Journal of Experimental Psychology:
Human Perception and Performance
2002, Vol. 28, No. 5, 1228–1242

0096-1523/02/$5.00 DOI: 10.1037//0096-1523.28.5.1228

Masked Priming Effects With Syllabic Neighbors in a Lexical Decision Task

Manuel Carreiras
Universidad de La Laguna

Manuel Perea
Universitat de València

Four lexical decision experiments using a masked priming paradigm were conducted to analyze whether the previous presentation of a syllabic neighbor (a word sharing the same 1st syllable) influences recognition performance. The results showed an inhibitory effect of more frequent syllabic primes and some facilitation of nonword syllabic primes (Experiments 1–3). When monosyllabic pairs were used (Experiment 3), no priming effects of the 2 initial letters were found. Finally, when using only syllables as primes, latencies to words were shorter when preceded by primes that corresponded to the 1st syllable than by primes that contained 1 letter more or less than the 1st syllable (Experiment 4). Results are interpreted using activation models that take into account a syllabic level of representation.

Recent research on orthographic neighborhood effects in visual word recognition has found that the identification of a word is modulated by the number and frequency of similarly spelled words (e.g., see Andrews, 1997; Carreiras, Perea, & Grainger, 1997; Grainger & Jacobs, 1996; Pollatsek, Perea, & Binder, 1999, for recent reviews). Although investigation of the effects of lexical similarity provides valuable information into the processes underlying word recognition, most of these studies have focused on short monosyllabic words, which may not be representative of the language and even less in some languages than in others. For instance, whereas 12% of English words are monosyllabic (Cutler, 1990), less than 2% of Spanish words are monosyllabic (Justicia, Santiago, Palma, Huertas, & Gutiérrez, 1996). (However, when a token count is used, the percentage of monosyllabic words in Spanish is much higher, at 36%.) As Rastle and Coltheart (2000; see also Andrews, 1997; Forster & Taft, 1994) pointed out, any comprehensive model needs to confront the problems that arise when multisyllabic words are considered.

The focus on monosyllabic words is not accidental. It is closely related to the fact that interest in the perceptual processes of encoding has changed to focus on the nature of the representational structures and the organization of the mental lexicon (e.g., Coltheart, Curtis, Atkins, & Haller, 1993; Grainger & Jacobs, 1996; McClelland & Rumelhart, 1981; Morton, 1969; Seidenberg & McClelland, 1989). The search for a perceptual unit underlying word reading, which was an important topic of research 20 years ago, has almost disappeared from recent discussions on word recognition because of the change of metaphors guiding research in the field, as well as the implicit assumptions of most of the current computational models. Nonetheless, the fact that it has been overshadowed does not necessarily mean that it is not important or that it is not implicit in the assumptions of the models. All computational models rely on untested assumptions about the perceptual unit underlying reading, but these seemingly theoretically irrelevant assumptions are critical for the success of the models. For instance, the different types of input that are implemented in the interactive activation model (McClelland & Rumelhart, 1981), the dual route cascaded model (DRC model; Coltheart et al., 1993; Coltheart, Rastle, Perry, Ziegler, & Langdon, 2001), the connectionist model of Plaut, McClelland, Seidenberg, and Patterson (1996), and the connectionist model of Ans, Carbonnel, and Valdois (1998) allow the explanation of different effects.

The interactive activation model assumes independent, position-specific letter detectors and has been implemented for only four-letter words. Therefore, the model is completely insensitive to the relationship between letters at different positions, as well as to how to deal with similar words of different length. Such assumptions are critical to the model's performance because they determine which words are considered similar and, therefore, the cohort of words activated by a particular input. Thus, this model would predict that words that share the same letters, but in a different order, should not be considered similar, and neither should words that share some initial parts but are of different length. Thus, they should not influence the time required to select and recognize a target word that shares either the same letters in a different order or an initial syllable if they are of different length in terms of number of letters. However, recent research on lexical similarity challenges the position independence assumption (e.g., Andrews,

Manuel Carreiras, Departamento de Psicología Cognitiva, Universidad de La Laguna, Tenerife, Spain; Manuel Perea, Departament de Metodologica, Universitat de València, València, Spain.

This research was supported by grants to Manuel Carreiras from the Spanish Ministry of Science and Technology (BSO2000–0862), from the Comisión Interministerial de Ciencia y Tecnología—Fondo Europeo para el Desarrollo Regional (IF97–0927), and the Canary Islands Government (PI2001/058). This research was also supported by a grant to Manuel Perea from the Secretaría de Estado de Educación y Universidades of Spain.

We thank Moisés Betancort for his assistance in collecting the data. We are also grateful to Marc Brysbaert, Jonathan Grainger, Ken Paap, Nuria Sebastián, Marcus Taft, and an anonymous reviewer for helpful comments on earlier versions of this article.

Correspondence concerning this article should be addressed to Manuel Carreiras, Departamento de Psicología Cognitiva, Campus de Guajara, Universidad de La Laguna, 38205 Tenerife, Spain. E-mail: mcarreir@ull.es

1996) as well as the fact that words that share the first syllable but have a different number of letters seem to be activated during the process of word recognition (Perea & Carreiras, 1998).

The word length problem is considered in Coltheart et al.'s (1993) DRC model. This model allows the activation of all monosyllabic words that share the initial parts so the DRC will be sensitive to similarities between the beginnings of the words but not when these overlap at the ends. However, there is evidence that orthographic bodies play a major role in word recognition in English (Forster & Taft, 1994; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995).

The Plaut et al. (1996) model, which is a computational implementation of the parallel, distributed processing approach to visual word identification, makes strong assumptions about the perceptual units. Subsyllabic segments of *onset, vowel,* and *coda* are considered perceptual units in the model. This seems a very efficient way of coding within-word position for monosyllabic words. Among other things, it avoids the dispersion problem present in the interactive activation model, and it makes it unnecessary to code the order of elements within the letter string. Such efficiency of using subsyllabic segments derives from the high degree of constraint on the phonemes and letters that are legal in word onsets and codas. In short, these subsyllabic codes are in fact perceptual units. Thus, Plaut et al.'s simulations demonstrate the utility of subsyllabic segments to the representational structure of the lexical processing system.

Finally, Ans et al. (1998) proposed a connectionist distributed model for polysyllabic words in which mapping from orthography to phonology emerges from the integrated activation of previously experienced whole words and word syllabic segments. The model is composed of two orthographic input layers (one of which is a clean-up layer), a phonological output layer, and an intermediate layer mediating between them. Phonological encoding in the phonological layer takes into account three kinds of phonological units: phonemes, syllables, and syllabic constituents (onset and rime). However, is there any empirical evidence to sustain the idea that sublexical units such as the syllable are important in reading?

Evidence for Syllabic Parsing

Previous research has largely ignored the issue of how multisyllabic words might be processed. As Forster and Taft (1994) and Andrews (1997) pointed out, dealing with multisyllabic words raises a number of questions. On the one hand, it has been suggested that the syllable is an access unit for multisyllabic words (Taft, 1979; Taft & Forster, 1976), in which the first syllable is represented in the input system as a means of gaining access to the full information about the word (Taft, 1991). On the other hand, in the framework of an interactive activation model, Ferrand, Segui, and Grainger (1996; see also Colé, Magnan, & Grainger, 1999) suggested that sublexical input phonology could be coded syllabically. In either case, multisyllabic words might be susceptible to interference from syllabically defined neighbors.

Although the influence of the syllable in English is not entirely conclusive (see, e.g., Seidenberg, 1987, vs. Rapp, 1992; Prinzmetal, Hoffman, & Vest, 1991; Prinzmetal, Treiman, & Rho, 1986; Tousman & Inhoff, 1992)—in part because the boundaries among syllables are not well-defined (Taft & Radeau, 1995)—the syllable appears to play an important role in the visual recognition of multisyllabic words in languages with clearly defined syllable boundaries (e.g., French: Colé et al., 1999; Rouibah & Taft, 2001; Taft & Radeau, 1995; Spanish: Álvarez, Carreiras, & Taft, 2001; Álvarez, Taft, & Carreiras, 1998; Carreiras, Álvarez, & de Vega, 1993; Domínguez, de Vega, & Cuetos, 1997; Perea & Carreiras, 1995, 1998).

