Universidade do Minho
Escola de Psicologia

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The role of the syllable as the sublexical unit in visual word recognition in Portuguese: A study with skilled and developing readers

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Trabalho realizado sob a orientação da
Professora Doutora Ana Paula Carvalho Soares
e da
Doutora Helena Mendes Oliveira

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DECLARAÇÃO

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"The two most powerful warriors are patience and time"- Leo Tolstoy

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The role of the syllable as the sublexical unit in visual word recognition in Portuguese: A study with skilled and developing readers.

Abstract

The role of the syllable as a sublexical unit of visual word recognition has been established in languages such as Spanish and French. However, its role in European Portuguese (EP), a language with unique characteristics, remains unknown. EP has an intermediate depth orthography, highly diverse syllabic structures, and well defined syllabic boundaries. Furthermore, most studies fail to successfully disentangle syllabic effects from orthographic overlap effects, and only study this effect in monosyllabic and dissyllabic words. The present dissertation is composed of two main experiments. Experiment 1 aimed to analyze whether the syllable has a functional role at first stages of visual word recognition in EP by using a lexical decision task combined with a masked priming paradigm in skilled readers. In Experiment 2, we further analyze the developmental trajectories of this effect, by using dissyllabic and trisyllabic EP words with beginning (3rd graders), intermediate (5th graders) and a control group of skilled EP readers. Results showed reliable syllabic effects in skilled and intermediate readers, thus establishing the syllable as the sublexical unit of visual word recognition for EP.

Key-words: Syllable effects, visual word recognition, sublexical unit.

O papel da sílaba como unidade sublexical no reconhecimento visual de palavras do português: Um estudo com leitores aprendizes e proficientes

Resumo

O papel da sílaba como unidade sublexical no reconhecimento visual de palavras foi já estabelecido em línguas como o Espanhol e o Francês. No Português Europeu (PE), uma língua com características únicas, permanece desconhecido. O PE é uma língua com uma ortografia intermédia, estruturas silábicas diversas e limites silábicos bem demarcados. Além disto, a maioria dos estudos são incapazes de separar efeitos silábicos de ortográficos, e só estudam estes efeitos em palavras monossilábicas e dissilábicas. O presente estudo é composto por duas experiências. Na primeira experiência usámos uma tarefa de decisão lexical com paradigma de priming mascarado, usando palavras dissilábicas para estudar os efeitos da sílaba no Português em leitores experientes; na segunda experiência investigámos a trajetória desenvolvimental do efeito silábico em palavras dissilábicas e trissilábicas usando, para o efeito, um grupo de leitores aprendizes (alunos do terceiro ano), um grupo de leitores intermédios (alunos do quinto ano) e um grupo de controlo de leitores proficientes. Encontrámos um efeito de facilitação silábico para palavras dissilábicas e trissilábicas, tanto no grupo dos leitores experientes como no dos intermédios, estabelecendo assim o papel da sílaba no reconhecimento visual de palavras para o PE.

Palavras-Chave: Sílaba, reconhecimento visual de palavras, unidade sublexical.

Introduction

Reading is one of the basic cognitive skills that we use in our every-day life. Due to its importance, it has been the focus of many psycholinguistic investigations, and several computational models have been constructed to explain how readers process written words (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Perry, Ziegler, & Zorzi, 2007; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989; Ziegler, Perry, & Coltheart, 2000). However, most of the current visual word recognition models, can only account for the recognition effects of monosyllabic words (e.g., Coltheart et al., 2001; Plaut et al., 1996; Seidenberg & McClelland, 1989; Ziegler et al., 2000), thus failing to provide an adequate explanation on how we process polysyllabic words. This is an important limitation since polysyllabic words constitute the majority of the lexicon. For instance, in Portuguese, Soares et al. (2014a) highlighted that only 641 words (0.3%) of the P-PAL corpus (a printed corpus over 200 million words) were monosyllables, which means that 97.7% of the Portuguese lexicon is constituted by polysyllabic words. This is also true for other languages such English (e.g., Baayen, Piepenbrock, & van Rijn, 1993) and Spanish (e.g., Vitevitch & Rodriguez, 2004). Hence, understanding the processing of polysyllabic words is imperative (e.g., Yap & Balota, 2009). Moreover, its study introduces additional questions in visual word recognition research such as stress assignment, vowel reduction, and syllabic parsing (Brand, Rey, & Peereman, 2003). Thus, what is known about the processing of monosyllabic words might not be directly generalized to multisyllabic words and ascertaining the sublexical factors that can affect the word recognition beyond one syllable long has prompt an increasing number of studies (e.g., Perry, Ziegler, & Zorzi, 2010; Taft, 1979).

The favorite sublexical candidate is the syllable (Lima & Pollatsek, 1983; Rapp, 1992), due primarily to its importance in speech perception (e.g., Mehler, Dommergues, Fraunfelder, & Seguí, 1981, Morais, Content, Cary, Mehler, & Seguí, 1989). Indeed, many studies conducted in different languages (see, for example, in Spanish, Álvarez, Carreiras, & Taft, 2001; Carreiras, Álvarez, & de Vega, 1993; in French, Marín & Carreiras, 2002; and, in German, Conrad, Carreiras, & Jacobs, 2008) have analyzed the role of syllables in visual word recognition, mainly through the manipulation of syllable frequency (e.g., Álvarez et al., 2001; Carreiras et al., 1993) and/or the (in)congruency of the syllables shared between primes and targets in priming paradigms (e.g., Carreiras & Perea, 2002).

The rationale of the first type of studies is that, if readers parse printed words into syllables, then the frequency of the syllables should impact word recognition. For instance, Álvarez et al. (2001), using a lexical decision task (LDT), found that words with a high frequent first syllable produce longer response times and higher error rates than words with lower frequent first syllables. This inhibitory effect observed in high and low frequent words was explained based on the idea that words with higher frequency syllables activate more candidates (syllabic neighbors), thus delaying word recognition. Subsequent studies conducted in French (e.g., Mathey & Zagar, 2002) and in German (e.g., Conrad & Jacobs, 2004), successfully replicated this effect, thus showing that syllable effects are not restricted to Romance languages. Romance languages are considered particularly prone to syllabic effects in word processing because syllables are clearly marked in speech and have a simple structure in a relative low number syllable structures (note, however, that German is a non-Romance language with well-defined boundaries). For English, however, there is much less evidence for syllabic effects (e.g., Croot & Rastle, 2004; Ferrand, Segui, & Humphreys, 1997). This was explained on the basis that the English orthographic system is much more opaque which can lessen the use of phonological codes in word recognition. Furthermore, the majority of words in the English lexicon do not have clear syllabic boundaries, so it was proposed that readers segment words according to other sublexical units. Taft (1979, 1992), for instance, suggested that English words are segmented based either on the spoken syllable by maximizing the onset of the syllable (the Maximum Onset Principle), or according to the Basic Orthographic Syllabic Structure (BOSS), i.e. by maximizing the coda of the first printed syllable.

Moreover, it is important to note that the syllabic frequency effects survived even when controlling relevant factors that can muddle the results. For instance, Seidenberg (1987, 1989) highlighted the importance of taking into account the letter co-occurrences within and across syllables (the so-called bigram through) because the syllabic effect might simply be a by-product of the orthographic distribution of the bigrams within a word. That is, the bigram that forms the boundary between two syllables is usually much low frequent than the bigram within the syllable, which might explain the effect. Nonetheless, as Doignon and Zagar (2005) or Conrad, Carreiras, Tamm, and Jacobs (2009) demonstrated, syllable frequency effects are still present when the orthographic redundancy is controlled.

Note though, that, as Carreiras and Perea (2002) mentioned, syllable letter co-occurrences are typically high frequent within the lexicon, and without that control it is not possible to sustain that the effect is syllabic in nature. In an attempt to disentangle the orthographic from the syllabic effects, Álvarez, Carreiras, and Perea (2004) conducted a LDT study combined with a masked priming paradigm, in which dissyllabic Spanish words starting with either a CV (e.g., JU.NIO) or a CVC first-syllable structure (e.g., MON.JA) were used as targets that were proceeded either by a congruent syllable nonword prime (i.e., a nonword that shared the first three letters and the first-syllable with the target - e.g., ju.nas-JU.NIO, ver.bu-VER.JA), or by an incongruent syllable nonword prime (i.e., a nonword that shared the first three letters but not the syllabic boundary with the target - e.g, jun.to-JU.NIO, ve.rus-VER.JA). With this orthographic control (the incongruent syllable condition) they were able to demonstrate that the facilitation effects were indeed of syllabic nature, as they found significant differences between the congruent and the incongruent condition, though restricted to CV words. This syllable structure effect was explained based on the fact that the CV is the most common syllable structure in Spanish. Therefore, the system would firstly process a CV syllable in a CVC word, which would make the syllabic effect to fade.

