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Are syllables phonological units in visual word recognition?

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A number of studies have shown that syllables play an important role in visual word recognition in Spanish. We report three lexical decision experiments with a masked priming technique that examined whether syllabic effects are phonological or orthographic in nature. In all cases, primes were nonwords. In Experiment 1, latencies to CV words were faster when primes and targets shared the first syllable (*ju.nas-JU.NIO*) than when they shared the initial letters but not the first syllable (*jun.tu-JU.NIO*). In Experiment 2, this syllabic overlap could be phonological + orthographical (*vi.rel-VI.RUS*) or just phonological (*bi.rel-VI.RUS*). A syllable priming effect was found for CV words in both the phonological + orthographical and the phonological condition. In Experiment 3 we compared a "phonological-syllable" condition (*bi.rel-VI.RUS*) with two control conditions (*fi.rel-VI.RUS* and *vir.ga-VI.RUS*). We found faster latencies for the phonological-syllabic condition than for the control conditions. These results suggest that syllabic effects are phonological in nature.

One important issue in visual word recognition is to determine the role played by sublexical units such as the syllable. It has been claimed that words are not processed as a whole, but rather the lexical processor routinely uses the syllable as a sublexical unit (Lima & Pollatsek, 1983; Millis, 1986; Prinzmetal, Treiman, & Rho, 1986; Rapp, 1992; Spoehr &

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Smith, 1973; Taft & Forster, 1976; Tousman & Inhoff, 1992). Among these proposals, several authors have characterised the syllable in orthographic terms (Prinzmetal et al., 1986) or have argued for syllable-type processing units that include morphological and orthotactic restrictions (Taft, 1979). Nonetheless, because the syllable is a co-articulatory and a phonological structure in speech, syllabic effects in visual word recognition have usually been interpreted as involving phonological processing (Grainger & Ferrand, 1996; Spoehr & Smith, 1973).

Evidence in favour of syllabic processing during visual word recognition has been mostly obtained in Romance languages with clear syllable boundaries (e.g., Spanish or French) rather than in English. In Spanish, a number of experiments have found that positional token syllable frequency influences response times to words (Álvarez, Carreiras, & de Vega, 2000; Álvarez, Carreiras, & Taft, 2001; Álvarez, de Vega, & Carreiras, 1998; Carreiras, Álvarez, & de Vega, 1993; Carreiras & Perea, 2002; Marín & Carreiras, 2002; Perea & Carreiras, 1995, 1998). The main result is that words with high-frequency syllables produce longer response times than words with low-frequency syllables in lexical decision and progressive demasking tasks (see also Conrad & Jacobs, 2003; Mathey & Zagar, 2001, for evidence of this effect in German and in French, respectively). This inhibitory effect of syllable frequency has been interpreted in terms of competition at the word level: If the syllables are of high frequency, they will activate more word units than the syllables of low frequency. Hence, unique word identification will be delayed for words with larger syllabic neighbourhoods. This interpretation readily captures the fact that the number of higher frequency syllabic neighbours (i.e., words of higher frequency that share the first syllable with the target word) has an inhibitory effect in lexical decision (Perea & Carreiras, 1998; see also Álvarez et al., 2001). It is important to note that a number of other potential explanatory factors of the syllable-frequency effect have been discarded. It has been previously shown that bigram frequency (Carreiras et al., 1993), orthographic neighbourhood density/frequency (Perea & Carreiras, 1998; see also Álvarez et al., 2001), or morpheme frequency (Álvarez et al., 2001) cannot account for the previous findings. Furthermore, recent evidence seems to suggest that the first syllable of the word is more prominent in the process of activation of lexical units than the other syllables (Álvarez et al., 1998, 2000). This bias towards the initial syllable is in accordance with the view that word beginnings play a privileged role in visual word recognition (e.g., see Briihl & Inhoff, 1995; Grainger, O'Regan, Jacobs, & Segui, 1992; Inhoff & Tousman, 1990; O'Regan & Jacobs, 1992; Perea, 1998; Rayner, 1979).

Of particular relevance for our research goals is the evidence obtained with the masked priming technique (see Forster & Davis, 1984; Forster, Mohan, & Hector, 2003), which is the technique used in the present experiments. In this technique, a forward-masked, lowercase prime is presented briefly (for around 40–66 ms) and is subsequently replaced by the uppercase target. In a direct antecedent of the present research, Carreiras and Perea (2002) conducted four masked priming experiments that showed syllabic priming effects using disyllabic words. In Experiment 1, using primes of higher frequency than the target words, Carreiras and Perea found slower response times to target words when prime-target pairs shared the first syllable (e.g., *bo.ca-BO.NO*) than when the prime-target pairs were unrelated (*ca.ja-BO.NO*). (A dot marks the syllable boundary throughout this article, although the stimuli presented did not contain the dots.) In Experiment 2, in which they used nonwords as primes, the priming effects were facilitative. The different pattern of results with high-frequency words and nonwords as primes is consistent with previous results in which orthographic neighbours were used as primes (e.g., Forster & Veres, 1998; Perea & Rosa, 2000; Segui & Grainger, 1990). However, it could be argued that the syllabic neighbours in the Carreiras and Perea (2002) experiments not only shared the first syllable but also the first two letters, so that the observed effects could be also attributed to orthographic overlap. To disentangle orthographic from syllabic overlap, Carreiras and Perea (2002) employed both monosyllabic (*zinc*) and disyllabic words (*ra.na*) as targets in Experiment 3. Monosyllabic words could be primed by monosyllabic pseudowords, either sharing the first two letters with the target: Related condition (*ziel*) or by unrelated pseudowords (*flur*). In addition, disyllabic words were preceded by a related pseudoword (*ra.jo*) or by an unrelated pseudoword (*cu.fo*). Thus, in the two related conditions, primes and targets shared the two first letters, but only in the case of disyllabic words did these letters form the first syllable. The results showed a facilitative priming effect only for disyllabic targets, suggesting that syllabic activation plays a role in the early stages of word recognition (see Carreiras & Perea, 2002).

Taken together, these results are consistent with an activation-based model in which sublexical input phonology is structured syllabically (see Ferrand, Segui & Grainger, 1996). As indicated by Carreiras and Perea (2002), it is not clear how visual word recognition models such as the original version of the interactive-activation model (McClelland & Rumelhart, 1981), the Dual-Route Cascaded [DRC] model (e.g., Coltheart et al., 2001), or PDP models (Plaut et al., 1996; Seidenberg & McClelland, 1989) could account for the observed syllabic effects without explicitly adding a syllabic level of processing. (Note for instance, that the computational version of the DRC model only applies to monosyllabic words.) However, although syllabic effects could be readily explained in activation-based models with a syllabically structured sublexical input

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phonology (e.g., Ferrand et al., 1996), it is important to gather empirical evidence on whether syllabic effects arise from a sublexical phonological level or from a sublexical orthographic level. This is the main aim of the present research.