It is interesting that Carreiras et al. (1993) found that disyllabic Spanish words with high-frequency syllables were identified more slowly than those with low-frequency syllables in a lexical decision task (*the syllable frequency effect*). They suggested that not only are orthographic neighbors (i.e., words that share all letters but one; e.g., the Spanish words *casa* and *cara*) being activated in the process of visual word recognition—as is usually supposed—but also syllabic neighbors (i.e., words that share a syllable with the target word, especially the first syllable) are being activated. That is, the word *casa* would be partially activated (or accessible) when the word *cazo* is presented. In later studies, we (Perea & Carreiras, 1995, 1998; see also Álvarez et al., 2001) found that the factor responsible for this inhibitory effect was not the frequency of the syllable per se but rather the number of higher frequency syllabic neighbors of the target word (at least in the lexical decision task and in the progressive demasking task). It seems that the number of higher frequency syllabic neighbors appears to modulate the lexical access of Spanish words (through lexical inhibition): Words with many higher frequency syllabic neighbors will be recognized more slowly than words with few higher frequency syllabic neighbors in tasks in which resolution of the candidate set is needed, such as the lexical decision task (i.e., assuming that the processing of the stimuli is deep; see Grainger & Jacobs, 1996). It is interesting that the syllable frequency effect is reliable when the materials are controlled for bigram frequency, orthographic or morphological factors (e.g., see Álvarez et al., 2001; Carreiras et al., 1993; Perea & Carreiras, 1995, 1998). In summary, the basic conclusion from these studies is that "any model of lexical access has to incorporate a syllabic level of representation or include the syllable as a sublexical unit of processing in Spanish" (Álvarez et al., 2001, p. 553).

The main goal of this study was to examine, using a priming paradigm, the nature of the similarity relationships between lexical representations, as this procedure can provide insight into how coactivation of a syllabic neighbor might influence activation of a target representation (see Andrews, 1997). It is important to bear in mind that in experiments with a single-word paradigm such as those described above, the concern is whether partial activation of neighboring words that were never presented influences responses to the target word. However, in a priming paradigm, an item is explicitly activated and the effect on target performance is measured. Furthermore, a priming paradigm avoids the potential contamination from uncontrolled variables that may occur in an unprimed paradigm (see Forster, 2000). In this context, the masked priming paradigm (Forster, 1987, 1998; Forster & Davis, 1984; Forster, Mohan, & Hector, in press) provides a simple and clean methodological tool for manipulating the hypothetical competition from a given word's syllabic neighbors. Furthermore, the application of conscious strategies is severely hampered by this procedure, and the obtained priming effects are supposed to reflect automatic processes rather than strategic effects (see Forster, 1998). Even in such extreme conditions, that is, with a brief prime presentation duration and forward masking, it is hypothesized that processing has been initiated on the prime stimulus, causing a rise in activation of any representations involved in such processing. Thus, when the target stimulus is presented immediately after prime offset, a certain number of lexical representations will be in a heightened state of activation when processing begins on the target word. If this target word shares the first syllable with the prime, then the activation levels of some representations that were raised during prime processing will continue to be supported by information from the target word. In this way, these representations that remain in a heightened state of activation during target processing will influence target recognition. If we assume that the initial access to a lexical entry in a disyllabic word can be obtained through the first syllable (e.g., Taft, 1979), it is the first syllable that controls the priming effect across neighboring items.

Form-Priming Effects Obtained With the Masked Priming Technique

The literature on form-priming effects in the lexical decision task (e.g., using *blue* to prime *BLUR*) with the masking technique combined with limited prime exposition durations has primarily focused on monosyllabic word–word or nonword–word pairs. It is interesting that the lexical status of the prime is relevant to the priming effect (Drews & Zwitserlood, 1995; Grainger, 1992), at least when close distractors are used as nonword targets (e.g., *UNIVORSE*; see Forster & Veres, 1998, for a discussion of this point). When the primes are words, form-priming effects are ordinarily inhibitory (compared with an unrelated control condition), at least when the prime is of higher frequency than the target (see Bijeljac-Babic, Biardeau, & Grainger, 1997; De Moor & Brysbaert, 2000; Ferrand & Grainger, 1994; Grainger, 1992; Grainger, Colé, & Segui, 1991; Perea, Paap, Gotor, Hooper, & Algarabel, 1995; Segui & Grainger, 1990; but see Forster & Veres, 1998). Nonetheless, these effects are facilitative when word pairs are related in form and meaning (e.g., *made–MAKE*; see Forster, Davis, Schocknecht, & Carter, 1987; Grainger et al., 1991). In contrast, when the primes are nonwords similar in orthography (or phonology) to the target, priming effects tend to be facilitative (e.g., Ferrand & Grainger, 1992, 1993, 1994; Forster, 1987; Forster et al., 1987; Forster & Taft, 1994; Sereno, 1991).

These results can be readily explained in the context of activation-based models (e.g., see Ferrand & Grainger, 1994; Grainger, 1992; Grainger & Ferrand, 1996; Grainger & Jacobs, 1996; McClelland & Rumelhart, 1981). If the prime is a nonword (and perhaps a low-frequency word), only sublexical units (e.g., letters and, possibly, letter clusters) will be significantly activated at the beginning of target processing, but no lexical units will be significantly activated. Because of the sublexical facilitation, the processing of targets that share letters with the prime will be faster than the processing of unrelated targets. However, if the prime is a high-frequency word, it is likely that the primes will activate their corresponding word units. When the related target is presented, the prime nodes will be likely to receive further activation (because of orthographic similarity), and lateral inhibition at the lexical level will cancel out any sublexical facilitation from the related target. As a result, inhibition may occur, especially for low-frequency targets (because these are subjected to a longer period of inhibition from the high-frequency related words).

In addition, at a 57-ms stimulus onset asynchrony (SOA), Ferrand and Grainger (1994) found phonological priming using nonword primes in French that shared only one letter in the same position but had the same pronunciation (e.g., the prime *mair* and the target *MERE* are pronounced identically in French). However, at that SOA, no effects of orthographic priming were found (although these appeared at shorter SOAs). Ferrand and Grainger (1994) suggested that there are two pathways from the letter level to the word level: One would be orthographic (sublexical input orthography), and the other would be phonological (sublexical input phonology). More recently, Ferrand et al. (1996) suggested that sublexical phonological representations might be organized syllabically. Given that the syllabic representations located at the level of sublexical input phonology would send activation to whole-word representations, words that share one syllable could influence the process of word recognition (see Ferrand et al., 1996). If this is so, it is likely that syllabic neighbors (especially words that share the first syllable) will show masked priming effects in much the same way as orthographic neighbors. Consequently, when the prime is a high-frequency word, its activation level will be large enough to send some inhibition to lower frequency syllabic neighbors. We tested this possibility in Experiment 1. In contrast, some facilitation (or a null effect) is expected for nonword syllabic primes through sublexical facilitation because no lexical units will be strongly activated; therefore, some sublexical facilitation due to the letter and syllable levels may appear. We tested this possibility in Experiment 2.

Only a few published studies have examined masked priming effects with word pairs in which the related condition was composed of word primes that were not orthographic or phonological neighbors of the targets, although they were different from those used in the present series of experiments. Grainger et al. (1991; Experiment 2) found that primes that share the initial letters with the target (e.g., the French word *murir*) inhibited the processing of the related targets (*MURET*; compared with an unrelated control condition) at a 64-ms SOA. In contrast, pairs that shared final information (e.g., *accord–REBORD*) did not show any priming effects at all. Grainger et al. (1991) suggested that this could well be due to a left-to-right bias effect, in which priming effects are stronger for words sharing initial information than final information. Nonetheless, an alternative explanation is that because most of the related primes in the orthographic condition in the Grainger et al. study shared the first syllable with the target, part of the inhibitory effect might have been due to lexical inhibition through the syllable level. In addition, Drews and Zwitserlood (1995) used a 66-ms SOA with the masked priming technique in the lexical decision task. The orthographically related primes used by Drews and Zwitserlood always contained the target word plus a pseudo-affix (e.g., *kerst–KERS*; the Dutch words for *Christmas* and *cherry,* respectively). That is, orthographically related pairs were not merely orthographically similar but also had a meaningful cluster in common (an existing lexical morpheme). Drews and Zwitserlood (1995) found some inhibition when the primes were orthographically related words, whereas they failed to find facilitative priming effects when the primes were orthographically related nonwords (compared with an unrelated word condition). These findings suggest that lexical units other than those with the same number of letters as the target word are activated during the word recognition process (see also Carreiras et al., 1993; De Moor & Brysbaert, 2000; Perea & Carreiras, 1998).