In spite that genuine syllable effects are established in languages such as French and Spanish, its role in European Portuguese (EP), a language with unique linguistic characteristics, remains unknown. Just like French and Spanish, EP has clear syllabic boundaries, its orthographic system is more deep than Spanish (but more shallow than French and English, Viana, Andrade, & Trancoso, 1991), and, importantly, has one of the richest syllabic structures of all Romance languages. Furthermore, and unlike Spanish, that is considered a syllable-timed language, EP, like English, is a stress-timed language. Therefore EP is a in between language considering the characteristics of English and Spanish, which makes it a pivotal language in the study of syllable effects in visual word recognition. In this work we aimed to analyze, for the first time to the best of our knowledge, the role of syllables at early stages of visual word recognition in Portuguese by conducting two sets of studies. Experiment 1 aimed to analyze if the syllable is or a sublexical unit in lexical access in Portuguese with skilled readers, and Experiment 2 aimed to further analyze the developmental trajectories of syllable effects in EP, by using developing readers (3rd and 5th grade children). With these two sets of experiments we aimed not only to overcome the gap of the absence of syllable studies in EP, but also to contribute to the study of how this effect evolves during reading acquisition, a neglected topic in literature. In both experiments we used a LDT (though in Experiment 2 its Go-No-Go variant) combined with a masked priming paradigm that tap first stages of visual word recognition. Following Álvarez et al. (2004) CV and CVC target words (dissyllabic in Experiment 1 and di- and trisyllabic in Experiment 2) were preceded either by a syllabic congruent prime (e.g., .g., ru.mis-RU.MOR; for.pa-FOR.NO), or a syllabic incongruent prime (e.g., rum.pa-RU.MOR, fo.rou-FOR.NO). We decided to introduce an extra unrelated condition in order to analyze whether the effects observed were of facilitation or of inhibition relative to the baseline unrelated condition. In line with results observed in other Romance languages, we expect to observe syllable effects in the visual word recognition, though these might be more subtle, since they are of phonological nature and as we mentioned, EP is an intermediate-depth language. Moreover, EP has a more diverse and complex syllable structure than other Romance language, which means that the differences observed between syllable structures in Spanish, might be less noticeable. Note that the CV syllable structure is three times more frequent than the CVC syllable structure (see Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000), and in EP the differences between CV and CVC syllable structure is not near as great. Indeed, if we consider for example all the dissyllabic words in the Portuguese Procura-PALavras lexical database (P-PAL; Soares et al., 2014a), 38% showed a CV first-syllable structure while 30.2% showed a CVC first syllable structure. Besides, when considering all the corpus, EP showed 40 different first-syllable types, while Spanish showed only 16 syllable types as obtained from the EsPal lexical database (Sebastián-Gallés, et al., 2000).

Experiment 1: Skilled adult readers

Method

Participants. Thirty-six undergraduate students from Minho University (M_{age}=19.4; SD_{age}= 3.57; 32 female) took part in the experiment. All of them were native speakers of EP and had normal or corrected-to-normal vision.

Materials. A total of 96 dissyllabic Portuguese words were selected from the P-PAL lexical database as target words. Of these, 48 presented a CV (e.g., *RU.MOR*[rumor]) and 48 a CVC (e.g., *FOR.NO*[oven]) first-syllable structure. CV and CVC words were matched (all *p*'s >.05) in several psycholinguistic variables, as number of letters (M_{CV} = 5.0, M_{CVC} = 5.0), per million word frequency (M_{CV} = 2.4, M_{CVC} = 3.0), neighborhood size (N) (M_{CV} = 6.4, M_{CVC} = 6.7), Levenshtein Distance (OLD_{20}) (M_{CV} =1.6, M_{CVC} = 1.5), number of higher frequency neighbors (M_{CV} = 2.2, M_{CVC} = 2.2), and the mean frequency of the most frequent neighbor (M_{CV} = 65.5, M_{CVC} = 76.8). Furthermore, CV and CVC words were also matched (all *p*'s > .05) in several positional and non-positional type and token syllable measures, such as the number of words that share the same syllable structure (M_{CV} = 106.9, M_{CVC} = 120.7), the mean frequency of these words (M_{CV} = 53.5, M_{CVC} = 60.4), or the summed frequency (LOG10 transformed) of the frequencies (M_{CV} = 2.7, M_{CVC} = 2.2).

For each target, three types of orthographic legal nonword primes were created: (i) nonwords that shared the first three letters and the first syllable with the target (i.e., syllable-congruent condition - e.g., ru.mis-RU.MOR[rumor], for.pa-FOR.NO[oven]); (ii) nonwords that shared the first three letters, but not the first syllable with the target (i.e., syllable-incongruent condition - e.g., rum.pa-RU.MOR, fo.rou-FOR.NO); and lastly (iii) nonwords that did not share any letters or syllables with the target (i.e., unrelated condition - e.g., ca.fas RU.MOR, pou.me-FOR.NO). Additionally, a set of 96 legal nonwords targets were also created for the purpose of the LDT. Nonword targets were created by replacing one or more two letters in other Portuguese words with similar characteristics as the experimental words. The manipulation for the nonword and word targets was the same. Three lists of materials were created to counterbalance targets in the three prime conditions. Participants were randomly assigned to each list, assuring the same number of participants per list. Target words and nonwords and primes are presented in the Appendix A.

Procedure. The experiment was run individually in a sound-proof booth. Presentation of the stimuli and recording of responses were controlled by DMDX software (Forster & Forster, 2003). Participants were asked to decide as quickly and accurately as possible if the string of letters presented in uppercase (targets) at the center of the computer screen was or was not a real word in Portuguese. If participants considered that the string of letters was a real word in Portuguese they should press the “M” key on the keyboard (“*sim*”[yes] response). Conversely, if they considered that it was not a real word in Portuguese they should press the “Z” key on the keyboard (“*não*”[no] response). The LDT was composed of 192 trials (96 words and 96 nonwords) that were randomly presented to participants. Each trial consisted of a sequence of three visual events presented at the center of the computer screen: a forward mask (#####), presented for 500 ms, the prime, presented in lowercase for 50 ms, and the target, presented immediately after the prime, in uppercase. Targets remained on the screen, until participants’ response or until 2500 ms had elapsed. Participants were not informed about the presence of lowercase stimuli (primes). Prior to the experimental trials, participants received 12 practice trials (six words - three with a CV structure and three with a CVC structure, and six nonwords) with the same manipulation as that in the experimental trials to familiarize them with the task. The whole session lasted approximately 15 minutes per participant.

Results

Incorrect responses for target words (4.8%) were excluded from the analysis. Words with an error rate above 33% were also excluded (these occurred for 10 words in total). In addition, reaction times (RTs) that were below 300 ms and above 1500 ms were also excluded. We also eliminated RTs below and above 3.0 standard deviations from the average of each participant. The mean of the RTs for the correct responses and the percentage of errors committed for the target words in each of the six experimental conditions are presented in Table 1.

Table 1.

Mean of lexical decision times (in ms) and of the percentage of errors committed (in brackets) on target words by experimental condition.

Word first-syllable structure	Prime first-syllable structure		
	CV.	CVC.	Unrelated
CV.	762 (5.7)	812 (7.0)	813 (6.4)
CVC.	826 (7.1)	818 (7.4)	828 (7.2)

Repeated-measures of variance (ANOVAs) considering participants (F_1) and items (F_2) were conducted based on a 3 (type of prime: syllabic congruent, syllabic incongruent, and unrelated) x 2 (type of target: CV vs. CVC) x 3 (list: List 1, List 2, List 3) mixed design, both on RT and accuracy data. In the F_1 analyses, type of prime and type of target were considered as within-subject factors, and list as a between-group factor, while in the F_2 analyses, type of prime was considered a within-subject factor, and type of target and list as between-group factors. List was included in the analyses to remove the error of variance due to the counterbalance of the items across conditions (Pollatsek & Well, 1995).

On RT data the ANOVA showed a main effect of the type of prime, $F_1(2, 66) = 7.499$, $MSE = 5741.150$, $p < .001$, $\eta^2_p = .185$; $F_2(2, 160) = 7.585$, $MSE = 3987.950$, $p < .001$, $\eta 2_p = 0.087$, showing that participants were significantly faster in the syllable-congruent than in the unrelated condition ($M = 790$ and 821, respectively, $p <.001$), and critically that the differences between the syllable-incongruent and the unrelated conditions did not reach statistical significance (*M* = 821 and 819, respectively, $p = 1.000$). Importantly, results also showed that the differences between syllable-congruent and incongruent conditions (*M* = 790 and 819, respectively, $p = .004$) reach statistical significance, thus revealing that the syllable effect observed is not due to the orthographic overlap between primes and targets. The ANOVA also showed a significant main effect of type of target, $F_1(1, 33) = 15.193$, $MSE = 2798.441$, $p < .001$, $\eta^2_p = .315$, $F_2(1, 80) = 1.138$, $MSE = 22613.125$, $p = .148$, $\eta^2_p = .026$, though restricted to participants' data. This effect showed that participants were faster with CV (*M* = 796) than a CVC (*M* = 824) targets. The interaction between the word first-syllable structure and the type of prime also reached statistical significance, $F_1(2, 66) = 3.210$, $MSE = 6561.351$, $p = .047$, $\eta^2_p = .089$, $F_2(2, 160) = 3.771$, $MSE = 3987.950$, $p = .025$, $\eta^2_p = .045$. The pairwise comparisons revealed that the syllable priming effect reported above (i.e., faster RTs for syllable related primes than for the unrelated and orthographic primes) was restricted to CV words ($p < .001$). For CVC words there was no signs of priming effects.