It is important to bear in mind that the fact that syllables are phonological units in speech does not necessarily imply that any syllabic effects observed in visual word recognition experiments are due to the activation of phonological codes. Most readers in Spanish have learned to read via a syllabic method, taking advantage of the fact that Spanish has clear syllable boundaries. Accordingly, it could be the case that phonological syllables in speech turn out to be phonological processing units in the development of reading skills. However, there is a possibility that, because most Spanish readers learn to read "syllabically", they segment the visual input into units that correspond to syllables, but that these syllables may remain orthographic units (i.e., without a mandatory involvement of phonological coding). We will call these hypothetical orthographic units "orthographic syllables". Indeed, in other languages (e.g., in English), it has been claimed that readers can segment words according to orthographic sublexical units that do not necessarily correspond to phonological syllabic units. For instance, it is possible that orthographic processing ignores the spoken structure and simply tries to maximise the size of the initial unit of orthographic processing (Taft, 1979, 1992). Specifically, Taft indicated that words in English could be segmented according to the spoken syllable by maximising the onset (e.g., *mur-der* or *si-ren*), or according to the Basic Orthographic Syllabic Structure (BOSS) which maximises the coda (e.g., *murd-er* or *sir-en*), and Taft empirically supported the idea that the coda of the first syllable is maximised. More recently, Taft (2001, 2002) modified his conclusion that the BOSS is always preferred as an orthographic structure to the syllable; this would only be true for better readers. Consequently, it is debatable whether the syllabic effects reported in Spanish are phonological in nature.

In sum, there is a growing body of evidence supporting the role of the syllable as a relevant sublexical unit in reading words, at least in Spanish. However, the orthographic/phonological status of the syllable has not been systematically studied. In addition, it is uncertain if the phonological codes are structured syllabically (as proposed for instance by Ferrand et al., 1996). To disentangle the effect of phonological syllables from the effect of orthographic syllables, we used prime-target pairs that shared the phonological, but not the orthographical first syllable. We chose a lexical decision task rather than a naming task as the naming task may have an intrinsic phonological component independent of lexical access.

The paradigm used in the present series of experiments, the masked priming paradigm, has proved to be effective in studying the possible early activation and use of phonological information without the intervention of conscious processing (see Ferrand & Grainger, 1992, 1993, 1994; Frost, Ahissar, Gottesman, & Tayeb, 2003; Grainger & Ferrand, 1996; Lukatela, Frost & Turvey, 1999; Lukatela, Savič, Urosevič, & Turvey, 1997; but see Shen & Forster, 1999). By using pseudohomophones as primes, phonological priming effects have been found at very short stimulus-onset asynchronies (SOAs) in lexical decision. For instance, Lukatela, Frost, and Turvey (1998) found that a target word such as *CLIP* was responded to more quickly in a lexical decision task when preceded by its pseudohomophone *klip* than when it was preceded by the orthographic control *plip* (see also Drieghe & Brysbaert, 2002; Frost et al., 2003; Lukatela, Eaton, Lee, Carello, & Turvey, 2002, for similar results and discussion).

To summarise, the present lexical decision experiments examined whether syllables are used as phonological units during reading in Spanish. To test the presence of syllabic priming effects with the masked priming technique, target words in Experiment 1 were preceded by nonword primes that always shared the first three letters, but only half of the cases shared the first syllable (e.g., *ju.nas-JU.NIO* vs. *jun.tu-JU.NIO*). The goal of Experiments 2 and 3 was to ascertain whether phonological syllables play an important role in the early stages of the process of visual word recognition. To that end, participants in Experiment 2 were presented with target words (e.g., *BA.LÓN*) preceded by nonwords primes that shared phonological syllables (*va.lis*), orthographical syllables (*ba.lis*), or did not share any syllable (*bal.ti*, *valti*). In Experiment 3, besides comparing a phonological-syllable condition (e.g., *va.lis-BA.LÓN*) and its nonsyllabic orthographic control (e.g., *val.ti-BA.LÓN*), we examined the role of a rime-only condition (e.g., *fa.lis-BA.LÓN*) on the basis that rimes may play an important role as a sublexical representation between the letter and word levels. The SOA in all three experiments was 64 ms (see Carreiras & Perea, 2002).

EXPERIMENT 1

Before examining the issue of whether syllables are phonological or orthographic in nature, it is relevant to replicate the presence of the involvement of the syllable in the early stages of word recognition. Experiment 1 was designed to disentangle syllabic overlap from segmental overlap with the masked priming technique. As stated in the Introduction, Carreiras and Perea (2002; Experiment 3) found that disyllabic prime-target pairs that shared the first syllable (and the initial two letters; e.g., *ra.jo-RA.NA*) produced an advantage over an unrelated condition (*cu.fo-RA.NA*), whereas monosyllabic pairs that shared the initial two letters (e.g., *ziel-ZINC*) did not produce an advantage over an unrelated condition (*flur-ZINC*). However, this result should be treated with some caution, since the unrelated condition differed from the related condition in terms of the number of shared letters (two letters in common vs. zero letters in common). To avoid this potential problem, we now used pairs of disyllabic items of five letters with a CV or a CVC initial syllable: One condition involved primes and targets that shared the first three letters and the first syllable (e.g., *ju.nas-JU.NIO*) and the other condition involved primes and targets that also shared the first three letters but not the first syllable (e.g., *jun.tu-JU.NIO*). We employed pseudowords as primes, and the targets had a CV or a CVC syllabic structure in the first syllable. According to a syllabic parsing account, faster reaction times should be found for those pairs that shared the first syllable (see Ferrand et al., 1996).

Method

Participants. Forty students from introductory psychology courses at the University of La Laguna took part in the experiment to fulfil a course requirement. All were native speakers of Spanish.

Materials. Forty-four disyllabic Spanish words, all of them consisting of five letters, were selected from the Spanish word pool (Alamada & Cuetos, 1995; Cobos et al., 1995). Twenty-two words had a CV structure in the first syllable, and the other twenty-two words had a CVC structure in the first syllable. The mean frequency of the CV words was 18 (range: 7–45) per one million words and the average number of orthographic neighbours was 8.4 (range: 0–16). The mean frequency of the CVC words was 14 (range: 8–27) per one million words and the average number of orthographic neighbours was 6.3 (range: 1–12). In all cases, primes were pseudowords of five letters (the mean number of orthographic neighbours across conditions varied from 1.4 to 3.0). Primes and targets shared the first three letters. Word targets were preceded by a prime that either shared the first syllable or did not. For instance, the CVC word *mon.ja* could be preceded either by *mo.nis* or *mon.di*, whereas the CV word *ju.nio* could be preceded either by *ju.nas* or *jun.tu*. In addition, we used forty-four disyllabic nonwords in order to perform a lexical decision task, twenty-two of them with a CV structure in the first syllable and the other twenty-two with a CVC structure in the first syllable. Similarly to word targets, nonword targets were preceded by CV nonword primes or CVC nonword primes.