In summary, the present experiments explored whether the previous presentation of a syllabic neighbor influences recognition performance in Spanish using a masked priming paradigm. Experiments 1 and 2 addressed the question of whether inhibitory effects can be produced on low-frequency targets when they share their initial syllable with a high-frequency prime (Experiment 1) and whether they become facilitative when they share their initial syllable with a nonword prime (Experiment 2). The rationale behind this manipulation is that the matching of an initial syllable could facilitate sublexical processing; however, this facilitation could be overwhelmed by lexical inhibition when the matching of the initial syllable forms a high-frequency neighbor. To minimize the influence of strategic processes, we used short SOAs between the prime and the target (64 and 80 ms) in Experiments 1 and 2. These two SOAs were chosen on the basis of a pilot study in our laboratory (Carreiras & Perea, 1995).

Recently, Forster and Veres (1998) found that when the nonword distractors do not have any similarly spelled words (e.g., *ANIVORSE*), form-priming effects—at least for long words—tend to be facilitative with word and nonword primes. Perhaps this effect was due to shallow processing of the stimuli, because the lexical status of the prime was relevant when the nonword distractors had similarly spelled words (e.g., *UNIVORSE*; Forster & Veres, 1998, Experiment 2). (For instance, lexical decisions with easy nonword distractors could be made on the basis of a global lexical activity rather than on the basis of unique word identification; see Coltheart et al., 2001; Grainger & Jacobs, 1996; Paap & Johansen, 1994.) Although it may be interesting to examine which type of distractor gives the clearest picture of the underlying processes, in the present series of experiments, nonword distractors were created by changing a single letter from a Spanish word. As a result, it seems reasonable to assume that responses to word targets on most trials would be based on a lexical unit reaching threshold rather than a lexical decision response made on the basis of global lexical activity.

Finally, the purpose of Experiments 3 and 4 was to tease apart whether the priming effects are due to syllabic structure or simple orthographic overlap. That is, Experiment 3 involved primes and targets that shared the first two letters and the first syllable in one condition (as in Experiments 1 and 2) and primes and targets that shared the first two letters but not the first syllable (by using pairs of monosyllabic items; e.g., *ziel–ZINC*) in another condition. Experiment 4 addressed the question of whether latencies to words are shorter when preceded by primes that correspond to the first syllable than when preceded by primes that contained one letter more or less than the first syllable (e.g., *pa****–PASIVO* vs. *pas***–PASIVO*; *pa****–PASTOR* vs. *pas***–PASTOR*), similar to the Ferrand et al. (1996) experiments.

Experiment 1

Method

Participants. A total of 80 psychology students from the Universidad de La Laguna took part in the experiment to fulfill a course requirement. All were native speakers of Spanish.

Materials. Forty-two disyllabic Spanish words, all of them of four letters, were selected from the Spanish word pool (Alameda & Cuetos, 1995; Cobos et al., 1995), which is based on a count of two million Spanish words. Forty words had a consonant–vowel–consonant–vowel (CV·CV) structure, and two words had a VC·CV structure.[1] All the target words were of low frequency, with a mean frequency of 6.8 (range = 1–22) per two million words. The average number of orthographic neighbors for the target words was 13.1 (range = 1–25). We also selected 42 disyllabic high-frequency words (mean frequency = 435.5; range = 78–2,097) of four letters sharing the first syllable with their corresponding target (e.g., *bo·ca–BO·NO*). The items used in the word conditions are listed in the Appendix. In addition, 42 unrelated control primes that matched in length, syllabic structure, and word frequency with the related primes were also selected. None of the unrelated primes shared any letters (in any position) with their corresponding targets (e.g., *ca·ja–BO·NO*).

In addition, we used 42 nonwords, 40 with a CV·CV structure, and two with a VC·CV structure. In all cases, nonwords were orthographically legal and were constructed by changing one middle letter from a Spanish word that was not in the experimental set. Similar to word targets, nonword targets were preceded by related word primes (e.g., *fa·ro–FA·ZA*; *faro* is the Spanish word for *lighthouse*) or unrelated word primes (e.g., *bo·lo–FA·ZA*; *bolo* is the Spanish word for *skittle*). The average number of orthographic neighbors for the target nonwords was 8.7 (range = 1–17).

Design. SOA (64 or 80 ms) was varied between participants (40 participants in each group), whereas syllabic priming (related or unrelated) was varied within participants.

Procedure. Participants were tested individually in a quiet room. Presentation of the stimuli and recording of reaction times (RTs) were controlled by PC-compatible microcomputers. RTs were measured from target onset until participants' response. On each trial, a forward mask consisting of a row of four pound signs (####) was presented for 500 ms on the center of the screen. Next, a centered, lowercase prime word was presented for 64 or 80 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. This decision had to be made as quickly and as accurately as possible. Once the participant responded, the target disappeared from the screen. After an intertrial interval of 1 s, the next trial was presented. Participants were not informed of the presence of lowercase words. Both word–word pairs and word–nonword pairs were counterbalanced across two experimental lists so that if the pair *bo·ca–BO·NO* was in one list, *BO·NO* would be preceded by its unrelated prime, *ca·ja,* in the other list. Stimulus presentation was randomized, 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 84 experimental trials. Each participant was given a total of 84 experimental trials: 42 word–word trials and 42 word–nonword trials. The whole session lasted approximately 13 min.

Results and Discussion

Incorrect responses (11.5%) were excluded from the latency analysis. In addition, to avoid the influence of outliers, we excluded RTs less than 300 ms or greater than 2,000 ms (less than 1% of the data) in a first pass, and then we excluded all RTs more than 2.0 standard deviations above or below the mean for that participant in all conditions.[2] These conventions were applied throughout the series of experiments. The percentages of trials that were removed during the screening procedure were similar in the related and the unrelated condition. For target words, these per-

[1] Throughout this article, we denote syllable structure using a dot [·], although the stimuli themselves did not contain the dot.

[2] Because of a typing error in the input file, the words *CAZO, LOTE,* and *PETO* were discarded from the data analysis.

centages were 4.6% and 6.1% for the related and unrelated conditions, respectively.

Participant and item analyses of variance (ANOVAs) based on the participants' and items' response latencies and percentages of error were conducted using a 2 (SOA: 64 or 80 ms) × 2 (syllabic relatedness: related or unrelated) × 2 (list: List 1 or List 2) design. List was included in the analysis to extract the variance due to the lists (see Pollatsek & Well, 1995). SOA and list were nonrepeated measures factors in the by-participants analysis (F_1), whereas syllabic relatedness was a within-participants factor. In the analysis by items (F_2), list was the only nonrepeated measures factor. The mean lexical decision times and the percentages of error on the words in each experimental condition are displayed in Table 1.

The ANOVA on the latency data showed that the effect of syllabic relatedness was statistically significant, $F_1(1, 76) = 4.27$, $MSE = 1{,}631$, $p < .05$; and $F_2(1, 37) = 4.44$, $MSE = 1{,}383$, $p < .05$; which reflected that, on average, targets preceded by syllabic neighbors were responded to 13 ms more slowly than targets preceded by unrelated words. The main effect of SOA was not significant, although the RTs were slightly shorter at the 64-ms SOA, $F_1 < 1$; and $F_2(1, 37) = 3.21$, $MSE = 1{,}321$, $p < .09$. Finally, the interaction between syllabic relatedness and SOA was not significant (both Fs < 1).

The ANOVA on the error data showed only a nonsignificant trend for an inhibitory effect of syllabic relatedness, $F_1(1, 76) = 2.21$, $MSE = 37.8$, $p > .10$; and $F_2(1, 37) = 3.13$, $MSE = 40.7$, $p < .09$. Although the interaction between syllabic relatedness and SOA was not significant, $F_1(1, 76) = 1.37$, $MSE = 37.8$, $p > .10$; and $F_2(1, 37) = 1.74$, $MSE = 39.0$, $p > .10$; most of the inhibition was caused by the syllabic neighbors at the 80-ms SOA, $F_1(1, 76) = 3.35$, $MSE = 37.7$, $p < .07$; and $F_2(1, 37) = 4.88$, $MSE = 39.0$, $p < .04$; rather than at the 64-ms SOA (both Fs < 1).

The results of the present experiment are clear-cut: High-frequency words appear to inhibit the processing of low-frequency syllabic neighbors (compared with unrelated controls), in a similar way to the studies using orthographic neighbors (e.g., Bijeljac-Babic et al., 1997; Davis, in press; De Moor & Brysbaert, 2000; Grainger, 1992; Ferrand & Grainger, 1994; Grainger et al., 1991; Perea et al., 1995; Segui & Grainger, 1990).

For brevity's sake, we report only the results for the word targets because it is difficult to affirm any strong conclusions on the basis of *no* responses in a masked priming paradigm, given that negative responses are thought to be made using a temporal deadline (e.g., see Forster, 1998; Forster, Davis, & Krolikowski, 1998; Grainger & Jacobs, 1996). In any event, the general pattern of data shows some small syllabic facilitation. For instance, related nonword targets in the present experiment were responded to 11 ms faster than the unrelated nonword targets, although the effect failed to reach statistical significance.