The ANOVA on accuracy data showed a significant effect of type of target, $F_1(1, 33) = 4.462$, $MSE =$, $p = .042$, $\eta^2_p = .119$, $F_2(1, 80) = 1.408$, $MSE = .017$, $p = .239$, $\eta^2_p = .017$, though only on the participants' data. In line with the results on the RTs data, participants committed fewer errors with CV (*M* = 8.2%) than CVC words (*M* = 6.3%). Neither the effect of type of prime nor the interaction between the two factors reached statistical significance.

In sum, our major findings in this first experiment were clear cut and established, for the first time, a genuine syllable effect in Portuguese skilled readers. Moreover, the results also showed that although Portuguese has a much more diverse and complex syllable structures than other Romance languages (the differences between CV and CVC syllables are much less pronounced), the syllable effect observed was restricted to CV words, thus replicating the results previous observed in the Spanish language by Álvarez et al. (2004). Having established the syllable effect in EP with skilled readers, Experiment 2 aimed to investigate how this effect evolves during reading acquisition.

Experiment 2: Developing Readers

As mentioned in the Introduction, studies conducted with children are scarce and the few investigating the sensitivity of small children to the syllable in printed words lead to inconsistent results (Chetail & Mathey, 2012; Colé, Magnan, & Grainger, 1999; Katz & Baldasare, 1983). For instance, while Katz and Baldasare (1983) in a TDL study with 2nd English graders found no syllabic effects in a TDL, Colé et al. (1999), using a visual segment monitoring task with 1st French grade children, found significant syllabic effects. Besides language differences that can account for the inconsistency of the results observed, the studies conducted with children also face a lot of criticism because they either do not use the same experimental paradigms as the ones used with skilled readers or the tasks used do not necessarily force participants to access to their lexicon (e.g., Colé et al., 1999). In an attempt to overcome these limitations, Chetail and Mathey (2012) conducted recently a study with French intermediate readers (6th graders) by using the same paradigm used by Álvarez et al. (2004) with CV and CVC dissyllabic French words. Chetail and Mathey (2012) found faster recognition times for words preceded by a syllable-congruent (e.g., vo.liar-VO.LUME; vol.tie-VOL.CAN), than by a syllable-incongruent (e.g., vol.cer-VO.LUME; vo.lode-VOL.CAN) prime, both for CV and CVC words, thus replicating the syllabic effect observed with French skilled readers (e.g., Marín & Carreiras, 2002), that were not restricted to CV words as in Spanish and also in Portuguese as our first experiment demonstrated. However, what happens with earlier stages of reading acquisition (beginning readers) and also with words that extend two-syllables remains unanswered (note that the abovementioned studies conducted with 1st and 2nd graders did not use the same paradigm). This is an important point, since in EP dissyllabic words only represent 6.9% of the words in the entire P-PAL corpus. Therefore, what we know about syllabic effects in visual word recognition may constitute not the rule but the exception at least in EP. To the best of our knowledge up to now only two studies tried to investigate syllabic effects using words with more than two syllables. Ferrand, Segui, and Grainger (1996) in a naming task study with French skilled readers found facilitation effects, both for dissyllabic and trisyllabic CV and CVC words (thus replicating the results also found in visual word recognition studies – Álvarez et al., 2004). However, in Italian, Bertinetto and Finocchiaro (2003) using a TDL combined with a masked priming paradigm as Álvarez et al. (2004) study, failed to found any syllabic effect both with CV and CVC trisyllabic words. This is a surprising result since Italian, as Spanish, has a shallow orthographic system, and previous studies with dissyllabic words showed a reliable syllabic effect. Therefore, word syllable length can be an important variable that should be further investigated. For that reason, in this second experiment we aimed not only to analyze the dynamics of syllabic effects as the reading acquisition process unfolds (note that we used not only intermediate readers as Chetail and Mathey, but also beginning readers with same masked priming paradigm), but also to further analyze if the number of syllables and not only syllable structure (CV and CVC), will affect the speed and/or accuracy with which Portuguese developing readers will recognize di- and trisylabic Portuguese words. In Experiment 2, we also use an identity prime condition as typically used in studies with developing readers (e.g., Moret-Tatay, & Perea, 2011) to guarantee that the task worked appropriately with developing readers (particularly with the youngest).We also used another group of Portuguese skilled readers, as control.

Method

Participants. Thirty-six 3rd grade (M_{age} = 8.7 years; SD_{age} = 4 months; 22 female), 36 5th grade children (M_{age} = 10.6 years; SD_{age} = 3 months; 20 female) from two private schools, and 36 undergraduate students from Minho University (M_{age} = 21.5; SD_{age} = 5.2; 31 female) participated in the experiment. All of them were native speakers of EP and had normal or corrected-to-normal vision.

Materials. A total of 144 Portuguese words (72 dissyllabic and 72 trisyllabic) were selected from the ESCOLEX lexical database (Soares et al., 2014b) as target words. On each syllable length, half of the words have a CV structure (e.g., BA.ZAR[bazar], CA.RACOL[snail]) and the other half a CVC syllabic structure (e.g., CIS.NE[swan], PER.FUME[perfume]). CV and CVC target words were matched (all *p*'s > 0.5) in number of letters (*M*cv = 6.0: *M*cvc = 6.0), per million word frequency (*M*cv = 4.2; *M*cvc = 3.7), and contextual diversity (*M*cv = 0.099; Mcvc = 0.097) measures, as obtained from the ESCOLEX, and additionally in neighborhood size (N) (*M*cv = 4.4; *M*cvc = 4.5), mean frequency of orthographic neighbors (*M*cv = 6.2; *M*cvc = 17.8), number of higher frequency orthographic neighbors (*M*cv = 1.2; *M*cvc = 1.4), mean frequency of higher frequency orthographic neighbors (*M*cv = 31.7; *M*cvc = 38.3), and the Levenhstein distance (OLD_{20}) (*M*cv = 1.8; *M*cvc = 1.7) as obtained from the P-PAL database. Note that CV and CVC words were also matched (all *p*'s < .05) on the number of words that share the first bigram in Position 1 (*M*cv = 170.5; *M*cvc = 206.8), the number of words that share the first bigram in any position (*M*cv = 537.7; *M*cvc = 561.7), the summed frequency of words sharing the first bigram in any position (*M*cv = 2519.5; *M*cvc = 2862.9), as well as the summed frequency of words (LOG10 transformed) that share the first trigram in Position 1 (*M*cv = 83.7; *M*cvc = 148.8), the number of words that share the second trigram in Position 2 (*M*cv = 25.7; *M*cvc = 20.0), and the summed frequency of words that share the second trigram in any position (*M*cv = 309.0; *M*cvc = 530.9).

As for Experiment1, in this experiment each target-word was preceded by nonword primes that could be syllable-congruent (e.g., ba.zis-BA.ZAR[bazar], cis.ra-CIS.NE[swan], ca.romai-CA.RACOL[snail], per.tano-PER.FUME[perfume]), syllable-incongruent (e.g., baz.fa-BA.ZAR[bazar], ci.ser-CIS.NE[swan], car.navo-CA.RACOL[snail], pe.rilno-PER.FUME[perfume]), or unrelated (e.g., de.cre-BA.ZAR[bazar], zar.vo-CIS.NE[swan], no.codat-CA.RACOL[snail], gas.lono-PER.FUME[perfume]) with the target. Additionally, we used an identity prime condition (i.e., the repetition of the target) to assure that the children (particularly the youngest) performed the task appropriately. A set of 144 legal nonwords were created as targets for the purpose of the TDL. Nonword targets were created by replacing one or more letters in other Portuguese words with similar characteristics to the experimental words. The manipulation for the nonword and word targets was the same. Four lists of materials were created to counterbalance targets across the four prime conditions. Participants were randomly assigned to each list, assuring that in each list we had the same number of participants. Target words and nonwords are presented in the Appendix B.

