CV and CVC EP words were matched in the syllabic neighbourhood density measure, as well as in several other orthographic and phonological variables known to affect visual word recognition, including the summed frequency of orthographic syllable neighbours (i.e., token syllable frequency), using the syllable congruency masked priming paradigm as in previous studies. Although, as mentioned before, manipulating the number of syllabic neighbours of CV and CVC words would have been the preferable methodological option, the strict control imposed to the stimuli and the characteristics of the EP language did not allow us to select either a sufficient number of CV words with a sufficiently low number of syllabic neighbours or an adequate number of CVC words with a sufficiently high number of syllabic neighbours, in order to achieve the syllabic neighbourhood density manipulation. Nevertheless, the control of the CV and CVC words on their number of syllabic neighbours (besides all the other variables) led us to hypothesize that if syllabic neighbourhood density accounted for the syllable structure effect observed in the EP, similar facilitative syllable priming effects should be observed for CV and CVC words.

The results obtained from the lme analyses revealed, however, that genuine syllable priming effects were still only observed for CV EP words, as participants were not only significantly faster at recognizing CV words preceded by syllable-congruent primes than by unrelated primes but, importantly, also significantly faster at recognizing CV words preceded by syllable-congruent primes than by syllable-incongruent primes. For CVC words, however, the differences across prime conditions failed to reach statistical significance, including differences between both the syllable-congruent and the syllable-incongruent conditions when compared to the unrelated condition, replicating previous findings in EP (Campos et al., 2018). It is important to mention that the use of unrelated primes that shared the same syllable structure with the target (e.g., pu.cas-JU.ROS and bin.va-TUR.BO), as done in this study and in the study of (Campos et al., 2018), could possibly attenuate orthographic priming effects, particularly with a short prime duration. Note that not only in CVC targets were there no significant differences between the syllable-congruent, syllable-incongruent, and unrelated conditions, but, in CV targets, only for the syllable-congruent condition was there a facilitation effect, as no significant differences were found between the syllable-incongruent and unrelated conditions. Critically, however, this result further sustains the claim that the advantage of the syllable-congruent condition stems from a genuine syllable activation. Results in the pseudoword data also replicated those previously observed in EP (Campos et al., 2018), showing no evidence of a syllable effect.

Thus, these results showed, once again, that reliable syllable congruency priming effects in EP were only observed for CV words (e.g., Campos et al., 2018, 2020), as seen in other languages (Spanish: Álvarez et al., 2004; French: Chetail & Mathey, 2009) even when the number of syllabic neighbours was controlled for. Although these results seem to suggest that the syllabic neighbourhood density of CV and CVC words does not account for the syllable structure effect, it is relevant to highlight that, before definitive conclusions can be drawn, it would be important to conduct other studies matching the CV and CVC words not only on the orthographic syllable neighbourhood density, as we have done here, but also on the phonological syllable neighbourhood density. Note that, because EP is an intermediate-depth language, where the correspondences between graphemes and phonemes are not regular and unambiguous, as observed in shallow orthographies such as Spanish, there are considerable differences when the orthographic and the phonological codes are considered. For instance, in many cases, words might have a higher number of syllabic neighbours when we consider phonology rather than orthography. An example of this found in our stimuli would be the CV word *xadrez* [chess], which has 7 orthographic syllable neighbours but 41 phonological syllable neighbours. The contrary also happens, however, and, in many cases, orthographically there are more syllabic neighbours than phonologically, such is the case of the CVC word *pasmo* [stunned] that has 47 orthographic syllable neighbours and only 8 phonological syllable neighbours. Thus, this makes it that the simultaneous control between phonological and orthographic syllable neighbours would be extremely difficult in the EP language, and as mentioned, it was not possible for the purposes of this study to have both the orthographic and the phonological syllable neighbourhood density controlled at the same time. Nevertheless, it would be important for future studies, particularly in transparent languages such as Spanish, to have this simultaneous control of orthographic and phonological syllable variables in order to investigate the influence of syllabic neighbourhood density on the syllable structure effect.