Experiment 2 was analogous to Experiment 1, except in that primes were nonwords instead of words. Given that nonwords can only partially activate whole-word representations, lexical inhibition is less important than sublexical activation. Thus, priming effects should be facilitative (or null) rather than inhibitory (given that no word nodes will be significantly activated) in a similar way to the form-priming literature (e.g., Ferrand & Grainger, 1992, 1994; Forster et al., 1987; Forster & Taft, 1994; Perea & Rosa, 2000).

Table 1
Mean Lexical Decision Times (in Milliseconds; With Percentages of Error) on Target Words in Experiment 1

	Syllabic priming		
SOA (ms)	Related	Unrelated	U − R
64	742 (11.0)	735 (10.6)	−7 (−0.4)
80	763 (13.2)	744 (10.6)	−19 (−2.6)

Note. Primes were always high-frequency words. The percentage of error for nonwords was 5.4%. SOA = stimulus onset asynchrony; U − R = the difference between the unrelated and related conditions.

Experiment 2

Method

Participants. A total of 80 students from introductory psychology courses at the Universidad de La Laguna took part in the experiment to fulfill a course requirement. None of them had participated in the previous experiment. All were native speakers of Spanish.

Design, materials, and procedure. The materials and design were the same as in Experiment 1, except that the primes were nonwords rather than words. All nonwords were orthographically legal in Spanish and had been constructed by replacing a letter from a Spanish word that was not part of the experimental set. The syllabic structure of the nonword primes was exactly the same as the word primes in Experiment 1. Thus, word and nonword targets were preceded by related nonword primes (e.g., *bo·pa–BO·NO*) or unrelated nonword primes (e.g., *ca·ya–BO·NO*). The items used in the word conditions are listed in the Appendix. The procedure was identical to that in Experiment 1.

Results and Discussion

Similar to Experiment 1, incorrect responses (10.4%) were excluded from the latency analysis. In addition, RTs less than 300 ms or greater than 2,000 ms (less than 0.5% of the data) were excluded in a first pass, and all RTs more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded. The percentages of trials that were removed during the screening procedure were similar in the related and the unrelated condition. For target words, these percentages were 5.3% and 5.0% for the related and the unrelated conditions, respectively. Participant and item ANOVAs based on the participants' and items' response latencies and percentages of error were conducted using a 2 (SOA: 64 or 80 ms) × 2 (syllabic relatedness: related or unrelated) × 2 (list: List 1 or List 2) design. The mean lexical decision times and the percentages of error on the words in each experimental condition are shown in Table 2.

The ANOVA on the latency data showed that the effect of syllabic relatedness was statistically significant, $F_1(1, 76) = 7.56$, $MSE = 1{,}294$, $p < .008$; and $F_2(1, 40) = 7.49$, $MSE = 1{,}271$, $p < .01$. On average, word targets preceded by syllabic neighbors were responded to 16 ms more rapidly than word targets preceded by unrelated nonwords. The main effect of SOA was significant in the analysis by items, $F_1(1, 76) = 1.50$, $MSE = 21{,}899$, $p > .10$; and $F_2(1, 40) = 30.60$, $MSE = 1{,}061$, $p < .001$. On average, participants were faster at the 80-ms SOA than at the 64-ms SOA. Finally, the interaction between syllabic relatedness and SOA was

Table 2
Mean Lexical Decision Times (in Milliseconds; With Percentages of Error) on Target Words in Experiment 2

SOA (ms)	Syllabic priming		U − R
	Related	Unrelated	
64	753 (11.2)	772 (10.1)	19 (−0.9)
80	728 (10.0)	740 (9.8)	12 (−0.2)

Note. Primes were always nonwords. The percentage of error for nonwords was 7.1%. SOA = stimulus onset asynchrony; U − R = the difference between the unrelated and related conditions.

not significant (both *F*s < 1). The ANOVA on the error data did not show any reliable effects (all *p*s > .20).

Again, the data are quite straightforward. By using the same target words as in Experiment 1 (but using nonword primes instead of word primes), the influence of syllabic primes was facilitative (16 ms) instead of inhibitory.

Unfortunately, the manipulation of syllabic relatedness in Experiments 1 and 2 presents an obvious shortcoming: Syllabic neighbors also share their first two letters (*bo·ca–BO·NO*), so that one could argue that the observed effects are due merely to the similarity in the first two letters. One way to disentangle syllabic overlap from orthographic overlap is to use a condition that involves primes and targets that share the first two letters and the first syllable (as in Experiments 1 and 2) and another condition that involves primes and targets that share the first two letters but not the first syllable (by using pairs of monosyllabic items; e.g., *ziel–ZINC* vs. *flur–ZINC*). This is the procedure used in Experiment 3. Because it was not possible to obtain a relatively high number of word primes of higher frequency than their corresponding targets in Spanish, primes were always pseudowords. If facilitation in Experiment 2 was mainly due to the syllable level, facilitative priming effects should be greater for disyllabic than for monosyllabic words. It is important to bear in mind that the phonological information shared by monosyllabic pairs is smaller than the information shared by disyllabic pairs. The SOA was set to 64 ms as the priming effect in Experiment 2 was slightly higher with that SOA than with the 80-ms SOA.

Experiment 3

Method

Participants. A total of 78 students from introductory psychology courses at the Universidad de La Laguna took part in the experiment to fulfill a course requirement. None of them had participated in the previous experiments. All were native speakers of Spanish.

Materials. Forty-eight Spanish words, all of them of four letters, were selected from the Spanish word pool (Alameda & Cuetos, 1995; Cobos et al., 1995). Twenty-four words had two syllables (22 words with a CV·CV structure and 2 words with a VC·CV structure) and had been randomly selected from the pairs used in Experiment 2. Twenty-four words were monosyllabic. The mean frequency of the two-syllable words was 7.8 (range = 2–22) per two million words, and the average number of orthographic neighbors was 11.6 (range = 3–20). The mean frequency of the monosyllabic words was 5.6 (range = 1–16) per two million words, and the average number of orthographic neighbors was 2 (range = 0–5). We also selected 24 monosyllabic pseudowords of four letters sharing the first two letters with their corresponding target to act as related primes (e.g., *ziel–ZINC*). Twenty-four monosyllabic pseudowords were also selected to act as unrelated primes for the monosyllabic pairs (*flur–ZINC*). (For the disyllabic pairs, we used the same unrelated primes as in Experiment 2.) None of the unrelated primes shared any letters in common (in any position) with their corresponding targets.

In addition, we used 48 pseudowords as nonword targets: 24 of these had two syllables (and had been used in Experiment 2) and 24 were monosyllabic. In all cases, pseudowords were orthographically legal and had been constructed by changing one letter from a Spanish word other than those in the experimental set.

Design. Prime–target relationships (related vs. unrelated) and syllabic structure (monosyllabic vs. disyllabic words) were varied within subjects. Each participant was given a total of 96 experimental trials: 48 nonword–word trials and 48 nonword–nonword trials.

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

Results

Incorrect responses (18.1%) were excluded from the latency analysis. In addition, RTs less than 300 ms and greater than 2,000 ms (less than 1.4% of the data) were excluded in a first pass, and all RTs more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded. The percentages of trials that were removed during the screening procedure were similar in the related and the unrelated condition. For disyllabic words, these percentages were 5.8% and 5.7% for the related and the unrelated conditions, respectively. For monosyllabic words, these percentages were 6.2% and 5.9% for the related and the unrelated conditions, respectively. Mean RTs were submitted to separate ANOVAs, with syllabic structure, prime–target relatedness, and list as factors. The mean lexical decision times and the percentages of error on words in each experimental condition are shown in Table 3.

The ANOVA on the latency data showed that the effect of syllabic structure was statistically significant in the analysis by participants, $F_1(1, 76) = 10.00$, $MSE = 3{,}969$, $p < .003$; and $F_2(1, 44) = 2.17$, $MSE = 8{,}228$, $p < .15$. On average, disyllabic words were responded to 23 ms more rapidly than monosyllabic words. The main effect of relatedness was not significant, $F_1(1, 76) = 1.18$, $MSE = 2{,}340$, $p > .10$; and $F_2(1, 44) < 1$, $MSE = 982$, $p > .10$. It is interesting that the interaction between relatedness and syllabic structure was significant in the analysis by participants, $F_1(1, 76) = 4.50$, $MSE = 2{,}192$, $p < .04$; and $F_2(1, 44) = 1.29$, $MSE = 982$, $p > .10$. This interaction reflected a facilitative relatedness effect for disyllabic targets (17 ms), $F_1(1, 76) = 5.08$,

Table 3
Mean Lexical Decision Times (in Milliseconds; With Percentages of Error) on Target Words in Experiment 3

Syllable structure	Prime–target relationship		U − R
	Related	Unrelated	
Monosyllabic	825 (23.1)	819 (24.4)	−6 (1.3)
Disyllabic	791 (12.8)	808 (12.2)	17 (−0.6)

Note. Primes were always nonwords. The percentage of error for nonwords was 8.2% (monosyllabic nonwords = 4.7%; disyllabic nonwords = 11.5%). U − R = the difference between the unrelated and related conditions.