Procedure. Participants performed a Go-No-Go task combined with a sandwich masked priming technique. As in other studies with developing readers (e.g., Moret-Tatay, & Perea, 2011; Soares et al., 2014) we opted to use a Go-NoGo task because children are faster and more accurate in this variant of the LDT. We also used a sandwich priming paradigm instead of the traditional masked priming paradigm used in Experiment 1, because this procedure seems to maximize priming effects (Lupker & Davis, 2009)

The Go-NoGo task entailed 288 trials (144 words and 144 nonwords) that were randomly presented to the participants. Each trial consisted of a sequence of four visual events presented at the center of the computer screen: a forward mask (#######), presented for 500 ms, the target, presented in uppercase for 33 ms, the prime, presented in lowercase for 50 ms and the target again, presented in uppercase for 2500ms or until participants respond. Presentation of the stimuli and recording of responses were controlled by DMDX software (Forster & Forster, 2003). Participants were asked to decide as quickly and accurately as possible if the string of letters presented in uppercase (targets) at the center of the computer screen was or was not a real word in Portuguese. If participants considered that the target was a real word in Portuguese they should press the "M" key on the keyboard ("*sim*"[yes] response). Conversely, if they considered that it was not a real word in Portuguese they were instructed to refrain from responding. Participants were not informed about the presence of stimuli before target presentation. Prior to the experimental trials, participants received 8 practice trials (4 words and 4 nonwords) with the same manipulation as that in the experimental trials to familiarize them with the task. The whole session lasted approximately 25 minutes.

Results

Incorrect responses for target words (18.3% in beginning readers; 5.2% in the intermediate readers; 4.2% in the skilled readers) were excluded from the analysis. Words with an error rate above 33% (26 words beginning readers, 3 in intermediate readers, and none in skilled readers) were also excluded. In addition, RTs that were above 2000 ms and bellow 500 ms for the beginning and intermediate readers, and above 1500 ms and bellow 300 ms for the skilled readers, were also excluded. We also eliminated RTs below and above 3.0 standard deviations from the average of each participant. Table 2 presents the means of RTs for the correct responses and the percentage of errors committed by beginners, intermediates, and skilled readers to target words in each experimental condition.

Repeated-measures of variance (ANOVAs) considering participants (F_1) and items (F_2) were conducted based on a 4 (type of prime: identity, syllable-congruent, syllable-incongruent, and unrelated) x 2 (type of target: CV vs. CVC) x 2 (syllable length: dissyllabic vs. trisyllabic) x 4 (list: List 1, List 2, List 3, List 4) mixed design, both on RT and accuracy data for each reader group. In the F_1 analyses, type of prime, type of target, and syllable length were considered as within-subject factors, and list as a between-group factor, while in the F_2 analyses type of prime was considered a within-subject factor, while type of target, target length, and list were considered as between-group factors. List was included in the analyses to remove the error of variance due to the four counterbalancing lists (Pollatsek & Well, 1995).

Table 2.

Mean of lexical decision times (in ms) and of percentage of the errors (in brackets) on target words by experimental condition and reader group.

Type of target	Type of prime / Syllable length	Reader group: Beginners		Intermediates		Skilled	
		dissyllabic	trisyllabic	dissyllabic	trisyllabic	dissyllabic	trisyllabic
CV.	Identity	931 (8.0)	1102 (13.9)	838 (8.3)	916 (3.5)	684 (7.0)	690 (4.4)
	Congruent	970 (10.3)	1107 (12.9)	839 (8.5)	973 (7.0)	735 (5.3)	773 (3.9)
	Incongruent	986 (12.5)	1064 (8.3)	898 (6.0)	996 (5.9)	738 (2.7)	759 (4.4)
	Unrelated	1009 (14.4)	1191 (18.8)	926 (8.5)	1013 (8.8)	767 (4.5)	767 (5.1)
CVC.	Identity	971 (9.0)	1053 (12.3)	840 (4.3)	878 (4.0)	686 (2.8)	701 (2.7)
	Congruent	1001 (11.8)	1097 (8.3)	867 (5.9)	944 (2.2)	735 (3.3)	762 (4.8)
	Incongruent	1016 (15.2)	1115 (10.9)	885 (4.3)	961 (3.4)	724 (2.7)	764 (2.7)
	Unrelated	1060 (12.2)	1151 (14.2)	952 (6.8)	1010 (2.8)	767 (4.5)	794 (3.3)

Before presenting the results, it is important to note that we decided to conduct ANOVAs by reader group because conducting joint analyses will add another factor which will increase the complexity of the design, and highlight differences that we do not want to explore (e.g., adults are much faster than developing readers) and lessen others that probably emerge when conducting analysis separately.

In the beginning reader group, the ANOVA conducted on the RT data showed a significant main effect of syllable length, $F_1(1, 32) = 88.589$, $p <.001$, $MSE = 22239.524$, $\eta^2_p = 0.735$; $F_2(1, 102) = 29.094$, $p < .001$, $MSE = 46888.323$, $\eta^2_p =0.222$, revealing that 3rd graders were faster with di- ($M = 993$) than with trisyllabic ($M = 1{,}110$) words, as expected. The ANOVA also showed a significant main effect of type of prime, $F_1(3, 96) = 17.535$, $p < .001$, $MSE = 34033.365$, $\eta^2_p = 0.354$; $F_2(3, 306) = 17.684$, $p < .001$, $MSE = 32624.792$, $\eta^2_p = 0.148$. This effect revealed that, besides being faster in the identity condition than in the unrelated condition ($M = 1{,}014$ and $1{,}103$ respectively $p < .001$), as expected, beginning readers were also faster in the syllabic congruent condition than in the unrelated condition ($M = 1{,}044$ and $1{,}103$, $p = .002$). However, results also indicated that incongruent syllable primes also produced faster recognition times than unrelated primes ($M = 1, 045$ and $1{,}103$, $p = .002$), thus indicating that both syllable-congruent and incongruent primes facilitate word recognition. Moreover, the results of the ANOVA on accuracy data showed a significant main effect of syllable length, $F_1(1,32) = 4.381$, $p = .044$, $MSE = 0.020$, $\eta^2_p = .120$, $F_2(1, 102) = 2.304$, $MSE = .031$, $\eta^2_p = 0.022$, indicating that beginning readers committed few errors with dissyllabic ($M = 10.8\%$) than trisyllabic words ($M = 13.3\%$). Moreover, a significant main effect of word syllable structure emerged, $F_1(1,32) = 6.965$, $p = .013$, $MSE = 0.012$, $\eta^2_p = .179$, $F_2(1, 102) = 2.070$, $p = .153$, $MSE = .031$, $\eta^2_p = 0.020$, showing that 3rd graders committed few errors in CVC ($M = 10.9\%$) than in CV words ($M = 13.2\%$). The main effect of type of prime also reached significance, $F_1(3, 96) = 3.747$, $p = .037$, MSE = 0.043, $\eta^2_p =.105$, $F_2(3, 306) = 4.171$, $p = .022$, $MSE = .031$, $\eta^2_p = .039$. This effect showed that participants committed significantly less errors not only in the identity relative to the unrelated condition ($M = 10.8\%$ vs. 14.9%, $p = .043$), as expected, but importantly in the syllable-congruent condition relative to the unrelated condition ($M = 10.8\%$ vs. 14.9%, $p = .037$). The differences between the syllabic incongruent and the unrelated conditions ($M = 11.7\%$ vs. 14.9%) as well as between the syllabic congruent and incongruent conditions ($M = 10.8\%$ vs. 11.7%) failed to show statistical significance. These results showed that, although syllables eased word processing in beginning readers, the absence of statistical differences between the syllable-congruent and syllable-incongruent conditions mean that there was no genuine syllabic effect.

For 5th grade children, the ANOVA on the RTs data showed a significant main effect of syllable length, $F_1(1, 32) = 44.135$, $p < .001$, $MSE = 21312.623$, $\eta^2_p = 0.581$; $F_2(1, 125) = 10.583$, $p = .001$, $MSE = 75291.425$, $\eta^2_p = 0.078$, indicating that intermediate readers were faster with dissyllabic ($M = 881$) than trisyllabic words ($M = 962$). The ANOVA also showed a significant main effect of the type of prime $F_1(3, 96) = 46.928$, $p < .001$, $MSE = 19124.215$, $\eta^2_p = 0.595$, $F_2(3, 375) = 21.171$, $p < .001$, $MSE = 34723.053$, $\eta^2_p = 0.145$, indicating that besides being faster in the identity condition than in the unrelated condition ($M = 868$ vs. 976, $p < .001$), as expected, intermediate readers were also faster in the syllable-congruent condition than in the unrelated condition ($M = 906$ vs. 976, $p < .001$) and in the syllabic incongruent condition than in the unrelated condition ($M = 935$ vs. 976, $p = .001$), mimicking the results observed for 3rd graders. However, and importantly, with intermediate readers the differences between the syllable-congruent and the syllable-incongruent conditions reached statistical significance ($M = 906$ vs. 935, $p = .041$), thus establishing a genuine syllabic priming effect in intermediate readers, both in CV and CVC dissyllabic and trisyllabic words. Moreover, the ANOVA on accuracy data showed a significant main effect of syllable length, $F_1(1, 32) = 10.019$, $p = .003$, $MSE = .005$, $\eta^2_p = 0.238$, $F_2(1, 125) = 1.612$, $p = .207$, $MSE = .024$, $\eta^2_p = 0.014$, showing that, contrarily to 3rd graders, 5th graders committed more errors with dissyllabic ($M = 6.6\%$) than trisyllabic words ($M = 4.7\%$). A significant target first-syllable structure was also observed, $F_1(1, 32) = 24.308$, $p < .001$, $MSE = .005$, $\eta^2_p = .432$, $F_2(1, 125) = 5.010$, $p = .027$, MSE=.024, η^2_p =.039 indicating, as for beginner readers, that intermediate readers committed few errors in CVC ($M = 4.2$) than in CV words ($M = 7.1$).