Indeed, in EP, while orthographically the difference between the number of CV and CVC words is not very pronounced (i.e., 38% of words have a CV first-syllable structure and 30.2% have a CVC first-syllable structure), when we consider phonology, however, this difference is much more evident since CV first-syllable words occur for 43.9% of the words in the EP lexicon, whereas CVC first-syllable words only occur in 15.3% of the cases – data taken from the P-PAL lexical database (Soares et al., 2018; Soares et al., 2014). Consequently, CV words tend to have a greater number of syllabic neighbours, particularly when phonology is considered. Note that, in the pool of stimuli selected for our study, while orthographically CV words had an average of 45 syllabic neighbours and CVC words an average of 41 syllabic neighbours, phonologically CV words had on average 55 syllabic neighbours, but CVC words only had 33 syllabic neighbours, on average. One of the reasons for this disparity between the number of CV and CVC words when orthography or phonology are considered stems from the fact that CVC syllables can present a match, as in the word tur.bo [tˈuɾbu], which has a CVC orthographic (<tur>) and phonological structure ([tˈuɾ]); or, in a considerable number of cases, a mismatch between their orthographic and phonological syllable structure, as in the word *pente* [brush], which has a CVC orthographic structure (<pen>) but a CV phonological structure ([pȩ]). In the case of an orthographic-phonological mismatch, CVC words usually contain a nasal vocalic sound ([ã], [ẽ], [ĩ], [õ], and [ũ]), in this case, represented by the conjugation of a vowel (‘a’, ‘e’, ‘i’, ‘o’, ‘u’) with an <m> or an <n> (e.g., *bom* [bˈǫ; good]). Hence, while in print, the nasal vowel is represented by two letters, in speech only one sound is produced (see Barroso, 1999; Teixeira et al., 1999). For CV syllables, however, there is almost always a complete match between the orthographic and phonological syllable forms (e.g., *ju.ros* [ʒˈuɾuʃ], so in), the only exception being when the first consonant of a CV syllable is an <h>; because in EP that sound is silent (e.g., in the word *holofote* [olufˈɔtɨ]), so the first orthographic syllable has a CV structure, but the first phonological syllable has a V structure.

Thus, to gain further insights into the extent to which phonological variables could account for the results, we conducted an a posteriori analysis based on a new classification of the words used in our dataset into three categories: the CV words (e.g., CV, JU.ROS [ʒˈu.ɾuʃ]), the CVC words presenting both a CVC orthographic (O) and phonological (P) syllable structure (i.e., CVC_{O+P+}, e.g., TUR.BO [tˈuɾ.bu]), and the CVC words that present a CVC orthographic structure, but a CV phonological structure (i.e., CVC_{O+P-}, e.g., PEN.TE [pˈẽ.tɨ]). Because the CVC_{O+P-} words constitute a small pool of stimuli in our dataset (14 words), we selected 14 CV words out of the 48 CV words and other 14 CVC_{O+P+} words out of the remaining 34 CVC words, matched in all the variables in which the total pool of CV and CVC words were controlled for (see Table 1), to avoid confounds. Furthermore, concerning the number of phonological syllable neighbours, CV and CVC_{O+P-} words were also matched in this variable (M_{CV} = 63 and $M_{CVCO+P-}$ = 54; p = .968), though the same control was not possible for CVC_{O+P+} words ($M_{CVCO+P+}$ = 23). It is also relevant to mention here that although reliable phonological priming effects tend to be observed with longer prime durations, it is also worth mentioning that previous studies have shown phonological priming effects both with 50 ms and even with shorter prime durations (e.g., Comesaña et al., 2016; Davis et al., 1998; Frost et al., 2003; Lee et al.,1999; Lukatela et al., 1998; Perea & Lupker, 2004; Shen & Forster, 1999). Thus, if phonological syllable information is the driving force of the syllable structure effect, then we would expect CVC_{O+P-} words to behave similarly to CV words since both present the same CV phonological structure. Results from the lme analyses conducted based on the same experimental design, except that the Target type factor entered now with three levels (CV| CVC_{O+P+}|CVC_{O+P}), are presented in Appendix B. As can be noticed, although the effects failed to reach statistical significance, due probably to lack of statistical power (note that we only used data from 14 items per condition), participants tended to be faster responding to CVC_{O+P-} targets preceded by syllable-congruent primes than by both unrelated and syllable-incongruent primes, as observed for CV targets. Such a pattern was not observed for the CVC_{O+P+} words, where participants tended to respond even faster to CVC_{O+P+} words preceded by unrelated primes than by syllable-congruent and syllable-incongruent primes (see Appendix B).