MSE = 2,269, $p < .03$; and F_2 (1, 44) = 2.15, *MSE* = 982, *p* = .15; whereas monosyllabic targets showed a nonsignificant inhibitory effect (−6 ms; both *F*s < 1).[3] The ANOVA on the error data showed only a significant effect of syllabic structure, $F_1(1, 76) = 54.94$, *MSE* = 178.7, $p < .001$; and $F_2(1, 44) = 6.27$, *MSE* = 481.8, $p < .02$.

We should note that the percentages of error in the present experiment were quite high, especially for monosyllabic words. The fact that monosyllabic content words of four letters are not frequent in Spanish and the low frequency of the words provoked this error rate. It seems that participants were much more prone to answer *no* to monosyllabic items than to disyllabic items. In any case, we must note that the removal of the words with many errors (e.g., more than 33% of errors) did not alter the obtained priming effects.

Consistent with our predictions, the facilitative relatedness effect for disyllabic targets (17 ms) was remarkably similar to that obtained in Experiment 2 (19 ms at the 64-ms SOA), whereas monosyllabic targets showed a nonsignificant inhibitory relatedness effect in the latency data (−6 ms). Thus, it is possible to obtain a reliable facilitative priming effect with syllabic neighbors that share only two out of four letters even when the target word is extracted from a high-density neighborhood. In a similar manner, in a post hoc analysis of a recent masked priming experiment at a 66-ms SOA in Spanish (Perea & Rosa, 2000), there was a robust 26-ms priming effect for disyllabic word targets (e.g., *CISNE*; the Spanish word for *swan*) that were preceded by a pseudoword that shared the first syllable with the target (*cisde*), whereas there was a nonsignificant 5-ms priming effect for disyllabic word targets (e.g., *GLOBO*; the Spanish word for *balloon*) that were preceded by a pseudoword that did not share the first syllable with the target (*glabo*), which again suggests that syllabic activation plays a role at the earliest phases of word recognition.

It is worth noting that because of the orthotactic constraints of Spanish, monosyllabic words were extracted from low-density neighborhoods, whereas disyllabic words were extracted from medium- or high-density neighborhoods. The fact that monosyllabic words did not show any signs of a facilitative priming effect suggests once again that the priming effect for disyllabic targets was not just due to simple orthographic overlap. Furthermore, simulations on the interactive activation model (McClelland & Rumelhart, 1981) showed that this model (incorrectly) predicts some facilitative effect for the monosyllabic words but not for disyllabic words (see Table 4).[4] This is not surprising given that monosyllabic words tended to have very few neighbors: Most of the activation from the nonword primes goes to the word unit corresponding to the target word. (The model also failed to predict that disyllabic words were responded to faster than monosyllabic words.) The predicted priming effect for disyllabic words was negligible. Thus, it seems that a syllabic level may be necessary to capture the present pattern of priming effects.

Table 4
Mean Identification Times (Number of Processing Cycles) With the Interactive Activation Model on Target Words in Experiment 3

	Prime–target relationship		
Syllable structure	Related	Unrelated	U − R
Monosyllabic	21.2	22.4	1.2
Disyllabic	22.9	23.0	0.1

Note. U − R = the difference between the unrelated and related conditions.

As we said earlier, monosyllabic content words tend to be orthographically unusual and infrequent in Spanish, and participants seemed to have had a good deal of difficulty with these stimuli, given the time pressure of the lexical decision task (see Paap, Johansen, Chun, & Vonnahme, 2000, for a discussion of this issue). For that reason, we believe that it is convenient to use an alternative strategy to disentangle syllabic overlap from orthographic overlap. This was the goal of Experiment 4, in which the primes consisted of visual sequences that corresponded—or did not correspond—to the first syllable (e.g., *ca****–CA·SI·NO* vs. *cas***–CA·SI·NO*). We should note that this procedure was similar to the one used by Ferrand et al. (1996). They found that naming latencies for disyllabic words were shorter when preceded by primes that corresponded to the first syllable (*pa%%%%–PA·LACE*; *pal%%%–PAL·MIER*) than when preceded by primes that contained one letter more or less than the first syllable (*pal%%%–PA·LACE*; *pa%%%%–PAL·MIER*) at a 43-ms SOA. Ferrand et al. failed to obtain this syllable congruency effect with the lexical decision task at that same SOA. However, they suggested that syllable congruency effects should appear in the lexical decision task at longer prime exposures. To that end, in the present experiment we used the masked priming technique with longer prime durations (116 and 166 ms), in which the prime consisted of the initial syllable of the word or not. (We should note that a pilot experiment at a 66-ms SOA failed to show any reliable effects of syllable congruency.)

If the first syllable is used to access the lexicon, word targets preceded by primes corresponding to a word's first syllable (e.g., *ca****–CA·SI·NO*; *car***–CAR·TEL*) should enjoy some advantage relative to targets preceded by primes that are either longer or shorter than the first syllable (e.g., *cas***–CA·SI·NO*; *ca–CAR·TEL*). In addition, if there is no syllabic processing at all, one would expect shorter RTs (if anything) for the words preceded by CVC primes than by CV primes, independent of a word's syllabic structure: CVC primes contain more letters than CV primes and thus potentially convey more information about the target word. It

[3] The lack of a significant effect in the analysis by items is probably due to lack of power: The number of disyllabic words in the present experiment was 24, whereas in Experiments 1 and 2 it was 48. In any event, the size of the effect was remarkably similar in the two experiments (19 vs. 17 ms with the 64-ms SOA). Furthermore, because of the counterbalancing procedure in a priming experiment, reliability in the F_2 analysis is not critical for the interpretation of the results (see Raaijmakers, Schrijnemakers, & Gremmen, 1999).

[4] The interactive activation model was implemented with a Spanish lexicon of 1,449 four-letter words in an identical way to the implementation made by Jacobs and Grainger (1992). The threshold for word-node activation levels was set to 0.68 to obtain an approximate measure of identification latencies. The parameters used were the ones given as defaults by Rumelhart and McClelland (1982; McClelland & Rumelhart, 1981). As in the study of Jacobs and Grainger (1992), prime duration was two cycles, which is supposed to simulate an SOA of about 60 ms.

may be of interest to note that, despite the fact that participants can identify the primes in Experiment 4, the obtained effects are not likely to be strategic in nature. First, Hinton, Liversedge, and Underwood (1998) found the same pattern of form priming effects with masked primes at a 66-ms SOA and with unmasked primes at a 100-ms SOA. Second, we know of no published reports that have found a reliable effect of proportion of (associatively) related pairs at SOAs less than 200 ms (i.e., a strategic effect). In fact, there are a number of experiments that have failed to obtain an effect of proportion of related pairs at short SOAs (e.g., Den Heyer, Briand, & Dannenbring, 1983; Perea & Rosa, 2002).

Experiment 4

Method

Participants. A total of 68 students from introductory psychology courses at the Universitat de València took part in the experiment to fulfill a course requirement.

Materials. A total of 80 six-letter Spanish words were selected from the Spanish word pool (Alameda & Cuetos, 1995): 40 words had a CV·CV·CV structure (mean frequency = 43 per two million words; range = 1–319), and 40 words had a CVC·CVC structure (mean frequency = 38 per two million words; range = 3–186). For each target word (or nonword), we selected two types of primes: (a) primes that corresponded to the first syllable (e.g., *pa****–PA·SI·VO*, *pas***–PAS·TOR*) and (b) primes that did not correspond to the first syllable (*pas***–PA·SI·VO*, *pa****–PAS·TOR*). Prime–target pairs were counterbalanced in two lists so that no participant saw any target more than once, but each participant received the four experimental conditions (20 pairs per condition). In half of the trials, the primes corresponded to the first syllable, and in the other half, the primes did not correspond to the first syllable. In addition, 80 nonwords (40 nonwords with a CV·CV·CV structure and 40 nonwords with a CVC·CVC structure) were created for the purposes of the lexical decision task. All of these were orthographically legal in Spanish. In half of the trials, the primes corresponded to the first syllable, and in the other half, the primes did not correspond to the first syllable (in an analogous way to word targets). Each participant was given a total of 160 experimental trials: 80 nonword–word trials and 80 nonword–nonword trials.