Finally, the results from the adult skilled group showed that on the RTs data, showed a significant main effect of syllable length, $F_1(1, 32) = 15.297$, $p < .001$, $MSE = 3652.696$, $\eta^2_p = 0.323$; $F_2(1, 128) = 2.921$, $p = .090$, $MSE = 8432.327$, $\eta^2_p = .022$, showing that skilled readers were faster with dissyllabic ($M = 733$) than trisyllabic words ($M = 753$), as previously observed for beginner and intermediate readers. The ANOVA also showed a significant effect of the type of prime F_1 (3, 96) = 66.766, $p < .001$, MSE = 9696.179, $\eta^2_p = 0.676$, $F_2(1, 128) = 29.392$, $p < .001$, MSE = 21161.016, $\eta^2_p = 0.187$, showing, that besides being faster in the identity condition relative to the unrelated condition ($M = 690$ vs. 783, $p < .001$), adult skilled readers were also faster in the syllable-congruent condition ($M = 751$) than in the unrelated condition ($M = 751$ vs. 783, $p < .001$). Moreover, the effect revealed that the differences between the syllable-incongruent and the unrelated condition also were also significant (*M* = 746 vs. 783, $p < .001$), though the differences between the syllable-congruent and the syllable-incongruent conditions failed to reach statistical significance, as observed in intermediate readers. Additionally, neither the effect of type of target nor the interaction between the factors reached statistical significance.

These results were unexpected and showed that the syllable effect observed in Experiment 1 for skilled readers was not replicated in this second experiment. Besides the differences in stimuli composition (in Experiment 2 we used another set of dissyllabic words selected from the ESCOLEX database), the new (more complex) factorial design (note that we now have 16 experimental conditions since we use not only di- and trisyllabic words but also an extra identity prime condition), and the methodological options in data collecting procedures might underlie the differences in the results (note that in Experiment 1 we used the classic masked priming paradigm, while in Experiment 2 we used the sandwich masked priming paradigm). In order to test whether these potential explanations in the skilled reader group, we firstly improve our sample size to 52 participants (13 per list) and then we conducted an extra experiment (Experiment 3) with the same stimuli used in Experiment 2, but with the paradigm adopted in Experiment 1 (classic masked priming). Note that in a sandwich priming paradigm, since the target is also presented as a prime, this could allow for a higher target activation, thus justifying that the syllabic effect vanishes in Experiment 2. The results with 52 participants showed virtually the same pattern of results as in Experiment 1.

The mean of the RTs for the correct responses and the percentage of errors committed for the target words from Experiment 3 are presented in Table 3.

Table 3.

Mean of lexical decision times (in ms) and of the errors (%) on target words by experimental condition for the skilled readers group, using the masked priming paradigm.

Type of target	Type of prime	Syllable length	
		dissyllabic	trisyllabic
CV.	Identity	931 (8.0)	1102 (13.9)
	Congruent	970 (10.3)	1107 (12.9)
	Incongruent	986 (12.5)	1064 (8.3)
	Unrelated	1009 (14.4)	1191 (18.8)
CVC.	Identity	971 (9.0)	1053 (12.3)
	Congruent	1001 (11.8)	1097 (8.3)
	Incongruent	1016 (15.2)	1115 (10.9)
	Unrelated	1060 (12.2)	1151 (14.2)

The ANOVA on the RTs data following the same design as Experiment 2 replicated the syllable length effect, $F_1(1,48) = 35.282$, $p < .001$, $MSE = 6220.999$, $\eta^2_p = 0.424$, $F_2(1, 128)= 7.983$, $p = .006$, $MSE = 16146.278$, $\eta^2_p = 0.058$, observed in Experiment 2. Furthermore, the main effect of type of prime observed, $F_1(3, 144) = 12.189$, $p < .001$, $MSE = 13816.725$, $\eta^2_p = 0.203$, F_2 $(3, 384) = 13.192$, $p < .001$, $MSE = 9533.569$, $\eta^2_p = 0.093$, showing that participants were faster in the identity condition ($M = 749$) than in the unrelated condition ($M = 749$ vs. 785, $p <.001$), and in the syllable-congruent condition ($M = 759$) than in the unrelated condition ($M = 759$ vs. 785, $p =.001$). The differences between the incongruent condition ($M = 776$) and the unrelated condition ($M = 785$) were not significant ($p = .763$). Furthermore the differences between the syllable-congruent and the syllable-incongruent conditions ($M = 759$ vs. 776, $p = .021$), now reached statistical significance, thus revealing a reliable syllabic effect as in Experiment 1. However, since neither the effect of syllable structure (CV vs. CVC), nor the interaction between the factors reached statistical significance, contrary to the results of our first experiment, the results obtained in Experiment 3 showed that the syllable effect is not restricted to CV first-syllable structure, being observed now both of CV and CVC di- and trisyllabic Portuguese words. This will be further explored in the General discussion section. To sum up, the results from Experiments 2 and 3, showed a reliable syllabic priming effect only in the intermediate and skilled readers groups.

General Discussion

The aim of the thesis was two-unfold: to determine if the syllable is a sublexical unit at first stages of visual word recognition in EP words and to investigate the developmental dynamics of the syllabic effect in EP developing readers. Although previous studies conducted in deep and shallow syllable-timed languages, such as French and Spanish, respectively, have established the syllable as the sublexical unit of visual word recognition, its role in EP had been unattended so far. EP, as previously stated, is a language with unique characteristics since it is not only considered a stress timed language like English, but also presents an intermediate depth orthographic system which allows to distinguish it both from Spanish (that presents a shallow orthographic system), and French and English (with a deep orthographic system). Moreover, it presents a high diverse and complex syllable structures than any other Romance language. These features make, as mentioned, EP a pivotal language to study syllabic effects which also might contribute to ascertain which language characteristics might underlie the emergence of these effects across languages.

To that purpose we conducted two main experiments. Experiment 1 aimed to firstly analyze whether syllables are a sublexical unit in visual word recognition of CV and CVC dissyllabic EP words, by using a LDT combined with a masked priming paradigm. The results of the first experiment showed that, as for Spanish and French, in EP the syllable has indeed a functional role at first stages of visual word. Moreover, it also showed that this effect was restricted to CV first-syllable words. This result is in line with the study of Álvarez et al. (2004) with Spanish skilled readers and also with other studies with Spanish native speakers, using different tasks and paradigms (e.g., Costa & Sebastian-Galles, 1998; Marín & Carreiras, 2002). However, they were inconsistent with the results found by Morais et al. (1989) that found facilitation effects both for CV and CVC EP words in a detection of speech segments task. The results now observed might indicate that in reading, contrary to speech, the system is more fine-tuned in order to allow that only specific more frequent syllable structures (CV) can ease word visual recognition. In fact, this was the explanation advanced by Álvarez et al. (2004) for the syllable effect observed for CV but not for CVC Spanish words. Specifically, they stated that because in Spanish the CV is the most common syllable structure, this feature makes the cognitive system use the CV syllable to recognize words by default. Therefore, even when the system encounters a CVC syllable structure, it processes it as a CV structure which would delay word recognition for CVC words. The same argument can be used to explain the fact that in EP the syllabic effect was also restricted to CV words, although, unlike

Spanish, in EP the differences in the number of occurrences of CV and CVC words are not as pronounced as in Spanish. Therefore, the results of Experiment 1 established a genuine syllabic effect in EP, although EP is a more opaque language than Spanish, is a stress-timed language like English (where the syllabic effects have not been established), and has, by far, a more diverse and complex syllable structures than any other Romance language.

Experiment 2 aimed to understand the developmental trajectories of the syllabic effects observed in Experiment 1 in the visual word recognition of dissyllabic and trisyllabic CV and CVC Portuguese words. For that purpose, a go-no-go LDT with a sandwich priming paradigm using three groups of readers (beginning, intermediate, and skilled readers) was conducted. Results showed that, across groups, participants were faster responding to dissyllabic than trisyllabic words, which is in line with the word length effect observed in several languages (e.g., Ferrand & New, 2003; New, Ferrand, Pallier, & Brysbaert, 2006), particularly with low-frequent words, as the ones used in our experiment. Moreover, the results showed that a genuine syllabic effect was only established with intermediate readers (5^{th} graders), since beginning readers (3^{rd} graders) showed facilitative effects both for syllable-congruent and incongruent conditions, and also congruent and incongruent conditions did not differentiate statistically between each other. It is also important to note that, in the intermediate group, the syllabic effect observed in the latency data was observed both for CV and CVC di- and trisyllabic EP words. These results, although not replicating the results observed in Experiment 1, in which syllable effects were restricted to CV words, were consistent with the ones obtained by Chetail and Mathey (2012) with 6^{th} grade students.