Even though these results were statistically nonsignificant, they nevertheless provide interesting clues for future studies to examine the role phonological variables could play in the syllable structure effect observed in EP. Other factors that future studies should also consider is the similarity of the CV skeletal structure (i.e., the combination of vowels and consonants in a word) or the similarity of the consonantal structure (i.e., the consonants existing in a word) between primes and targets (e.g., Blythe et al., 2014; Chetail & Drabs, 2014; Chetail et al., 2016; Perea et al., 2018; Soares et al., 2014; see also Soares et al., 2020 for a letter similarity account on the consonant bias), even though they are not able to fully explain the results obtained here. While Chetail and Drabs (2014), using a same-different task, showed that readers were slower at naming “different” trials when the words shared the same CV skeletal structure (e.g., piorver–poivrer [CVVCCVC-CVVCCVC]) compared to when they had a different CV skeletal structure (e.g., povirer–poivrer [CVCVCVC-CVVCCVC]), suggesting that there was an early activation of the CV skeletal structure, this would not be able to account for the syllable structure effect. Note that in our study CV and CVC words present the same CV skeletal structure in the syllable-congruent condition (e.g., ju.ral- JU.ROS [CVCVC-CVCVC] and tur.ta-TURBO [CVCCV-CVCCV]) and a different CV skeletal structure in the syllable-incongruent condition (e.g., jur.ga-JU.ROS [CVCCV-CVCVC] and tu.res-TUR.BO [CVCVC-CVCCV]), so it does not explain the differences found between CV words and CVC words. More recently, however, Perea et al. (2018) demonstrated using a masked priming lexical decision task that, at the earliest stages of visual word recognition, it is not the CV skeletal structure of the words (e.g., PAISAJE [CVVCVCV]), but rather the consonantal structure of the words that is activated (i.e., [psj] in the word PAISAJE). Nevertheless, this account based on an early activation of the consonantal structure also cannot fully explain our results since the degree of overlap between the consonantal structure of CV and CVC conditions are roughly the same in the syllable-congruent and syllable-incongruent conditions, as the number of consonants preserved between primes and targets is the same - all except one as [jrl-jrs] in ju.ral-JU.ROS, [jrg-jrs] in jur.ga-JUROS; [trt-trb] in tur.ta-TUR.BO, and [trs-trb] in tu.res-TUR.BO.