Design. SOA (116 vs. 166 ms) was varied between participants (34 students participated at the 116-ms SOA and the other 34 students participated at the 166-ms SOA), whereas type of prime (CV vs. CVC) and type of target (CV vs. CVC structure) was varied within participants.

Procedure. Participants were tested in groups of 4–8 in a quiet room. Presentation of the stimuli and recording of RTs were controlled by Apple Macintosh Classic II microcomputers. The routines for controlling stimulus presentation and RT collection were obtained from Lane and Ashby (1987) and from Westall, Perkey, and Chute (1986), respectively. On each trial, a forward mask consisting of six pound signs (######) was presented for 500 ms. This was immediately followed by presentation of the prime for 116 or 166 ms, followed immediately by presentation of the target item (in uppercase letters). The target remained on the screen until the participant responded. The computer recorded the lexical decision times, measured from target onset until the participant's response. Participants were instructed to press one of two buttons on the keyboard (*ç* key for *yes* and *z* key for *no*) to indicate as rapidly and as accurately as possible whether the uppercase letter string was a legitimate Spanish word. This decision had to be made as quickly and as accurately as possible. When the participant responded, the target disappeared from the screen. After an intertrial interval of 1,500 ms, the next trial was presented. Stimulus presentation was randomized, with a different order for each participant. Each participant received a total of 24 practice trials prior to the 160 experimental trials. The session lasted approximately 14 min.

Results and Discussion

Incorrect responses (3.8%) were excluded from the latency analysis. In addition, RTs less than 300 ms or greater than 2,000 ms (less than 0.4% of the data) were excluded in a first pass, and all RTs more than 2.0 standard deviations above or below the mean for that participant in all conditions were also excluded. The percentages of trials that were removed during the screening procedure were similar in the CV and the CVC priming conditions. For CVC target words, these percentages were 5.4% and 5.3% for the CV and the CVC primes, respectively, whereas for CV target words, these percentages were 4.8% and 4.6% for the CV and the CVC primes, respectively. Participant and item ANOVAs based on the participants' and items' response latencies and percentages of error were conducted using a 2 (SOA: 116 or 166 ms) × 2 (type of prime: CV or CVC) × 2 (type of target: CV·CV·CV or CVC·CVC) × 2 (list: List 1 or List 2) design. The mean lexical decision times and percentages of error on the stimulus words in each experimental condition are shown in Table 5.

The ANOVAs on the latency data showed that words at the 166-ms SOA were responded to faster than the words at the 116-ms SOA, $F_1(1, 64) = 4.72$, $MSE = 27{,}524$, $p < .04$; and $F_2(1, 76) = 134.66$, $MSE = 866$, $p < .001$. The main effect of type of target was significant in the analysis by participants, $F_1(1, 64) = 7.90$, $MSE = 1{,}412$, $p < .007$; and $F_2(1, 76) = 1.12$, $MSE = 9{,}870$, $p > .1$; whereas the effect of type of prime was not significant (both Fs < 1). More important, there was a significant interaction between type of target and type of prime, $F_1(1, 64) = 28.09$, $MSE = 706$, $p < .001$; and $F_2(1, 76) = 14.29$, $MSE = 1{,}640$, $p < .001$. CVC·CVC words were responded to faster when preceded by CVC primes than when preceded by CV primes, $F_1(1, 64) = 16.98$, $MSE = 843$, $p < .001$; and $F_2(1, 76) = 10.90$, $MSE = 1{,}640$, $p < .001$. In contrast, CV·CV·CV words were responded to faster when preceded by CV primes than when preceded by CVC primes, $F_1(1, 64) = 6.56$, $MSE = 964$, $p < .02$; and $F_2(1, 76) = 4.19$, $MSE = 1{,}640$, $p < .05$. The other interactions were not significant (all ps > .10).

The ANOVA on the error data showed only a significant effect of SOA, $F_1(1, 64) = 6.86$, $MSE = 25.9$, $p < .02$; and $F_2(1, 76) = 9.73$, $MSE = 20.3$, $p < .003$; which reflected higher percentages of error for target words at the 166-ms SOA than at the 116-ms

Table 5
Mean Lexical Decision Times (in Milliseconds; With Percentages of Error) on Target Words in Experiment 4

Structure	Type of prime: CV	CVC	CVC–CV
	SOA = 116 ms		
CV	704 (1.5)	721 (1.8)	15 (0.3)
CVC	709 (2.9)	699 (2.6)	−10 (−.03)
	SOA = 166 ms		
CV	668 (3.8)	678 (3.1)	10 (−0.7)
CVC	672 (4.1)	641 (4.3)	−31 (0.2)

Note. The percentage of error for nonwords was 3.9%. C = consonant; V = vowel; SOA = stimulus onset asynchrony.

SOA. In other words, there was a speed–accuracy trade-off in dependence with the SOA: Participants at the 166-ms SOA were faster but less accurate than the participants at the 116-ms SOA.

The results of this experiment are straightforward. There was a clear syllable congruency effect: CV·CV·CV targets preceded by CV primes were responded to faster than those preceded by CVC primes, whereas CVC·CVC targets preceded by CVC primes were responded to faster than those preceded by CV primes (for demonstrations of this effect with the naming task, see Ferrand et al., 1996). This finding reinforces the view that sublexical input phonology is structured syllabically, at least for languages with clear syllable boundaries (see Álvarez et al., 2001; Carreiras et al., 1993; Ferrand et al., 1996; Perea & Carreiras, 1995, 1998). Nonetheless, we acknowledge that the present results cannot in fact distinguish between phonological versus orthographic syllable accounts. It is interesting that the present data rule out a strong version of any visual word recognition models based on the notion of restrictiveness (inspired by the cohort model in auditory word recognition; Marslen-Wilson & Welsh, 1978). This family of models incorrectly predicts that as possible words that share the prime (i.e., the CVC prime) become fewer, the recognition becomes faster (e.g., Sánchez-Casas, 1996; Schiller, 1998).

It is also important to mention that our results differ from those obtained by Ferrand et al. (1996). They failed to obtain an effect of syllable congruency between primes and targets in the lexical decision task, whereas strong effects were obtained in word and picture naming. Nonetheless, the prime duration in the Ferrand et al. study was very short (43 ms: 29-ms exposure of prime plus 14 ms of a backward mask), and they did in fact point out that syllable priming effects might well be obtained in the lexical decision task with longer prime exposures, as actually occurred in the present experiment.

It may be important to mention that syllable congruency effects were obtained at longer SOAs (116 and 160 ms) than with the syllabic priming effects in Experiments 1–3 (64 and 80 ms). Although these two sets of results are clearly compatible with a syllabic account, they might also reflect a different stage of syllabic processing. We must keep in mind that the syllabic priming effects for disyllabic words in Experiments 1–3 reflect the comparison between a form-related syllabic condition and an unrelated (baseline) syllabic condition (*bo·pa–BO·NO* vs. *ca·ya–BO·NO*), whereas in Experiment 4, we did not use an unrelated (baseline) condition. Instead, the comparison is between targets preceded by congruent versus incongruent primes that share two or three letters with their corresponding target words (e.g., *pa****–PASIVO* vs. *pas***–PASIVO* and *pas***–PASTOR* vs. *pa****–PASTOR*).

General Discussion

The present experiments show evidence of syllabic priming effects in Spanish at brief SOAs. In other words, it seems that the codes generated from a masked prime can be structured syllabically (e.g., see Ferrand et al., 1996; Ferrand & Segui, 1998). When the prime is a high-frequency word and shares the first syllable with the target, the effect (compared with an unrelated control condition) is inhibitory for word targets (13 ms, Experiment 1), whereas when the prime is a nonword and the target is a word, the effect is facilitative (16 ms, Experiment 2; 17 ms, Experiment 3). In addition, when primes are visual sequences that correspond or not to the first syllable, CV·CV·CV targets preceded by CV primes are responded to faster than those preceded by CVC primes, whereas the reverse effect is obtained for CVC·CVC targets (Experiment 4), generalizing the findings of Ferrand et al. (1996).