Design. Type of prime (CV vs. CVC structure in the first syllable) and type of target (CV vs. CVC structure in the first syllable) for words was varied within participants. Each participant was given a total of

88 experimental trials: 44 nonword-word trials and 44 nonword-nonword trials.

Procedure. Participants were tested individually in a quiet room. Presentation of the stimuli and recording of reaction times were controlled by PC-compatible microcomputers. Reaction times were measured from target onset until participants' response. On each trial, a forward mask consisting of a row of five hash marks (#####) was presented for 500 ms on the centre of the screen. Next, a centred lowercase prime nonword was presented for 64 ms. Primes were immediately replaced by an uppercase target item. Participants were instructed to press one of two buttons on the keyboard to indicate whether the uppercase letter string was a legitimate Spanish word or not. This decision had to be taken as quickly and as accurately as possible. When the participant responded, the target disappeared from the screen. After an inter-trial interval of 1 second, the next trial was presented. Participants were not informed of the presence of lowercase nonwords. Both nonword-word pairs and nonword-nonword pairs were counterbalanced across two experimental lists so that if the pair *ju.nas-JU.NIO* was in one list, *JU.NIO* would be preceded by *jun.tu* in the other list. Stimulus presentation was randomised, with a different order for each participant. Each participant received a total of 20 practice trials (with the same manipulation as in the experimental trials) prior to the 88 experimental trials. The whole session lasted approximately 13 min.

Results and discussion

Incorrect responses for words (4.6%) were excluded from the latency analysis.[1] In addition, reaction times less than 300 ms or greater than 2000 ms (less than 0.5% of the data for words) were excluded in a first pass, and all reaction times more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded. The percentage of trials that were removed due to the screening procedure was similar in the syllabic and the orthographic conditions. For CVC target words, these percentages were 4.7% and 6.1% for the syllabic and the orthographic conditions, respectively; whereas for CV target words these percentages were 3.6% and 5.2% for the syllabic and the orthographic conditions. Mean reaction times on words were submitted to separate

[1] For brevity's sake, we will only report the results for the word targets since it is difficult to make any strong conclusions on the basis of "no" responses in a masked priming paradigm. Please bear in mind that negative responses are usually thought to be made via a temporal deadline (see Forster, 1998; Grainger & Jacobs, 1996).

TABLE 1
Mean lexical decision times (in ms) and percentage of errors (in parentheses) on target words in Experiment 1

	Syllabic structure of the prime		
	CV	*CVC*	*CVC-CV*
Words			
CV structure	702 (3.3)	744 (2.2)	42 (−1.1)
CVC structure	724 (5.5)	733 (7.3)	9 (1.8)

ANOVAs, with Type of prime, Type of target, and List as factors.[2] The mean lexical decision time and the error rate on the stimulus words in each experimental condition are shown in Table 1.

The ANOVA on the latency data showed that the effect of type of target was not statistically significant, both *F*s < 1. The main effect of type of prime was statistically significant, $F_1(1, 38) = 18.30$, $p < .001$; $F_2(1, 39) = 15.30$, $p < .001$: On average, participants responded faster when the prime had a CV structure than when the prime had a CVC structure. More importantly, the interaction between Type of prime and Type of target was significant, $F_1(1, 38) = 11.69$, $p < .002$; $F_2(1, 39) = 4.69$, $p < .04$. This interaction reflected that CV target words were responded to faster when the prime has a CV structure in the first syllable than when the prime had a CVC structure, $F_1(1, 38) = 31.54$, $p < .001$; $F_2(1, 39) = 18.07$, $p < .001$. However, there was no effect of type of prime for CVC targets, $F_1(1, 38) = 1.44$; $F_2(1, 39) = 1.56$.

The ANOVA on the error data only showed a significant effect of type of target, $F_1(1, 38) = 10.72$, $p < .001$; $F_2(1, 39) = 4.22$, $p < .05$; participants made more errors for CVC targets than for CV targets.

The results showed a substantial priming effect for CV target words that shared the first three letters and the first syllable (*ju.nas-JU.NIO*) relative to CV target words that shared the first three letters but not the first syllable (*jun.tu-JU.NIO*). This finding is in agreement with the results reported by Carreiras and Perea (2002), and it supports the view that syllabic priming effects can be obtained in the lexical decision task with brief SOAs (Carreiras & Perea, 2002). Rather surprisingly, we did not obtain any syllabic priming effects for CVC target words (i.e., faster recognition of the target word in the pair *ver.bu-VER.JA* than in the pair *ve.rus-VER.JA*). It is important to note that other recent studies using different tasks (e.g., picture naming, illusory conjunctions, and stem completion) and languages (Spanish and French) have also found distinct

[2] Because of a typing error in the input file, the word *LÁPIZ* was discarded from the data analysis.

patterns of results for CV and CVC words (e.g., see Costa & Sebastián, 1998; Marín & Carreiras, 2002; Peretz, Lussier, & Beland, 1998). One possible explanation for the advantage of CV primes is that the CV syllable is by far the most frequent syllabic structure in Spanish. As the CV syllable can be considered the canonical syllable, it could always be processed by default even if the processor finds a CVC structure in the first syllable. (We discuss this issue further in the General Discussion.)

EXPERIMENT 2

Experiment 1 provided further empirical evidence of the involvement of the syllable in the early stages of visual word recognition. However, it cannot be used to tease apart phonological and orthographic accounts of the syllabic effects. In the architecture proposed by Ferrand and Grainger, (1994); (Ferrand et al., 1996; Ferrand & Segui, 1998), sublexical phonological representations are coded syllabically. In contrast, in Taft's (1991) model, syllable-size orthographic representations intervene between letter units and whole-word representations.

The process of translating print into sound in Spanish is unambiguous. Each letter of the alphabet receives a unique pronunciation, but some graphemes map onto the same sound. Specifically, the letters which map onto the same sound are the following: ''j'' and ''g'' when followed by ''i'' and ''e'' are pronounced /x/; ''b'' and ''v'', which are mapped onto the phoneme /b/; ''k'' and ''c'' when followed by ''a'', ''o'' and ''u'' map onto the sound /k/. Finally, in the Canary Islands (as well as in Southern Spain and Latin America) the letters ''z'', ''s'', and ''c'' when followed by ''e'' and ''i'' are pronounced /s/.