Still, the different roles played by consonants and vowels during visual word recognition, in general, and in syllabic parsing, in particular, should be not disregarded in future studies. In fact, in EP, as in most languages, vowels are the nucleus of the syllable, and, as such, they are, presumably, automatically assigned to that syllable position (see Taft et al., 2017). Consonants, on the contrary, can be positioned either as the onset or as the coda of the syllable, except if they constitute the first or final letter of a word, in which case they can only assume the role of onset or coda, respectively (see Lee & Taft, 2009; Taft et al., 2017; Taft and Krebs-Lazendic, 2013). Thus, while in a CV syllable, the consonant and the vowel are unambiguously assigned to their positions, in CVC syllables, the second consonant could potentially be assigned either to the coda of the first syllable or the onset of the second syllable. This issue is further complexified by the fact the vast majority of CVC syllables in EP have a permissible CV syllable embedded. It is relevant to note here that our results with CVC words seem to support this notion that there might be a competition between the CVC syllable and the CV syllable embedded, at early stages of visual word recognition, since although the advantage was only numerical, for CVC words, participants had shorter RTs in the unrelated condition than in the syllable-congruent and syllable-incongruent condition, which could be due to this particular factor in CVC syllables. This ambiguity and potential competition between the different positions in which the last consonant can be assigned to, may also contribute to hamper CVC syllable activation and word recognition, which should be further explored in future studies by considering, for example, if CVC syllables with and without a CV syllable embedded show the same processing. Future studies should also use techniques more sensitive to the temporal course of processing, such as eye-tracking or Event-Related Potentials (ERPs). The use of those techniques would allow to better investigate the temporal course of syllable effects, especially for CVC syllables, since there is a possibility that this activation occurs at such early stages of visual word recognition, that the use of a masked priming paradigm might not be well suited to capture them.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDIX A

Prime-target pairs from the MS "*Syllabic Neighbourhood Density Effects in the Visual Word Recognition of CV and CVC Words: Evidence From Syllable Congruency Masked Priming Paradigm*"

The items are arranged in triplets in the following order: syllable-congruent prime, syllable-incongruent prime, and unrelated prime for the word and nonword targets.

Words.

bicro; bicte; dugue; BICAS; bicla; bicta; dales; BICHO; bifco; bifor; tunha; BIFES; bilhos; biltro; gelaos; BILHAR; cetar; cetca; ricra; CETIM; cidos; cidto; rasal; CIDRA; cunol; cunvo; nitra; CUNHA; dadal; dadpa; xucos; DADOR; dicor; dicto; vobro; DICAS; diqua; diqta; zicre; DIQUE; ducar; ducta; tunho; DUCHE; dunim; dunca; bides; DUNAS; duqua; duqta; renho; DUQUE; febas; febga; degue; FEBRE; fedim; fedma; lelha; FEDOR; fetor; fetpo; lefro; FETAL; feves; fevco; dinho; FEVRA; furis; furva; vosas; FUROR; genil; genva; piror; GENES; gomer; gompa; noque; GOMOS; gotir; gotco; jecor; GOTAS; jagro; jagma; gulher; JAGUAR; judor; judco; gorai; JUDEU; jural; jurga; pucar; JUROS; lonor; lonvo; docal; LONAS; lotim; lotca; tilhe; LOTES; luces; lucta; tinho; LUCRO; murim; murvo; noses; MURAL; naral; narjo; vinza; NARIZ; natim; natco; cacra; NATAL; nator; natmo; raler; NATAS; negul; negmo; midel; NEGRA; ninal; ninca; varol; NINHO; nobas; nobta; munho; NOBRE; nozal; nozfo; vicos; NOZES; nudal; nudma; ronho; NUDEZ; nuvar; nuvco; sunos; NUVEM; pudes; pudta; focol; PUDIM; punaos; punjo; fobras; PUNHAL; rumal; rumpa; vonas; RUMOR; sigor; signe; cebro; SIGLA; sinar; sinva; recal; SINOS; tumas; tumpa; litra; TUMOR; tutal; tutpa; liles; TUTOR; vocer; vocto; muter; VOCAL; vogor; vogmo; naque; VOGAL; xadins; xadtar; palhos; XADREZ; zebes; zebco; conhe; ZEBRA; balto; balor; torfa; BALDE; borbo; borim; lanto; BORLA; canco; canol; mosce; CANJA; carfo; carel; mesme; CARGA; carsa; carom; mesca; CARNE; carlho; carous; mesbro; CARTAZ; casgo; casor; morgo; CASPA; ceril; cerma; zinva; CERCO; cinro; cinos; mesco; CINZA; confro; conaos; vintra; CONCHA; conra; conus; vinva; CONDE; confa; conar; vinge; CONTO; culbo; culor; vongo; CULPA; curno; curom; misno; CURVA; cusfa; cuser; varfe; CUSPO; farne; farir; linge; FARSA; forve; forul; tesvo; FORCA; forse; forim; tesma; FORNO; funfe; funir; laspa; FUNGO; linva; linas; basmo; LINCE; manva; manal; vesca; MANSO; marpa; maral; cosbra; MARFIM; marba; marol; sosca; MARTE; mesfro; mesois; narlho; MESTRE; monfa; monul; vaspa; MONGE; morma; moriz; nasva; MORNO; parpes; parous; gostro; PARDAL; parna; paril; gosve; PARVO; pasca; paser; ferno; PASMO; penlo; penom; farlo; PENTE; paraus; perbal; finvas; PERDIZ; perce; perel; fince; PERNA; permo; peril; finvo; PERSA; pinvas; pinaus; jastos; PINCEL; pinfa; piner; jaspa; PINGO; pulfo; pulor; gampo; PULGA; pulma; puler; garta; PULSO; salro; salim; corme; SALSA; surba; surar; cosla;