The inhibition in Experiment 1 is readily explained in terms of an interactive activation model in which sublexical phonological representations are organized syllabically (e.g., Ferrand et al., 1996; see Taft, 1991; Taft & Radeau, 1995, for another implementation of the syllable in an activation model). As suggested in the introduction, there would be two possible pathways from the letter level to the word level: One would be orthographic (sublexical input orthography), and the other would be phonological (sublexical input phonology). Previous research suggests that phonological activation appears to be an automatic part of word identification in Spanish (e.g., Carreiras et al., 1993). A syllabic processor would convert the first visual syllable into a phonological representation (see Tousman & Inhoff, 1992). The syllabic representations located at the level of sublexical input phonology would send activation to the word level so that words that share one syllable can influence the process of word recognition (see Ferrand et al., 1996). In this way, if the prime word is a higher frequency syllabic neighbor of the target, its presentation serves to enhance interference effects that are already present when the target is presented in isolation (see Álvarez et al., 2001; Carreiras et al., 1993; Perea & Carreiras, 1995, 1998). The somewhat stronger inhibitory effect at the 80-ms rather than at the 64-ms SOA in Experiment 1 (19 ms and 2.6% of errors vs. 7 ms and 0.4% of errors, respectively) can be explained in terms of lexical activation of the high-frequency syllabic neighbors. It is probable that at the 64-ms SOA, the activation produced by the related prime is not large enough to produce a great deal of interference on the related target. (Nonetheless, this argument must be taken with caution as the critical interaction was not significant.) In addition, because within-level inhibition among activated word competitors might lead to a decrease of inhibition on the target word (see Grainger & Jacobs, 1996), we computed the correlation between the magnitude of priming (the difference between the unrelated and the related conditions) and the number of syllabic neighbors (in the first syllable). This correlation was statistically significant ($r = .38$), $F(1, 37) = 6.18$, $MSE = 1.186$, $p < .02$, and reflected the fact that word targets with few syllabic neighbors yielded some inhibition, whereas word targets with many syllabic neighbors tended to show some facilitation. Thus, had we selected all the words from small syllabic neighborhoods, the inhibitory effects would probably have been more robust.[5]

With respect to the nonwords primes (Experiments 2 and 3), the activation appears to be basically sublexical (through between-level, bottom-up activation), and no lexical units are significantly preactivated. In this case, inhibition from the lexical level on the target word will be very small, and, in fact, there is some sublexical facilitation. This activation may occur not only through the letter level but also through the syllabic level as no facilitative

[5] The correlation between the magnitude of priming and the number of orthographic neighbors of the target was also significant, but slightly smaller ($r = .32$), $F(1, 37) = 4.30$, $MSE = 1{,}240$, $p < .05$. However, it decreased dramatically when the number of syllabic neighbors was partialed out ($r = .04$).

priming effects were found for the monosyllabic words (Experiment 3). This facilitation for the disyllabic words was slightly stronger with the 64-ms than with the 80-ms SOA (19 vs. 12 ms, respectively). Thus, it is possible that some lexical inhibition from a number of lexical units at the 80-ms SOA—canceling out the sublexical facilitation—could have been responsible for the smaller priming effects at that SOA. (However, a more powerful design than that used in Experiment 2 would be needed to detect these small differences.)

It may be of interest to examine whether the syllabic priming effects in the present experiments could have been due to some confounding variable related to orthographic neighborhood that was not controlled properly. One variable that has been recently shown to influence word recognition is the shared neighborhood of primes and targets (see van Heuven, Dijkstra, Grainger, & Schriefers, 2001). van Heuven et al. (2001) found that form-priming effects (with nonword primes) were stronger for targets that did not share an orthographic neighbor with the prime (e.g., *samt–SALT*; note that *same* is an orthographic neighbor of *samt,* but not of *salt*) than for targets that did share an orthographic neighbor with the prime (*saln–SALT*; *saln* and *salt* share the orthographic neighbor *sale*). These effects can be readily captured by the interactive activation model (see van Heuven et al., 2001, Figure 1; see also Davis, in press) on the basis of lexical competition at the lexical level. In the first case, the prime *samt* activates *SAME,* but this is not a close competitor for the target word *SALT.* In the second case, the prime *saln* also activates competitors of the target (e.g., the shared neighbor *SALE*; see Davis, in press), and this competitor delays the identification of the target word *SALT.* In the present study, the interactive activation model predicts a robust priming effect for monosyllabic targets preceded by related nonword primes (1.2 processing cycles; see Table 4 for details on the simulations), which is not surprising given the low density of the monosyllabic words in Spanish (i.e., the prime *ziel* activates strongly the target word *ZINC*). In contrast, the model predicts a negligible priming effect for disyllabic targets preceded by related nonword primes (a facilitative effect of 0.1 cycles), presumably because of lexical competition at the word level. (The relatedness effect in Experiment 1 was −0.2 cycles.) However, neither of these predictions was supported by the data. In any event, it is worth noting that the empirical evidence concerning the effect of shared neighborhoods is not entirely conclusive (see Forster et al., in press). Furthermore, the effect of shared neighborhoods cannot account for the syllabic congruency effect found in Experiment 4.

A differential phonological similarity among primes and targets in the critical conditions cannot account for our results either. Spanish is a shallow orthographic language with very regular rules that allow a straightforward mapping from print to sound. The pronunciation of each letter, whether vowel or consonant, does not depend on the surrounding letters, leaving aside the presence of coarticulation effects and two exceptions of context-dependent pronunciation in the consonants *c* and *g* (i.e., as in English, the pronunciation of these two consonants depends on the following grapheme). Nonetheless, even in these cases, their pronunciation is not irregular. For example, *c* followed by *a, o,* or *u* is always pronounced /k/, and *c* followed by *e* or *i* is always pronounced /θ/. There were very few items containing these consonants in our experiments, but even in those cases, the orthographic and phonological similarity between primes and targets was the same. Furthermore, the same CV combination was used in the related prime–target pairs (e.g., *cafa–CAZO*), resulting in the same pronunciation for both prime and target. It is also worth noting that, unlike other languages, vowels in Spanish are pronounced the same when followed by a coda as when they end the syllable. For instance, the pronunciation of the vowel *a* in *pasivo* and *pastor* is the same.

Thus, taken together, our data appear to indicate that the obtained priming effects were due to syllabic effects. The fact that these effects were found with a lexical decision task suggests that syllabic effects are due not only to speech production processes (Levelt, Roelof, & Meyer, 1999) but also to access processes. Thus, it seems that, at least in Spanish, syllables are represented in the phonological input that connects with word units in the lexicon (e.g., Carreiras et al., 1993; Domínguez et al., 1997; Perea & Carreiras, 1995, 1998). Although Experiments 1 and 2 might be interpreted in terms of orthographic priming effects rather than syllabic priming effects—because there was a confounding between the first syllable and the first two letters—Experiments 3 and 4 successfully disentangled syllabic and orthographic priming effects. Experiment 3 showed priming effects for disyllabic pairs that shared the first two letters (*bo·pa–BO·NO*) but not for prime–target monosyllabic pairs that shared the first two letters (*ziel–ZINC*). Also, the fact that a syllable congruency effect (see Experiment 4) can be clearly observed shows that participants are able to represent words in terms of syllables and use this representation to perform the lexical decision task (see Bradley, Sánchez-Casas, & García-Albea, 1993; Pallier, Sebastián-Gallés, Felguera, Christophe, & Mehler,1993; Sebastián-Gallés, Dupoux, Segui, & Mehler, 1992; Tabossi, Collina, Mazzetti, & Zopelo, 2000, for similar results in speech perception).[6]

Our results also have important implications for current models of word recognition. As stated in the introduction, most models have focused (for simplicity's sake) on monosyllabic words, overshadowing the importance of sublexical units, such as the syllable, in reading. It is not clear to us how the interactive activation model (McClelland & Rumelhart, 1981), the DRC model (Coltheart et al., 1993, 2001), and the connectionist model of Plaut et al. (1996) could readily account for the present results without adding a syllabic level of processing. As for the Ans et al. (1998) model, a string of letters will be considered to be a word or not depending on the ability of the orthographic checking process to detect a difference between the activity patterns in the two orthographic input layers. Although no simulations of priming effects are reported in the Ans et al. study, it seems reasonable to assume that there would be some remaining syllabic activation in the network from a briefly presented disyllabic item; if so, the model could, in principle, account for the syllabic effects obtained in the present

[6] We should note that, in another series of masked priming experiments, when nonword primes and word targets shared the first three letters, the recognition of CV words (e.g., *ju·nio*) was faster when the target and the prime shared the initial syllable at a brief SOA (*ju·nas* vs. *jun·tu*). However, the presence of nonword primes that shared the first initial syllable with the target item (*ver·bu*) or did not share this syllable (*ve·rus*) did not influence lexical decision responses to CVC words (e.g., *ver·ja*). The finding of a different pattern of results for CV and CVC words is not novel (e.g., Costa & Sebastián-Gallés, 1998, in a speech production study; Peretz, Lussier, & Beland, 1998, in an implicit visual–auditory task; Sebastián-Gallés et al., 1992, in speech perception with a syllable monitoring task), although we are currently examining the reasons of this apparent discrepancy.

study. However, in its present implementation, the model cannot simulate results from a lexical decision task including orthographically familiar nonwords. In fairness to Ans et al. (1998), however, we note that this model is focused basically on word and nonword naming. Simulations on an implemented activation-based model with a syllabic level (e.g., in an implementation of the Ferrand et al., 1996, model) would be necessary to examine whether it can capture the basic pattern of observed effects.