In the present experiment, we take advantage of the fact that some consonant letters share the same pronunciation, in order to investigate whether syllabic effects are phonological or orthographical in nature. In particular, to examine whether syllable-size units are represented in the phonological input, we include nonword primes that share the same orthographic and phonological initial syllable (e.g., *vi.rel-VI.RUS*) or only the same phonological initial syllable with the target (e.g., *bi.rel-VI.RUS*; ''v'' and ''b'' share the same sound in Spanish, /b/). We also used control primes that shared the same number of letters with the targets as with the experimental primes, but did not share the initial syllable (e.g., *vir.ga-VI.RUS* and *bir.ga-VI.RUS*). If syllables are phonological units of processing, priming effects should be observed either as a result of orthographic overlap or phonological overlap in the syllabic conditions. If the advantage of the syllabic over the non-syllabic control conditions is similar in the orthographic + phonological condition and in the phonological-only condition, this could be taken as favouring a phonological representation of the syllable—as proposed by Ferrand et al. (1996).

Method

Participants. Forty students from introductory psychology courses at the University of La Laguna took part in the experiment to fulfil a course requirement. None of them had participated in the previous experiments. All were native Spanish speakers of the Canary Islands. We would like to stress that, in this region of Spain, the graphemes "s" and "z", as well as the grapheme "c" (before "i" and "e") correspond to the same sound /s/.

Materials. Ninety-six disyllabic Spanish words, all of them consisting of five letters, were selected from the Spanish word pool (Alamada & Cuetos, 1995; Cobos et al., 1995). Forty-eight words had a CV structure in the first syllable, and the other forty-eight words had a CVC structure in the first syllable. The mean frequency of the CV words was 18 (range: 1–110) per one million words and the average number of orthographic neighbours was 5.9 (range: 0–15). The mean frequency of the CVC words was 20 (range: 2–70) per one million words and the average number of orthographic neighbours was 5.8 (range: 0–15). The average number of orthographic neighbours for the target nonwords was 2.6 (range: 0–11). In all cases, primes were pseudowords of five letters (the mean number of orthographic neighbours across conditions varied from 0.6 to 2.3). Of these 96 disyllabic pseudowords, half had a CV structure in the first syllable and the other half had a CVC structure in the first syllable. As in Experiment 1, in the orthographic + phonological condition word and nonword targets were preceded by a prime that either shared the first orthographic and phonological syllable or did not. However, in the phonological condition, word and nonword targets were preceded by a prime that either shared the first phonological syllable or did not. Orthographic + phonological syllables differed from the phonological syllables in their initial letters, but not in their pronunciation. For instance, the CVC word *GES.TA* could be preceded in the orthographic + phonological condition by *ge.ser* or *ges.po*, and in the phonological condition by *je.ser* or *jes.po*. The CV word *VI.RUS* could be preceded in the orthographic + phonological condition either by *vi.rel* or *vir.ga*, and in the phonological condition by *bi.rel* or *bir.ga*. In addition, we used 96 disyllabic nonwords, 48 of them with a CV structure in the first syllable and the other 48 with a CVC structure in the first syllable. Similarly to word targets, nonword targets were preceded by CV nonword primes (either orthographic + phonological or only phonological) or CVC nonword primes (either orthographic + phonological or only phonological).

Design. Type of prime (CV vs. CVC prime), type of target (CV vs. CVC target) and orthographic-phonological relation of primes and targets (orthographic + phonological vs. only phonological) was varied within participants. The design was the same for words and nonwords. Each participant was given a total of 192 experimental trials: 96 nonword-word trials and 96 nonword-nonword trials.

Procedure. The procedure was the same as in Experiment 1.

Results and discussion

Incorrect responses for words (7.0%) were excluded from the latency analysis. A preliminary analysis revealed that five words provoked a high error rate (over 40%): *cirio* = 42.5%, *zares* = 85%, *visor* = 52.5%, *visir* = 80%, *vulgo* = 87.5%. These five items were therefore excluded from the analyses reported below. (The ANOVAs yielded the same results with and without these five items.) In addition, reaction times less than 300 ms or greater than 2000 ms (less than 0.7% of the data for words) were excluded in a first pass, and all reaction times more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded. The percentage of trials that were removed due to the screening procedure was similar in the syllabic and the orthographic conditions. For CVC target words, these percentages were 4.3% and 4.6% for the syllabic and the orthographic conditions, respectively; whereas for CV target words these percentages were 5.7% for both the syllabic and the orthographic conditions. Mean reaction times on words were submitted to ANOVAs by subjects and by items, with the Type of prime, Type of target, Orthographic-phonological relation between primes and targets, and List as factors. The mean lexical decision time and the error rate on the stimulus words in each experimental condition are shown in Table 2.

The ANOVA on the latency data showed that the effect of orthographic-phonological relation was significant, $F_1(1, 36) = 12.93$, $p < .001$ $F_2(1, 83) = 8.13$, $p < .01$: participants responded faster when the prime-target relation was orthographic + phonological (719 ms) than when it was only phonological (733 ms). The main effect of type of prime was also statistically significant, $F_1(1, 36) = 15.30$, $p < .001$; $F_2(1, 83) = 16.12$, $p < .001$: On average, participants responded more quickly when the prime had a CV structure than when the prime had a CVC structure. Although the interaction between Type of prime and Type of target was not significant, $F_1(1, 36) = 1.95$; $F_2(1, 83) = 1.49$, CV target words were responded to faster when the prime had a CV structure than when the prime had a CVC structure, $F_1(1, 36) = 11.87$, $p < .01$; $F_2(1, 85) = 6.65$, $p < .02$, as in Experiment 1. In contrast, the effect of type of prime for

TABLE 2
Mean lexical decision times (in ms) and percentage of errors (in parentheses) on target words in Experiment 2

	Syllabic structure of the prime		
	CV	*CVC*	*CVC-CV*
Words			
Orthographic + phonological			
CV structure	705 (9.5)	738 (10.0)	33 (0.5)
CVC structure	709 (6.3)	726 (6.1)	17 (−0.2)
Phonological			
CV structure	722 (6.8)	757 (6.6)	35 (−0.2)
CVC structure	717 (4.5)	737 (6.1)	20 (1.6)

CVC targets was significant only in the analysis by participants, $F_1(1, 36) = 6.52$, $p < .02$; $F_2(1, 85) = 2.03$, $p < .15$ but in the same direction as for the CV words: an advantage of the CV primes. The other interactions were not significant (all ps $> .15$).

The ANOVA on the error data also showed that the effect of orthographic-phonological relation was significant, $F_1(1, 36) = 8.94$, $p < .005$; $F_2(1, 83) = 5.10$, $p < .05$. Participants made more errors when the prime-target relation was orthographic + phonological (8.0%) than when it was only phonological (6.0%). The main effect of type of target was also significant, but only in the analysis by participants, $F_1(1, 36) = 8.39$, $p < .01$; $F_2(1, 83) = 1.98$. The other effects and interactions were not significant (all ps $> .15$).