SURDO; surla; sures; cosja; SURTO; tanca; tanes; bisfa; TANGO; tarbo; taral; borfa; TARTE; tenva; tenos; larna; TENRO; turta; tures; binva; TURBO; tursa; turam; linca; TURCO; verda; verel; cosma; VERBO; verpro; vereil; coster; VERNIZ; verva; veram; cosne; VERSO;

Pseudowords.

balim; balva; teixo; BALUR; besor; besro; vesur; BESAS; birom; birva; ducra; BIRUS; carem; carca; vocre; CALUS; caner; canva; vemem; CANUS; conur; convo; serus; CONIM; cunor; cunsa; vumar; CUNES; curum; curzo; vecos; CURES; doler; dolsa; boiva; DOLOS; donal; donco; bosxa; DONHE; dorim; dorne; lasne; DORAR; dunel; dunvo; tucel; DUNHA; fisum; fisra; loces; FISIR; focis; focta; lunha; FOCRO; garui; garne; jocus; GARAS; garem; garca; poras; GARIR; gavil; gavco; pusco; GAVAS; giler; gilve; vutas; GILOS; gopos; gopto; joges; GOPRA; goser; gosca; jusro; GOSUM; jenas; jenca; polas; JENHO; jesos; jesna; JESAL; junam; junca; recas; JUNOS; lalem; lalco; tesva; LALOS; lasor; lasmo; bezos; LASES; lesum; lesmo; tivos; LESIR; losar; losce; baror; LOSUS; menca; menar; nures; MENHO; pacia; pacte; jocio; PACLA; paqal; paqma; jofas; PAQUE; pigal; pigma; fucro; PIGUE; ranor; ranvo; juces; RACAS; rapom; rapti; sifes; RAPRA; recam; recda; vecha; RECRO; reron; rerxa; xaxca; RERUS; robas; robca; salga; ROBEL; ronum; ronva; vaves; RONER; serar; serco; caxor; SERUS; silom; silxo; veice; SILAR; vanom; vanva; momos; VANIL; vasas; vasva; coriu; VASOR; vener; venvo; ceror; VENAS; vense; remur; VENOR; veqra; veqpa; fical; VEQUE; verar; verzo; xares; VERUS; vilam; vilna; ruico; VILOR; zeror; zervo; mecer; ZERAS; berna; berur; linve; BERVO; canxe; canor; vervo; CANCA; carim; carlu; misra; CARDE; ceral; cerza; ponco; CERME; cerno; ceros; virna; CERVE; corpe; coril; nempa; CORFO; cusve; cusom; virve; CUSNO; derzo; derim; borve; DERSA; dunso; dunir; birce; DUNVA; firve; firor; lusmo; FIRCA; funva; funus; porva; FUNCE; gasve; gasem; curxe; GASCA; gorzo; gorer; pesze; GORMA; genfo; genhos; verza; GENDA; gilne; gilom; penve; GILCO; gisna; gisum; jurzo; GISMO; jesva; jesur; porma; JESME; jeslo; jesir; vorba; JESTA; junlu; junas; gaslo; JUNFA; jurca; jurim; pisva; JURNO; larfo; laras; firgo; LARTA; lenvo; lenos; binja; LENCA; lorve; lores; tusne; LORCA; lunza; lunes; tirva; LUNCO; merna; meris; nosco; MERVE; munzo; munur; virve; MUNCA; nenvo; nenam; vorve; NENCE; perte; perim; gisla; PERFO; pirva; piral; farca; PIRMO; punxa; punim; jorca; PUNZO; pusno; pusor; jermo; PUSVA; rarmo; raril; nunvo; RARCA; rinze; rinam; xurce; RINCO; risfa; risal; culca; RISJO; sance; sanis; xunre; SANVA; sinvo; sinho; nirmo; SINCA; sisvi; sisil; nirso; SISCA; sunvo; sunos; zerna; SUNCE; tinva; tinos; bunza; TINCO; tirvo; tiror; lesne; TIRSA; turso; turol; dindo; TURZA; vampo; vamir; birjo; VAMBA; vanfa; vanor; corve; VANJO; vasre; vasor; murso; VASCA; verno; verir; mosme; VERVE; vispa; visim; conja; VISGO; vorca; vorus; casza; VORMO; vosme; vosir; mirmo; VOSCA;