Although the reasons for the differences observed with EP skilled readers in Experiment 1 and 2 are not immediately interpretable (note that, besides syllable length, the stimuli characteristics between words in Experiments 1 and 2 were quite similar in all the psycholinguistics characteristics considered), it is possible that t trisyllabic EP words can account for the absence of the syllable structure effect. Although the triple interaction between syllable structure, syllabic length and type of prime, failed to reach statistical significance, a further analysis of the data considering those factors revealed a clear tendency for a different pattern of results in CV and CVC words in dissyllabic and trisyllabic words. In dissyllabic words the syllabic priming effect tends to be restricted to CV words, while in trisyllabic words the syllabic effect tends to occur both for CV and CVC words.

Therefore, although the effect was not statistical significant, we believe that improving our sample size in future studies can allow for the significance, showing that in trisyllabic words both CV and CVC syllables ease processing, as observed by Ferrand et al. (1996) in a naming task study with French skilled readers. If this effect is confirmed it might suggest that syllable word length is an important factor that modulates the effect of syllable structure in visual word recognition, and that future studies on syllabic effects should account for this neglected variable in literature.

In sum, the experiments presented in this dissertation, showed that the syllabic effect observed in other Romance (e.g., Spanish, French) and non-Romance languages (e.g., German) was successfully replicated in EP, and also that this effect seems to emerge as development/reading skills evolve, being observed only at intermediate levels of reading, as previously observed by Chetail and Mathey (2012) for intermediate (6^{th} graders) French readers. Although the syllable primes help 3^{rd} grade children to process written words, this effect was not genuine, since both orthographic control primes and syllable primes eased recognition. A reliable syllabic effect only occurred at intermediate levels of reading proficiency, when the reading system is more developed and automatized, and with skilled readers though only when the classic masked priming paradigm was used, suggesting that the effect occurs at early stages of visual word recognition.

Future studies in EP should use other paradigms more sensitive to the time course of processing (e.g., eye-tracking, ERPs), other syllable lengths and syllable structures, since EP has a highly diverse and complex syllable structures and most the studies conducted so far only focus on CV and CVC first-syllable structure words.

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APPENDIX 1

Prime-target pairs in Experiment 1

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

babur; babpa; dudot; BABEL; bagra; bagmo; dopur; BAGOS; batur; batco; debro; BATOM; bazum; bazco; vefra; BAZAR; bifur; bifto; gatra; BIFES; bocor; bocte; dupre; BOCAL; cabel; cabco; netro; CABRA; cetar; cetpo; mujis; CETIM; curir; curnu; mazem; CURAS; dicre; dicta; pijer; DICAS; dunir; dunve; bivel; DUNAS; facur; facte; lovre; FACAS; farot; farfu; dixor; FAROL; febum; febco; colur; FEBRA; fedum; fedno; lefor; FEDOR; fezom; fezco; gevra; FEZES; figor; figna; lapra; FIGAS; forur; forlo; buzit; FORAL; funat; funti; lenar; FUNIL; furim; furne; toviz; FUROR; gater; gatpe; vaber; GATIL; jejar; jejco; delom; JEJUM; latre; latca; facri; LATIM; licem; licta; gotro; LICOR; luver; luvco; baver; LUVAS; murer; murze; namor; MURAL; natre; natco; zales; NATAS; nudam; nudco; velis; NUDEZ; nuvro; nuvca; vuvis; NUVEM; pirir; pirva; rusco; PIRES; polum; polno; jadro; POLAR; pudur; pudca; tefas; PUDIM; pudas; pudno; febos; PUDOR; pulis; pulzo; fande; PULOS; remer; rembe; vonar; REMOS; robir; robta; zorlo; ROBES; ruble; rubco; nitus; RUBRA; rumum; rumpi; niver; RUMOR; sinai; sinra; nacro; SINOS; sobur; sobpu; befro; SOBRA; tiqro; tiqta; lapos; TIQUE; tirer; tirjo; larel; TIRAS; tutro; tutca; fazir; TUTOR; vapel; vapca; nejus; VAPOR; varom; vardo; norei; VARIZ; visim; visca; nunva; VISOR; vogur; vogma; pazer; VOGAL; zebor; zebno; dalim; ZEBRA; barto; barel; lerto; BARBA; berno; beram; losvo; BERMA; casra; casim; veiza; CACO; calba; catle; nebta; CALDO; cenza; cenur; raica; CENSO; cerma; ceros; mosce; CERNE; cinle; cinor; zerda; CINTO; cinvo; cinum; vismo; CINZA; corbe; corim; surbo; CORDA; corzo; corum; zasna; CORVO; cosna; cosai; sesna; COSMO; dergo; deros; lasno; DERME; farne; farer; lerzo; FARSA; forve; foris; tunzo; FORCA; forza; forau; tusge; FORNO; funja ;funer; tespa; FUNGO; gampe; gamor; fesdo; GAMBA; garda; garel; prela; GARFO; genfa; genom; jarce; GENRO; gosvo; gosim; pinzo; GOSMA; lasve; lasom; benve; LASCA; lesro; lesum; tarco; LESMA; manvo; manul; vormo; MANGA; morza; morum; craze; MORNO; mosro; moser; ninzo; MOSCA; nesco; nesur; vrapo; NESGA; ninte; ninel; mirlo; NINFA; percor; parost; grobot; PARDAL; parme; parus; gerpa; PARGO; parbe; parim; gonfe; PARTO; pasna; pasem; genza; PASMO; perme; peram;

foszo; PERSA; porma; porus; jesva; PORCO; rambe; ramei; drojo; RAMPA; rusmo; rusil; varpe; RUSGA; sarge; sarim; zesgo; SARJA; surbe; surer; crala; SURTO; talna; talum; bilva; TALCO; tambe; tamou; fesgo; TAMPO; tanju; tanes; larxa; TANGO; tarbo; tarer; bonfo; TARTE; tesbo; tesur; larfe; TESTA; tosdo; toclo; forfe; TOSTA; turde; turom; disda; TURBO; vervo; verer; creco; VERME; verma; veris; masva; VERSO; vesda; vesam; zesje; VESGO; vesmo; vesou; crago; VESPA;

Nonwords

bager; bagma; dajul; BAGIL; begul; begno; jonha; BEGRA; bepui; bepco; lanus; BEPRA; bevur; bevda; magur; BEVOL; bicel; bicte; fopra; BICRA; bodus; bodpo; terol; BODIO; bubra; bubpo; lapta; BUBIM; budei; budco; ravra; BUDIA; bupei; bupco; sigue; BUPLA; cadul; cadpo; rogul; CADRE; conel; conve; ficro; CONUL; dapul; dapco; bujro; DAPIL; datur; datca; tibro; DATRO; facum; facta; mucra; FACIZ; fanur; fanvo; defar; FANOL; fetra; fetco; bidro; FETOM; fonem; fonve; denus; FONUS; foter; fotco; gonua; FOTAI; gedum; gedmo; pisor; GEDRA; gomua; gompo; tucre; GOMER; gotre; gotce; pegro; GOTAM; jedem; jedca; panir; JEDUR; letro; letca; puler; LETOM; lezum; luzco; vernu; LUZAR; nefer; nafte; zejro; NAFEM; nager; nagmo; capra; NAGAM; nagum; nagco; zaqua; NAGIA; nague; nagma; nomui; NAGOU; natei; natpa; cogra; NATUO; necal; necte; xuzre; NECRU; pabpa; pabre; tomul; PABRO; pafum; pafca; vezul; PAFIR; paner; panjo; jacro; PANOL; pebut; pebpa; gafus; PEBIL; pogro; pogme; zapau; POGUA; ridre; ridmo; xadal; RIDAR; sabar; sadca; reces; SADRIL; satas; satpa; pofir; SATIO; tagre; tagma; verpo; TAGIO; tezil; tezca; zada; TEZUE; timis; timbo; fenus; TIMAO; vatra; vatpo; somus; VATAU; venil; venfe; lagro; VENOI; zebim; zebpa; nigua; ZEBIO; zenos; zenja; xixas; ZENAL; zevar; zevga; mefro; ZEVOU; zilom; zilxe; cocra; ZILAM; zunim; zunxa; rozou; ZUNUR; barxa; barum; fosma; BARMO; basda; basur; rilfo; BASFO; biscu; bisom; tosxo; BISZA; bolfa; bolus; palna; BOLDA; bolxe; bolil; dosgo; BOLPA; carmi; carum; xenco; CARCA; dande; damum; brifo; DAMBU; dempo; demul; bofus; DEMPA; desfe; desum; valca; DESPO; dolza; dolui; xalca; DOLCO; fapco; fapre; brapo; FAPSA; fesxu; fesim; derxo; FESMO; forpe; forer; lanja; FORGO; fosje; fosel; dorpe; FOSGO; galba; galui; palne; GALFA; gasfu; gasul; proce; GASPO; ginva; ginus; palso; GINCA; gonfo; gonal; jenel; GONTA; gunsa; gunis; zasne; GUNZO; jorxa; jorum; nesfa; JORZA; josdo; josir; feica; JOSCE; julza; juler; valro; JULTE; larne; larom; venco; LARFA; mulxo; mulir; goute; MULSA; nasto; nasil; xonim; NASTRE; nolbu; nolai; nalfa; NOLTE; palfo; palil; loilo; PALDE; pesfu; pesis; jarca; PESMO; pesza; pesoi; vospe; PESTAR; pisja; pisau; jisca; PISMO; porja; porul; ponja; PORPO; permo; peril; dalba; PURNA; rolxo; rolus; reica; ROLRO; sanvre; sanaol; frana; SANTRA; segmo; seguo; lisvo; SEGNA; sonza; sonis; roumo; SONCE; texva; texol; busbo; TEXFO; tinzo; tiner; bulma; TINDA; tornu; torui; falno; TORMA; valta; valus; fengo; VALBO; vanza; vaner; nouma; VANCE; vaszu; vasum; verzo; VASMO; verjo; velor; junro; VERFA; vigmo; viguo; grofo; VIGNA; vosfe; vosur; xerla; VOSMA; zalva; zalum; crofo; ZALCO; zalne; zaler; rispo; ZALMO; zermu; zerar; lasba; ZERCE;