The main results of this experiment can be summarised as follows: first, CV words were responded to more quickly when they were preceded by a nonword with the same initial syllable than when they were preceded by a nonword with a different initial syllable. Although, similarly to Experiment 1, CVC words showed faster response times when preceded by CV primes, this effect was far from significant in the analysis by items (we defer a discussion of this issue until the General Discussion). Second, the fact that the syllabic structure of the prime (CV prime vs. CVC prime) yielded similar effects for the orthographic + phonological condition and for the phonological condition suggests that syllabic priming effects are phonological in origin. This outcome implies that phonological syllabic activation is taking place in addition to pure orthographic processing: A priming effect is observed as a result of orthographic overlap as well as a result of a pure-phonological (but syllabic) overlap. Finally, we would like to note that although participants were faster in the orthographic + phonological condition than in the phonological condition—which may suggest that orthography plays a role over and above phonology in the process of visual word recognition, this advantage is compromised by a speed-accuracy trade-off. Finally, it is important to note that these results cannot be explained simply in terms of orthographic overlap, since in the phonological conditions (syllabic and non-syllabic), primes and targets shared only the same two letters (the second and the third).

EXPERIMENT 3

The results obtained in Experiment 2 indicate that the syllable priming effect for CV target words occurs when primes and targets share the first phonological syllable. However, one could argue that the advantage of the phonological + orthographic condition over the phonological-only condition in the response times was due to the fact that the former condition, primes and targets shared more letters. Moreover, the syllabic priming effect in the phonological-only condition could also have been produced by the prime-target pairs sharing the rime/body, rather than the whole first syllable. Indeed, several studies have shown priming effects independently of whether prime and targets shared onsets in lexical decision tasks (e.g., Grainger & Ferrand, 1996). Likewise, it has been claimed that subsyllabic units such as rimes play an important role as a sublexical representation between the letter and word levels (see Forster & Taft, 1994; Grainger & Ferrand, 1996; Treiman & Chafetz, 1987).

The main aim of Experiment 3 was to examine if the phonological effects found in Experiment 2 were indeed caused by the first phonological syllable rather than the rime/body. To test this hypothesis, a phonological-syllable priming condition (e.g., *va.lis-BA.LÓN*) was compared with a rime-only condition (e.g., *fa.lis-BA.LÓN*). For comparison purposes with Experiment 2, we also included a phonological control condition in which primes and targets shared the first three phonemes, but not the initial syllable (e.g., *val.ti-BA.LÓN*). An advantage of the phonological-syllable condition over the two control conditions (rime-only and phonological control) would reinforce the notion of the syllable as a sublexical phonological processing unit.

Method

Participants. Thirty-six undergraduate students from the University of La Laguna took part in the experiment, receiving course credits for their participation. None of them had participated in the previous experiments. All were native Spanish speakers from the Canary Islands.

Materials and design. Forty-five disyllabic Spanish words, all of them consisting of five letters, were selected from the Spanish word pool (Alameda & Cuetos, 1995; Cobos et al., 1995). Words had a CV structure in the first syllable and a CVC structure in the second one (e.g., *BA.LÓN*). The mean frequency was 63 (range: 1–637) per one million words and the average number of orthographic neighbours was 3.7 (range: 0–13). In all cases, primes were pseudowords of five letters with very few orthographic neighbours (from 0.6 to 1.1 orthographic neighbours across conditions). Primes and targets always shared the second and the third letters. Word targets were preceded by three prime conditions: (1) a prime that shared the first phonological syllable, but not the orthographic one (e.g., *va.lis-BA.LÓN*); (2) a prime that shared only the rime or body (*fa.lis-BA.LÓN*); and (3) a prime that shared the first three phonemes but not the first syllable (*val.ti-BA.LÓN*). In addition, we used forty-five disyllabic nonwords preceded by nonwords primes with the same manipulation as that for the word targets.

Procedure. The procedure was the same as in Experiments 1 and 2.

Results and discussion

Incorrect responses for words (4.6%) were excluded from the latency analysis. In addition, reaction times less than 300 ms or greater than 2000 ms (less than 0.5% of the data for words) were excluded in a first pass, and all reaction times more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded (3.4%). Mean reaction times and error rates for words were submitted to separate ANOVAs, with Type of prime and List as factors. The mean lexical decision time and the error rate on the stimulus words in each experimental condition are shown in Table 3.

The ANOVA on the response times to word stimuli showed a significant effect of type of prime, $F_1(1, 33) = 6.49$, $p < .05$; $F_2(1, 42) = 4.52$, $p < .05$. The ANOVA on the error data did not show a significant effect of type of prime (both *p*s $> .1$).

Planned comparisons on the response times showed that target words were responded to faster when preceded by primes that shared the phonological-syllable than when preceded by primes that only shared the rime/body (695 vs. 755 ms), $F_1(1, 33) = 4.87$, $p < .05$; $F_2(1, 42) = 8.34$, $p < .05$. In addition, target words preceded by primes that shared the

TABLE 3
Mean lexical decision times (in ms) and percentage of errors (in parentheses) on target words in Experiment 3

Priming condition	*Phonological syllable*	*Rime/body*	*Phonological control*
	695 (5.6)	755 (4.1)	740 (4.0)

phonological-syllable were responded to faster than when preceded by primes that shared the first three phonemes but not the initial syllable (695 vs. 740 ms, respectively), $F_1(1, 33) = 6.49, p < .05$; $F_2(1, 42) = 4.71, p < .05$. The difference between the rime/body condition and the phonological control phonemes was not significant (both ps $> .1$).

The results of the present experiment are straightforward: response times to target words were substantially faster when primes and targets shared the first phonological syllable than when primes and targets only shared the first three phonemes (but not the first syllable) or when they only shared the rime/body of the initial syllable. That is, leaving aside the finding of an advantage of the phonological syllable against the phonological control (replicating Experiment 2),[3] we also found a superiority of the phonological syllable over the rime-only condition. We should note that there is empirical evidence that shows that the rime of the syllable acts as a relevant processing unit in English, and possibly this evidence is even stronger than the evidence which supports the syllable as a sublexical unit (Jared, 1997; Forster & Taft, 1994; Treiman & Chafetz, 1987; Treiman & Zukowski, 1988; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995). However, this does not seem to be the case in Spanish: we found a clear superiority of the syllable over the rime. Thus, our data reinforce the results obtained in Experiment 2 and provide further evidence that syllabic effects are phonological in origin. This pattern suggests that phonological input phonology may be structured syllabically (Ferrand et al., 1996).

Finally, and even though we are not dealing with the time course of the phonological effects, the present results are in accordance with previous studies that have found phonological priming with similar (or even shorter) SOAs (e.g., Ferrand & Grainger, 1992, 1993; Frost et al., 2003; Lukatela & Turvey, 1994; Lukatela et al., 1998).