APPENDIX B

In the a posteriori analyses, in order to compare the three types of words: CV, CVC with a match between the orthographic and phonologic syllable forms (i.e., CVC_{O+P+} - e.g., TUR.BO), and the CVC words with a mismatch such that they have a CVC orthographic first syllable but a CV phonologic first syllable (i.e., CVC_{O+P-} - e.g., PEN.TE); 14 CV words and 14 CVC_{O+P+} words were selected from our materials to be matched with the 14 existing CVC_{O+P}, keeping all the psycholinguistic variables in which the total pool of stimuli (48 CV and 48 CVC words) were controlled for (see Table 1), except for the number of phonemes (Mcv = 4.86, $M\text{cvc}_{o+p+}$ = 5.07 and $M\text{cvc}_{o+p-}$ = 4.07; $p < .001$). The analyses performed here mimicked the ones conducted with all the CV and CVC words even though the factor Target type has here three levels (CV| CVC_{O+P+}| CVC_{O+P-}) instead of two (CV|CVC).

Regarding reaction times, neither the main effects of prime type, $F(2, 1307.89) = 0.0196$, $p = .981$, target type, $F(2, 39.35) = 1.4694$, $p = .242$, nor the interaction between prime type and target type $F(4, 1307.91) = 1.7562$, $p = .135$ reached statistical significance. As for the accuracy data, neither the main effects of prime type, $\chi = 1.256$, $p = .534$, target type, $\chi = 1.352$, $p = .509$, nor the interaction between prime type and target type, $\chi = 8.324$, $p = .080$ were statistically significant.

Table B1
Mean and Standard Deviations (in Brackets) of Response Times (RTs) and Percentage of Errors (%E) per Prime Condition.

Target type	Prime type					
	Congruent		Incongruent		Unrelated	
	RT	%E	RT	%E	RT	%E
CV	710 (219)	4.8 (21)	724 (171)	2.4 (15)	721 (190)	2.4 (15)
$CVCO_{+P+}$	792 (235)	4.2 (20)	768 (240)	3.6 (19)	736 (199)	6.0 (24)
CVC_{O+P-}	734 (183)	2.4 (15)	746 (214)	7.1 (26)	722 (188)	3.0 (17)

In Table B1, we present the means and standard deviations for the CV, CVC_{O+P+}, and CVC_{O+P-} regarding the reaction times and accuracy data.

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