APPENDIX 2

Prime-target pairs in Experiment 2

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

Words

bagas; bagem; bagco; depro; BAGAS; bazar; bazis; bazfa; decre; BAZAR; bicas; bicem; bicto; tamor; BICAS; cetim; cetos; cetma; vabus; CETIM; cofre; cofis; cofto; madas; COFRE; coral; corei; corpe; nevot; CORAL; dicas; dicom; dicma; bavom; DICAS; dunas; dunor; dunco; tamor; DUNAS; febre; febas; febca; telus; FEBRE; fera; fero; ferco; bama; FERA; fibra; fibes; fibco; latom; FIBRA; figos; figar; figma; pacar; FIGOS; fotos; fotam; fotme; pabar; FOTOS; gomas; gomum; gompa; paver; GOMAS; lebre; lebam; lebca; bogue; LEBRE; luzes; luzam; luzvo; facro; LUZES; magra; mages; magco; nevro; MAGRA; mimos; mimer; mimpa; vabus; MIMOS; mural; muroi; murvo; cocet; MURAL; nariz; naram; narva; movos; NARIZ; natas; nator; natmo; celes; NATAS; pires; piror; pirva; gavas; PIRES; podre; podiz; podco; gafar; PODRE; pudim; pudar; pudca; gotro; PUDIM; rosas; rosem; rosmo; casor; ROSAS; rubro; rubas; rubce; satas; RUBRO; rumor; rumes; rumba; vacra; RUMOR; sigla; siger; sigce; niblo; SIGLA; sobra; sobos; sobco; rapos; SOBRA; somas; somor; sombo; vanir; SOMAS;sopro; sopes; sopca; mafar; SOPRO; tecla; tecio; tecvo; bovro; TECLA; tigre; tigas; tigma; bacor; TIGRE; tumor; tumas; tumbo; lasas; TUMOR; vogal; vogei; vogco; cepro; VOGAL; zebra; zebes; zebco; coles; ZEBRA; bagagem; bagevar; bagcaro; lapapos; BAGAGEM; cabedal; cababoi; cabcano; votobei; CABEDAL; capataz; capebis; captaca; zogodre; CAPATAZ; caracol; caromai; carnavo; nocodat; CARACOL; carapau; caroque; carvoco; vovogos; CARAPAU; cicatriz; cicobaus; cictana; vonadras; CICATRIZ; ciclismo; cicairca; cictoma; vatalna; CICLISMO; ditador; ditobes; ditvoca; balifro; DITADOR; divisor; divasam; divcana; bezacra; DIVISOR; falador; falebas; falvona; bodelas; FALADO; fiambre; fiantas; fiacoda; louvano; FIAMBRE; fumador; fumebra; fumbada; tacobas; FUMADOR; garagem; garojar; garmapo; pevodar; GARAGEM; laranja; larompo; larvogo; tovocra; LARANJA; lateral; latomei; latcoma; tolevro; LATERAL; lavagem; lavofas; lavcofa; tocopro; LAVAGEM; lucidez; lucabas; luctavo; tavacra; LUCIDEZ; lutador; lutobra; lutvaba; balotes; LUTADOR; macaco; macoma; macvoma; vevama; MACACO; maxilar; maxabra; maxbama; nocates; MAXILAR; mineral; minanas; mincado; vamatro; MINERAL; miragem;

mirofas; mirvafa; novapro; MIRAGEM; monitor; monabre; moncade; vacales; MONITOR; nadador; nadebra; nadvoca; cabobas; NADADOR; patamar; patones; patcaco; golonos; PATAMAR; penugem; penafar; panvopo; favapra; PENUGEM; polegar; polafes; polcona; gabacro; POLEGAR; ralador; ralobam; ralcuba; vebobas; RALADOR; recado; recoba; recvapa; vanota; RECADO; regador; regebas; regcogo; vopabra; REGADOR; sagrado; sagorba; sagcoba; coproba; SAGRADO; sanita; sanebo; sanvado; comale; SANITA; secador; secobam; secvoa; vavabes; SECADOR; timidez; timelar; timbaco; lacabro; TIMIDEZ; tomate; tomoba; tompaco; bacolo; TOMATE; vegetal; vegibei; vegcado; zacidro; VEGETAL; balde; balbo; balais; durta; BALDE; bolso; bolca; boler; tunca; BOLSO; cesta; cesdo; ceser; morlo; CESTA; cinto; cinda; cinul; vamba; CINTO; cinza; cinvo; cinos; zorce; CINZA; cisne; cisra; ciser; zarvo; CISNE; dardo; darba; darar; besba; DARDO; dente; denlo; denol; bembo; DENTE; farda; farbo; farim; besfo; FARDA; fungo; funfa; funar; lorpe; FUNGO; ganga; ganfo; ganer; posjo; GANGA; ganso; ganca; ganim; jorca; GANSO; garfo; garba; garur; jesda; GARFO; genro; genca; genur; paszo; GENRO; lesma; lesno; lesom; tarco; LESMA; lince; linra; linas; tuszo; LINCE; manga; manfe; manur; nesje; MANGA; marte; marvo; maros; nusfo; MARTE; melro; melce; melum; cusce; MELRO; molde; molba; molis; namo; MOLDE; monge; monfa; monar; sasjo; MONGE; mosca; mosno; moses; zerso; MOSCA; musgo; musfa; musum; virpa; MUSGO; panda; panto; panur; josbo; PANDA; pinga; pinvo; pinor; gorjo; PINGA; polpa; polgo; poles; garje; POLPA; poste; posba; posur; jarla; POSTE; pulga; pulco; pulis; gerso; PULGA; pulso; pulna; pulur; ginza; PULSO; risca; rismo; riser; serno; RISCA; surdo; surbe; surom; resba; SURDO; tarte; tarba; tarus; losla; TARTE; tenda; tenle; tenar; fembo; TENDA; teste; tesba; tesis; larlo; TESTE; tosta; tosde; toser; farfo; TOSTA; valsa; valmo; valir; zonco; VALSA; bandido; banfala; banalbo; losbabo; BANDIDO; bengala; benfobo; benovlo; fosjebo; BENGALA; bondade; bontota; bonilba; fasbebe; BONDADE; canguru; canfaca; caneper; zosjaca; CANGURU; cantina; canduco; canelco; sosbamo; CANTINA; carpete; cargoba; carapos; nosgado; CARPETE; cascata; casmobe; casosde; vernobo; CASCATA; cintura; cinlumo; cinalco; rambavo; CINTURA; compota; combada; comaple; rasgabe; COMPOTA; cortina; corluno; corolvo; vasbevo; CORTINA; costura; cosdama; cosulno; nurfaco; COSTURA; dentada; denleto; denilzo; barlobo; DENTADA; donzela; donvado; donumbo; larcefo; DONZELA; fartura; fardavo; farelco; deslevo; FARTURA; formiga; forcepo; forinjo; basnupo; FORMIGA; fortuna; forlame; forilmo; lesfove; FORTUNA; gordura; gorbavo; goralva; jambado; GORDURA; jangada; janjobe; janoplo; gorjube; JANGADA; largura; larjavo; larepus; tusjaco;