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[3] The goal of Experiments 2 and 3 was to investigate whether the syllabic effects obtained in previous research (including Experiment 1 in the present paper) could be of phonological nature. Indeed, Experiments 2 and 3 show that there is an advantage for CV target words when primes and targets share the first syllable relative to when they do not, even when all items share the three first letters/phonemes. A different question is to ask whether it is possible to obtain phonological effects for disyllabic words when there is no syllabic compatibility between primes and targets, but different degrees of phonological overlap. This question has not been systematically addressed in the present study, and the answer may depend on the differential degree of overlap between primes and targets across conditions. It may be worth noting that, in an unpublished experiment in which primes and targets differed in syllabic structure, we failed to find any reliable differences when prime-target pairs shared three out of five phonemes (e.g., *val.ja-BA.LAS*) and when prime-target pairs shared two out of five phonemes (e.g., *ral.ja-BA.LAS*).

GENERAL DISCUSSION

The present findings add further empirical support to the general notion that syllables are fundamental units of processing in this language, and they also extend previous research that suggested that syllabic effects are phonological in nature (Álvarez et al., 1998, 2000, 2001; Carreiras & Perea, 2002; Carreiras et al., 1993; Dominguez, de Vega, & Cuetos, 1997; Perea & Carreiras, 1998).

We found syllabic priming effects at very brief SOAs in all three experiments. In Experiments 1 and 2 we found syllabic priming effects for CV words when letter overlap between primes and targets was perfectly controlled. In particular, CV targets preceded by pseudoword primes that shared the first three letters with the target were recognised faster when primes and targets shared the first CV syllable than when they did not. Experiment 2 studied phonological syllabic priming effects by using an orthographic + phonological condition (e.g., *vi.rel-VI.RUS*) pitted against a purely phonological condition (e.g., *bi.rel-VI.RUS*; note that "b" and "v" sound the same in Spanish). Syllabic priming effects were obtained in both conditions for CV targets; that is, the syllabic priming effects of Experiment 1 were also found when primes and targets shared only the first phonological (but not orthographic) syllable. We consider this result remarkable, since we found an advantage of the syllabic primes not only when prime and target shared the first "orthographic" syllable (both sounds and letters) but also when prime and target shared just the first phonological syllable. We are not implying, however, that orthographic processing plays a secondary role in the process of visual word recognition. What we argue is that the computation of the phonological units at a syllable level can facilitate the recognition of the word target. This can be deduced from the fact that a syllabic priming effect can be observed when some orthographic information is omitted (the first letter), while the first phonological syllable is intact. It could be argued that this conclusion may be problematic because equivalent syllabic priming effects were obtained in both in the orthographic + phonological condition and in the phonological-only condition (note that, in the former case, more information is shared by prime and targets). However, this argument only stands if we accept that orthographic and phonological priming effects combine additively, an issue that has been challenged recently (e.g., in terms of morphological and form priming; see Forster & Azuma, 2000).

In Experiment 3, we replicated the syllabic priming effect when primes and targets shared the initial phonological syllable (e.g., *va.lis-BA.LÓN*) relative to when primes and targets only shared the first three phonemes (e.g., *val.ti-BA.LÓN*). Furthermore, we found an advantage of the phonological-syllable condition (*va.lis-BA.LÓN*) relative to a rime/body condition (e.g., *fa.lis-BA.LÓN*) hence ruling out an account of syllable priming effects in terms of rime/body overlap. Taken together, these results indicate that the codes produced or generated from masked primes are structured syllabically, as proposed by Carreiras and Perea (2002; see also Ferrand et al., 1996). More importantly, they also suggest that these syllabic priming effects (when they do arise) are phonological in nature and cannot be attributed to purely orthographic factors or some initial (non-syllabic) phonemic overlap.

One possible objection to this conclusion, however, is to argue that a grapheme-grapheme conversion mechanism is at work, as proposed by Taft (1982), instead of a grapheme-phoneme mechanism—as we have assumed. According to Taft (1982), orthographic similarity may be dictated by phonological similarity. Thus, the consonant letters ''b'' and ''B'' are always perceived as graphemically equivalent because they are pronounced the same way. What is more, one could argue that for instance, the b/v alternation in Spanish could work in a similar way to case alternation. There is, however, one important difference between case alternation and the change of consonants that map onto the same sound (e.g., b/v): In a masked priming paradigm, case alternation always implies a repeated access to the same lexical entry, whereas change of consonants like b/v or z/s may result in two different lexical items (e.g., pairs such as *va.ca-ba.ca*, *ca.bo-ca.vo*, *ca.za*, and *ca.so*, etc., have different meanings in Spanish).

Most of the research focused on the influence of phonology in visual word recognition, in particular studies using priming paradigms and pseudohomophones (or homophones) as primes, has employed mono-syllabic words and nonwords, maximising phonological similarity between primes and targets. In Experiment 3 we used disyllabic prime-target pairs in which the orthographic similarity between the phonological-syllable prime (*va.lis-BA.LÓN*) and the rime/body prime (*fa.lis-BA.LÓN*) was the same: In both conditions, the first letters of the primes (the onsets) were different compared with the first letters of the targets. Likewise, primes and targets shared the same syllabic structure. The finding of robust phonological syllable priming effects under conditions in which letter and sound overlap between primes and targets is relatively low provides additional support for the view that readers are able to represent words in terms of phonological syllables. Additionally, the results in Experiment 3 do not corroborate the common finding in English that subsyllabic units such as rimes play an important role in visual word recognition (Forster & Taft, 1994; Grainger & Ferrand, 1996; Treiman & Chafetz, 1987). Instead, at least in a Romance language like Spanish, the syllable (rather than the rime) seems to act as the most relevant sublexical unit of processing. Further research is needed to examine whether the present findings can be generalised to other languages, especially all other syllable-timed languages. Studies comparing the role of the syllable (and other sublexical units) across languages offer a promising way of examining this issue. For instance, Álvarez, Taft, and Carreiras (1998), using English-Spanish homographic in a lexical decision task with split stimuli (e.g., *fi.nal*), found that Spanish readers produced faster responses to stimuli segmented after the syllable boundary (*fi//nal*) than segmented after the BOSS (*fin//al*). However, English good readers produced the opposite pattern, suggesting the presence of different segmentation strategies across languages during reading. Indeed, unlike the mixed evidence in English on the role of the syllable in visual word recognition, the syllable seems to be a relevant unit in visual word processing in French (e.g., Colé, Magnan, & Grainger, 1999; Mathey & Zagar, 2001; Taft & Radeau, 1995).

One unexpected result in both Experiments 1 and 2 that deserves comment refers to the results with the CVC targets. As indicated above, we found that CV words such as (*JU.NIO*) were responded to faster when they were preceded by a prime nonword with the same initial syllable (*ju.nas*), than when they were preceded by a prime nonword with a different initial syllable (*jun.tu*). However, lexical decision responses to CVC words (e.g., *VER.JA*) were not modulated by the presence of nonword primes that shared the first initial syllable with the target item.[4] A replication of Experiments 1 and 2 with a different set of materials (i.e., six-letter items) found a similar pattern: A syllabic priming effect for CV target words but not for CVC target words. Thus, this divergence between CV and CVC words seems to be real and, indeed, it has always been documented in the literature: Previous studies have also found a different pattern of results for CV and CVC words (Costa & Sebastián, 1998, in a speech production study; Peretz et al., 1998, in an implicit visual/auditory task; Marín & Carreiras, 2002, in visual word recognition in Spanish using perceptual discrimination tasks). Peretz et al. (1998) suggested that these asymmetrical syllabic effects for CV and CVC are related with distributional organisation for the lexicon, because there are more French words starting with CV than with CVC segments. A tentative explanation for this pattern of results is that the CVC word structure is a much less frequent pattern in Spanish and French (e.g., CVC syllables are three times less frequent than CV syllables in Spanish; see Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000). Thus, unlike CV syllables—the canonical syllable for Spanish, CVC syllables might not give rise to an optimal level of sublexical activation and/or the activation they produce may not be

[4] A combined analysis of Experiments 1 and 2 failed to find any signs of syllabic priming effects for CVC target words in the analyses by items ($p > .20$).

quick enough to influence target recognition. For instance, Marín and Carreiras (2002) found robust syllabic effects employing an illusory conjunction paradigm. However, in the case of words with initial CVC syllables, both the CVC syllable and the embedded (illicit) CV syllable (illicit because it was not the current syllable) showed a similar number of illusory conjunctions. They concluded that CV and CVC segments collaborate rather than compete in the process of word segmentation: When processing a CVC syllable, the embedded CV syllable is also processed. This would explain an advantage for CV primes, if anything, for CVC targets. Clearly, the fact that CV and CVC words sometimes behave differently is a puzzling finding that needs further research. Nonetheless, it is important to stress that this issue does not undermine our claim that syllabic effects, when they do arise (as was the case in the CV target words in all three experiments), are phonological in nature. In addition, current computational models of visual word recognition are either restricted to monosyllabic words (DRC models) or do not include a syllabic level of processing (multiple read-out model) and as such cannot accommodate the observed syllabic effects. One would need to implement a quantitative model of visual word recognition with a syllabic level to examine whether or not this model can capture the divergence between CV and CVC targets.

Finally, the present results have important implications for visual word recognition models. The observed (phonological) syllabic priming effects are consistent with the proposals of an early and mandatory activation of phonology in (monosyllabic) word reading (Frost, 1998; Lukatela & Turvey, 1994; Lukatela et al., 1998, 2002; Pollatsek, Lesch, Morris, & Rayner, 1992; Van Order, 1987; Van Order, Johnston, & Hale, 1988). The empirical support for these proposals comes mainly from studies using monosyllabic homophones and pseudohomophones. As such, they do not address whether phonological processing is syllabically structured. To accommodate the present findings, an implement model should include a syllable-based phonological level. Alternatively, there are models in which words can be identified via an orthographic code without necessarily resorting to the computation of phonology (e.g., the DRC model; Coltheart et al., 2001; see also Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart & Rastle, 1994; Rastle & Coltheart, 1999). The current implementation of the DRC model is restricted to monosyllabic words, and as such, it does not include syllabic processing in the phonological route either. We believe that future implementations of the DRC model need to take into account the early activation of phonological codes (see also Frost et al., 2003) in multisyllabic words. In addition, the fact that similar syllabic priming effects were obtained when prime and target shared either the phonological-only syllable or the orthographic (and phonological) syllable can be explained by the entry-opening model (Forster & Davis, 1984; Forster et al., 2003). In this model, priming occurs when the prime has accessed the entry of the target word (e.g., when the prime is a close match for the target). Our results seem to suggest that both phonological-only syllabic overlap and orthographic and phonological syllabic overlap are establishing a closer match between the two stimuli than a non-syllable condition.

Our data can be readily accommodated within a model of multisyllabic word reading that incorporates a syllabic level of processing connected with a word level of representation. Specifically, they can be captured by the bimodal interactive activation model (Ferrand et al., 1996; Grainger & Ferrand, 1996; Grainger & Jacobs, 1996), which is a theoretical framework for word recognition and naming. Performance in tasks such as lexical decision is based not only on activity in the orthographic lexicon (composed by a level with sublexical orthographic units and another level with whole-word orthographic units) but also in the phonological lexicon (with a level of sublexical phonological units or sublexical input phonology and a word phonological level). The bi-directional connections between orthographic and phonological units allow the model to handle the early effects of phonology found in lexical decision. Ferrand et al. (1996) suggested that the sublexical input phonology would be organised syllabically. This notion is clearly supported by the present findings. Computer simulations with an implemented version of this model would, however, be necessary to examine whether this model can accommodate the observed discrepancy in syllabic priming effects for CV and CVC words.

In sum, the present findings strengthen the view that syllables are phonological sublexical units in visual word recognition. This notion can be accommodated in an activation-based model in which phonological syllables mediate between letter and word levels (e.g., the model proposed by Ferrand et al., 1996). Whether this theoretical proposal must be restricted to Spanish or can be generalised to other syllable-timed languages or to most languages is a question that merits further empirical research.

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APPENDIX

Prime-target pairs in Experiment 1

The items are arranged in triplets in the following order: CV prime, CVC prime, target word.

balir; balta; BALDE; banar; bante; BANDO; basus; bascu; BASTO; caler; calta; CALDO; casur; caste; CASCO; cinus; cincu; CINTA; colir; colsa; COLMO; curor; curla; CURSI; finel; fintu; FINCA; honir; honru; HONDA; maris; marti; MARZO; monis; mondi; MONJA; pales; palca; PALMO; parer; partu; PARDO; pasur; pasca; PASMO; pesis; pesmo; PESTE; salin; salge; SALDO; senis; sento; SENDA; tenur; tenge; TENSO; torri; torca; TORPE; venes; vengi; VENTA; verus; verbu; VERJA; basun; bascu; BASES; camiz; campu; CAMAS; casis; cascu; CASAR; celir; celte; CELOS; cosus; costi; COSER; curon; curvi; CURAS; genir; genta; GENES; hones; honta; HONOR; junas; juntu; JUNIO; lapes; lapse; LÁPIZ; marir; marzu; MARES; moner; montu; MONOS; palir; palmi; PALOS; pesir; pestu; PESOS; pisel; pisti; PISOS; recer; rectu; RECIO; salin; saldu; SALAS; secal; secti; SECOS; tenel; tensu; TENAZ; toral; torpa; TOROS; tumas; tumbi; TUMOR; venil; vendu; VENAS