LARGURA; malvado; malcoda; malosba; nonzabe; MALVADO; martelo; marfaca; marelfa; volbada; MARTELO; mendigo; menfaja; menulpa; vorlaja; MENDIGO; moldura; molbeco; molalvo; cambovo; MOLDURA; morcego; morvaja; morarpa; casroja; MORCEGO; mordomo; mortaca; morelcu; nasbave; MORDOMO; nervoso; nermera; nerasca; rasnura; NERVOSO; pancada; panrelo; panosbo; gorvebo; PANCADA; pantera; pandazo; panilcu; jurdaro; PANTERA; pantufa; pandoto; panildo; jusdamo; PANTUFA; perfume; pertano; perilno; gaslono; PERFUME; presunto; precasbo; prescaba; guomada; PRESUNTO; resgate; resjola; resepal; corpota; RESGATE; salgado; saljobe; salopla; zempuba; SALGADO; suspiro; susjuca; susopra; cargova; SUSPIRO; ternura; termaco; teranco; lesviso; TERNURA; vampiro; vambava; vamigas; corjava; VAMPIRO;

Nonwords

balur; balim; balva; tanxo; BALUR; besas; besur; besro; decro; BESAS; birus; birom; birva; durca; BIRUS; canus; caner; canco; vames; CANUS;conim; conus; convo; senus; CONIM; cunes; cunor; cunsa; vumar; CUNES; cures; curum; curzo; vecos; CURES; dorer; dorum; dorvo; bosxa; DORER; dorur; dorim; dorne; lasne; DORUR; fisir; fisum; fisra; loces; FISIR; garao; garui; garxe; jocus; GARAO; garir; garas; garca; poras; GARIR; gilos; giler; gilve; vutas; GILOS; gopra; gopos; gopto; joges; GOPRA; gosum; goser; gosca; jurso; GOSUM; jesir; jesos; jesna; pocro; JESIR; lases; lasor; lasmo; bezos; LASES; lesir; lesum; lesmu; tivos; LESIR; lusus; lusar; lusce; baror; LUSUS; merum; meres; mervo; nuces; MERUM; pelor; pelis; pelce; josas; PELOR; piror; pirim; pirva; juces; PIROR; rerus; rerom; rerxa; xaxca; RERUS; roner; ronum; ronva; vaves; RONER; serus; serar; serco; caxor; SERUS; silar; silom; silxo; venze; SILAR; vanis; vanom; vanva; munos; VANIS; vasor; vasis; vasva; coriu; VASOR; venas; vener; venvo; ceror; VENAS; venor; venam; vense; remur; VENOR; verus; verar; verzo; xares; VERUS; vilor; vilam; vilna; runco; VILOR; vuras; vuror; vurno; cacra; VURAS; xarus; xarem; xarca; vocre; XARUS; xunos; xunam; xunca; recis; XUNOS; zeras; zeror; zervo; mecer; ZERAS; benespa; benorgo; bencogo; duvorge; BENESPA; benoste; benarda; bencafa; luvarba; BENOSTE; calocra; calavim; calmoco; vebudro; CALOCRA; caruspa; carongo; carvujo; verasgo; CARUSPA; celovro; celacas; calnoma; vadames; CELOVRO; ceronva; cerasme; cersume; zecerso; CERONVA; cerorpa; ceresgo; cervajo; nesesgo; CERORPA; dasocro; dasives; dasmina; fuzenas; DASOCRO; denosgo; denarpe; densaja; bucrapa; DENOSGO; dususfa; dusorbo; duscade; bocrumo; DUSUSFA; fenorva; fenusmo; fensuno; bumasco; FENORVA; feranos; ferocra; fersane; pecromo;

FERANOS; ficabra; ficodos; fictovo; lavovro; FICABRA; funogue; funapro; funsaja; bovadra; FUNOGUE; garunjo; garespo; garvoge; junospe; GARUNJO; gasevem; gasunor; gascose; poracro; GASEVEM; gunocre; gunavas; gunsoze; josesma; GUNOCRE; junacra; junuvos; junseno; govenem; JUNACRA; jusetre; jusabos; jusnofo; pecades; JUSETRE; lusompa; lusasgo; lusvujo; ticraje; LUSOMPA; misasfe; misorba; misvelo; nocroda; MISASFE; nirosma; nirarvo; nirmeco; vicruvo; NIROSMA; nunosfo; nunarla; nuncuba; vemarle; NUNOSFO; nurasma; nurorvo; nurcone; cezarve; NURASMA; paroces; paranis; parmina; guvavra; PAROCES; pasosdo; paserba; pasvate; gucrote; PASOSDO; pesavre; pesomam; pesnoca; cavosas; PESAVRE; rariver; raromes; rarsoca; verucro; RARIVER; risorfa; risaslo; risvobo; virambo; RISORFA; rusapor; rusogas; rusnefa; vemojas; RUSAPOR; sirovre; siranus; sirmuna; revecam; SIROVRE; tirosbu; tiranta; tirvale; lucrefo; TIROSBU; tunorvo; tunanve; tuncama; lomasna; TUNORVO; venosje; venorgo; vensapa; corarpa; VENOSJE; veropre; verague; vermaga; carojas; VEROPRE; voleter; volabos; volcima; cebofas; VOLETER; berxo; berna; berur; linve; BERXO; canca; canxe; canor; vervo; CANCA; carde; carlu; carim; mirsa; CARDE; cusna; cusve; cusom; virve; CUSNA; dersa; derzo; derim; borve; DERSA; dunva; dunor; dunim; birce; DUNVA; firca; firve; firor; lusmo; FIRCA; funce; funva; funus; porva; FUNCE; gilco; gilne; gilom; penve; GILCO; gismo; gisna; gisum; jurzo; GISMO; gorma; gorzo; gorer; pesze; GORMA; jesme; jesva; jesur; porma; JESME; junfe; junlu; junis; gaslo; JUNFE; lorca; lorve; lores; tusne; LORCA; lunco; lunza; lunes; tirva; LUNCO; merve; merna; meris; nosco; MERVE; munxe; munza; munur; virve; MUNXE; nence; nenvo; nenam; vorve; NENCE; perfo; perte; perim; gisla; PERFO; punzo; punxa; punim; jorco; PUNZO; pusva; pusno; pusor; jermo; PUSVA; rinxo; rinze; rinam; xurce; RINXO; tinco; tinva; tinus; bunza; TINCO; tirsa; tirve; tiror; lesne; TIRSA; vasca; vasre; vasor; murso; VASCA; verve; verzo; verir; mosme; VERVE; visgo; vispa; visim; conja; VISGO; vormo; vorca; vorus; casza; VORMO; vosca; vosme; vosir; mirmo; VOSCA; xasca; xasve; xasem; curxe; XASCA; xerve; xerno; xerur; virve; XERVE; xesta; xeslo; xesio; vorba; XESTA; xirme; xirva; xirei; carca; XIRME; xunce; xunvo; xuner; zerna; XUNCE; zanva; zanxe; zanis; xunre; ZANVA; zurne; zurxa; zurim; xirvo; ZURNE; bervono; berzama; berinra; lincaza; BERNOVO; borpada; borjoco; borempo; lasgove; BORPADA; coldoca; colbivo; colapro; mambeve; COLDOCA; corcago; corveja; coruspe; vuncaje; CORCAGO; danvida; dancebe; danusle; bormoto; DANVIDA; duncada; dunvolo; dunasco; birvolo; DUNCADA; durcope; durmaga; durinjo; bisvaje; DURCOPE; falmido; falveba; faluste; beinata; FALMIDO; felcoma; felvuxo; felirce; lesvano; FELCOMA; fingada; finjobe;

finurlo; lurpote; FINGADA; fircado; firmete; firusla; tunvuce; FIRCADO; firmaca; firvono; firurme; busvuve; FIRMACA; fizcada; fizmobo; fizunle; basmobe; FIZCADA; ginvune; ginsaca; ginisza; parcama; GINVUNE; gunvopo; gunraga; gunisje; porcuga; GUNVOPO; gurpoto; gurgabe; guresla; pesgodo; GURPOTO; lanvida; lansebo; lanarto; birzole; LANVIDA; linvuta; lincode; linorfo; tornolo; LINVUTA; lumpada; lundobe; lumirlo; birjote; LUMPADA; morcama; morvore; morisno; viscuzo; MORCAMA; nesmida; nescobe; nesimbo; varnote; NESMIDA; nurmubo; nurvala; nuresde; vinsuta; NURMUBO; parfoco; parbime; paralva; gosdima; PARFOCO; pernaco; pervume; perunra; goscuve; PERNACO; rervipa; rercuje; rerungo; carcago; RERVIPA; rinvaba; rincido; rineste; vurmolo; RINVABA; rircifa; rirmudo; rirerbe; musmule; RIRCIFA; risfava; risbico; risudre; sanduce; RISFAVA; runcija; runvego; runerpe; virmipe; RUNCIJA; silvima; silmuno; silurce; vurvovo; SILVIMA; tincima; tinraco; tinanve; lorxuce; TINCIMA; tinfade; tintoba; tinilto; lurdota; TINFADE; tinfoce; tintama; tinelma; lerlasa; TINFOCE; turcope; turniga; turusjo; linraja; TURCOPE; vinjona; vinface; vinipre; cerpome; VINJONA; zinguda; zinjibe; zinipro; verpalo; ZINGUDA;