Prime-target pairs in Experiment 2

The items are arranged in quintuplets in the following order: CV prime (orthographic + phonological), CVC prime (orthographic + phonological), CV prime (phonological-only), CVC prime (phonological-only), target word.

balis; balta; valis; valta; BALDE; balir; balco; valir; valco; BALSA; bamin; bampe; vamin; vampe; BAMBU; banis; banfe; vanis; vanfe; BANCO; baner; banso; vaner; vanso; BANDA; banil; bansa; vanil; vansa; BANDO; barel; barle; varel; varle; BARBA; baren; barfo; varen; varfo; BARCA; basir; baspo; vasir; vaspo; BASTA; beliz; belte; veliz; velte; BELGA; binur; binte; vinur; vinte; BINGO; bolir; bolte; volir; volte; BOLSA; bolud; bolma; volud; volma; BOLSO; bomes; bompo; vomes; vompo; BOMBA; bomar; bompe; vomar; vompe; BOMBO; boras; borta; voras; vorta; BORDE; bules; bulma; vules; vulma; BULTO; burin; burto; vurin; vurto; BURLA; caluz; calta; kalux; kalta; CALCO; calir; calcu; kalir; kalcu; CALDO; caler; calde; kaler; kalde; CALMA; caloz; calmi; kaloz; kalmi; CALVO; canar; canri; kanar; kanri; CANTO; carun; carto; kaun; karto; CARGA; casur; caspi; kasur; kaspi; CASCO; casin; caslo; kasin; kaslo; CASPA; casor; casmo; kasor; kasmo; CASTA; celer; celto; seler; selto; CELDA; celur; celmo; selur; selmo; CELTA; cenur; cente; senur; sente; CENSO; ceril; cerma; seril; serma; CERCO; ceral; cerla; seral; serla; CERDO; cesur; cesmo; sesur; sesmo; CESTA; cinir; cindo; sinir; sindo; CINTA; cires; cirta; sires; sirta; CIRCO; colas; colta; kolaz; kolta; COLMO; corar; corma; korar; korma; CORTE; cosez; cosmi; kosez; kosmi; COSTA; culaz; culma; kulaz; kulma; CULTO; curer; curte; kurer; kurte; CURVA; geser; gespo; jeser; jesop; GESTA; vasud; vasla; basud; basla; VASCO; venor; vento; benor; bento; VENDA; venil; venso; benil; benso; VENTA; verel; vergo; berel; bergo; VERJA; verul; verma; berul; berma; VERSO; vular; vulme; bular; bulme; VULGO; zuril; zurma; suril; surma; ZURDO; balun; balte; valun; valte; BALAS; baliz; balma; valiz; valma; BALÓN; banor; bante; vanor; vante; BANAL; baral; barlo; varal; varlo; BARES; baser; basmo; vaser; vasmo; BASAL; bason; basli; vason; vasli; BASES; besun; besgo; vesun; vesgo; BESAR; bolen; bolto; volen; volto; BOLAS; bonar; bonta; vonar; vonta; BONOS; canis; cansi; kanis; kansi; CANAL; capel; capti; kapel; kapti; CAPÓN; comiz; combu; komix; kombu; COMER; carin; carle; karin; karle; CAROS; casiz; caste; kasiz; kaste; CASAR; celan; celma; selan; selma; CELOS; cenis; censi; senis; sensi; CENAR; cesol; cesme; sesol; sesme; CESAR; cinor; cinti; sinor; sinti; CINES; siras; cirla; siras; sirla; CIRIO; coler; colmi; koler; kolmi; COLAS; coper; copte; koper; kopte; COPIA; corun; corme; korun; korme; CORAL; corad; corfe; korad; korfe; COROS; cosil;

cosmo; kosil; kosmo; COSER; cunel; cunto; kunel; kunto; CUNAS; curol; curla; kurol; kurla; CURAR; gemal; gembo; jemal; jembo; GEMIR; genor; genta; jenor; jenta; GENES; genas; gensa; jenas; jensa; GENIO; girol; girte; jirol; jirte; GIRAR; valos; valca; balos; balca; VALER; vasel; vasma; basel; basma; VASOS; velor; velto; belor; belto; VELAS; velin; velta; belin; belta; VELOZ; vener; venfe; bener; benfe; VENAS; venos; venlo; benos; benlo; VENIR; verer; vermo; berer; bermo; VERAZ; vinar; vinla; binar; binla; VINOS; viros; virto; biros; birto; VIRIL; virel; virga; birel; birga; VIRUS; visal; visma; bisal; bisma; VISIR; viser; visga; biser; bisga; VISÓN; visus; vispa; bisus; bispa; VISOR; volon; volce; bolon; bolce; VOLAR; voril; vorgo; boril; borgo; VORAZ; zarir; zarga; sarir; sarga; ZARES; zonel; zonto; sonel; sonto; ZONAS; zumal; zumpa; sumal; sumpa; ZUMOS

Prime-target pairs in Experiment 3

The items are arranged in quadruplets in the following order: phonological prime, rime-only prime, control prime, target word.

valol; ralol; valja; BALAS; valis; falis; valti; BALÓN; vasun; fasun; vastu; BASES; vesel; fesel; vesde; BESOS; volen; folen; volme; BOLAS; kalud; lalud; kalfo; CALOR; kaner; maner; kange; CANAL; kasun; ñasun; kascu; CASOS; senud; penud; sengo; CENAR; sesol; jesol; sespo; CESAR; kolel; folel; koldo; COLAS; kolud; zolud; kolga; COLOR; komor; pomor; kombo; COMÚN; korez; vorez; kortu; CORAL; kosun; dosun; kosgo; COSAS; kosuz; gosuz; kosda; COSER; kuron; buron; kurgo; CURAR; jired; pired; jirco; GIRAR; zalen; galen; zalpa; SALAS; zaler; raler; zalul; SALÓN; zanel; tanel; zande; SANOS; zecod; becod; zecto; SECAR; zenin; fenin; zente; SENOS; zoled; joled; zolfo; SOLAR; zolin; nolin; zolpi; SOLOS; zonod; donod; zonte; SONAR; bacin; pacin; bactu; VACAS; basul; pasul; basmu; VASOS; becin; mecin; becna; VECES; elon; lelon; belge; VELAS; velud; melud; veldu; VELOZ; benol; penol; bensu; VENAS; benaz; zenaz; benti; VENIR; berun; serun; berpo; VERAZ; binul; rinul; binca; VINOS; boled; noled; volte; VOLAR; sonel; conel; sonde; ZONAS; zimue; pimue; zimbe; SIMIO; sumul; fumul; sumbe; ZUMOS; benol; tenol; benge; VENUS; balod; jalod; baltu; VALER; biroz; firoz; birno; VIRIL; saled; raled; zalne; SALIR; zerei; terei; zerto; SERIO; jenal; ñenal; jenca; GENIO