The explanation we have offered so far is in terms of an activation-based model. We now analyze whether a nonactivation model such as the serial search model can accommodate our results satisfactorily. Forster and Davis (1984; Forster et al., 1987) suggested that masked priming effects arise at a postaccess stage in which all the lexical entries that have been accessed (words similar to the prime) are left in a moderately excited state. That is, orthographic and phonological priming effects are considered to be a by-product of repetition priming effects. If we assume that the first syllable is an access unit for multisyllabic words (Taft & Forster, 1976), nonword primes might facilitate the recognition of syllabically related targets, as actually happened. In addition, this model could also cope with the effects of word primes tending to be inhibitory rather than facilitative (see Experiment 1; Ferrand & Grainger, 1994; Grainger et al., 1991; Grainger, 1992; Perea et al., 1995; Segui & Grainger, 1990) by assuming that the entries of the lower frequency neighbors have been closed down once the entry of the high-frequency related prime has been accessed.

In conclusion, the present experiments have provided converging evidence that the syllable is a perceptual unit for the process of word identification in Spanish. More research in this area is still needed to shed more light on the role of the syllable in visual word recognition, but evidence of the involvement of the syllable from different studies and different languages is clearly promising, at least for syllable-timed languages with clear syllable boundaries. Nonetheless, as we stated in the introduction, the status of the syllable in a language such as English is still controversial. In fact, it has been found that English readers are sensitive to intrasyllable structures in the form of bodies of the BOSS (basic orthographic syllabic structure; Taft, 1992), whereas French readers are sensitive to the syllable but not to the body of the BOSS (Taft & Radeau, 1995).[7] Thus, it seems that the syllable is more relevant to Spanish (or French or Italian) readers than to English readers because the syllable structure of Spanish is much more predictable and regular than is the syllable structure of English. In accordance with this, Álvarez et al. (1998) have shown that for English–Spanish homographs, either segmented in units corresponding to syllables or to the BOSS in a lexical decision task, Spanish readers responded more rapidly in the syllable condition than in the BOSS condition, whereas good English readers were faster in the BOSS condition than in the syllable condition. Future research may focus on topics such as the time course of syllabic effects with different experimental paradigms, as well as on how other factors, such as stress or syllabic structure, are being taken into account during lexical access of multisyllabic words.

[7] BOSS refers to the orthographically defined first syllable of a word (e.g., the *lam* portion of *lament*). The body of the BOSS refers to the part of the BOSS that follows the initial consonant (or consonants; e.g., the *am* portion of *lam,* where *lam* is the BOSS of *lament*).

References

Alameda, J. R., & Cuetos, F. (1995). *Diccionario de frecuencia de las unidades lingüísticas del castellano* [Dictionary of frequency of Spanish words]. Oviedo, Spain: Servicio de publicaciones de la Universidad de Oviedo.

Álvarez, C. J., Carreiras, M., & Taft, M. (2001). Syllables and morphemes: Contrasting frequency effects in Spanish. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 545–555.

Álvarez, C. J., Taft, M., & Carreiras, M. (1998, December). *The role of syllables and BOSSes in reading cognate words in English and Spanish.* Paper presented at the First International Workshop on Written Language Processing, Sydney, Australia.

Andrews, S. (1996). Lexical retrieval and selection processes: Effects of transposed-letter confusability. *Journal of Memory and Language, 35,* 775–800.

Andrews, S. (1997). The effect of orthographic similarity on lexical retrieval: Resolving neighborhood conflicts. *Psychonomic Bulletin & Review, 4,* 439–461.

Ans, B., Carbonnel, S., & Valdois, S. (1998). A connectionist multiple-trace model for polysyllabic word reading. *Psychological Review, 105,* 678–723.

Bijeljac-Babic, R., Biardeau, A., & Grainger, J. (1997). Masked orthographic priming in bilingual word recognition. *Memory & Cognition, 25,* 447–457.

Bradley, D. C., Sánchez-Casas, R. M., & García-Albea, J. E. (1993). The status of the syllable in the perception of Spanish and English. *Language and Cognitive Processes, 8,* 197–233.

Carreiras, M., Álvarez, C. J., & de Vega, M. (1993). Syllable frequency and visual word recognition in Spanish. *Journal of Memory and Language, 32,* 766–780.

Carreiras, M., & Perea, M. (1995, September). *The role of syllabic neighbours in visual word recognition.* Paper presented at the Seventh Conference of the European Society for Cognitive Psychology, Rome, Italy.

Carreiras, M., Perea, M., & Grainger, J. (1997). Effects of orthographic neighborhood in visual word recognition: Cross-task comparisons. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 857–871.

Cobos, P. L., Domínguez, A., Álvarez, C. J., Alameda, J. R., Carreiras, M., & de Vega, M. (1995). Diccionario de frecuencia silábica [Dictionary of syllabic frequency]. In J. R. Alameda & F. Cuetos (Eds.), *Diccionario de frecuencia de las unidades lingüísticas del castellano* (Vol. 2). Oviedo, Spain: Servicio de publicaciones de la Universidad de Oviedo.

Colé, P., Magnan, A., & Grainger, J. (1999). Syllable-sized units in visual word recognition: Evidence from skilled and beginning readers of French. *Applied Psycholinguistics, 20,* 507–532.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: Dual-route and parallel-distributed-processing approaches. *Psychological Review, 100,* 589–608.

Coltheart, M., Rastle, K., Perry, C., Ziegler, J., & Langdon, R. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108,* 204–256.

Costa, A., & Sebastián-Gallés, N. (1998). Abstract phonological structure in language production: Evidence from Spanish. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 886–903.

Cutler, A. (1990). Exploiting prosodic probabilities in speech segmentation. In G. E. T. Altmann (Ed.), *Cognitive models of speech processing* (pp. 105–121). Cambridge, MA: MIT Press.

Davis, C. (in press). Factors underlying masked priming effects in competitive network models of visual word recognition. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: State of the art.* Hove, United Kingdom: Psychology Press.

De Moor, W., & Brysbaert, M. (2000). Neighborhood-frequency effects when primes and targets have different lengths. *Psychological Research, 63,* 159–162.

Den Heyer, K., Briand, K., & Dannenbring, G. L. (1983). Strategic factors in a lexical-decision task: Evidence for automatic and attention-driven processes. *Memory & Cognition, 11,* 374–381.

Domínguez, A., de Vega, M., & Cuetos, F. (1997). Lexical inhibition from syllabic units in Spanish visual word recognition. *Language and Cognitive Processes, 12,* 401–422.

Drews, E., & Zwitserlood, P. (1995). Morphological and orthographic similarity in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 1098–1116.

Ferrand, L., & Grainger, J. (1992). Phonology and orthography: Evidence from masked nonword priming. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 45*(A), 353–372.

Ferrand, L., & Grainger, J. (1993). The time course of orthographic and phonological code activation in the early phases of visual word recognition. *Bulletin of the Psychonomic Society, 31,* 119–122.

Ferrand, L., & Grainger, J. (1994). Effects of orthography are independent of phonology in masked form priming. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 47*(A), 365–382.

Ferrand, L., & Segui, J. (1998). The syllable's role in speech production: Are syllables chunks, schemas, or both? *Psychonomic Bulletin & Review, 5,* 253–258.

Ferrand, L., Segui, J., & Grainger, J. (1996). Masked priming of words and picture naming: The role of syllabic units. *Journal of Memory and Language, 35,* 708–723.

Forster, K. I. (1987). Form-priming with masked primes: The best match hypothesis. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 127–146). Hillsdale, NJ: Erlbaum.

Forster, K. I. (1998). The pros and cons of masked priming. *Journal of Psycholinguistic Research, 27,* 203–233.

Forster, K. I. (2000). The potential experimental bias effects in word recognition experiments. *Memory & Cognition, 28,* 1109–1115.

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 680–698.

Forster, K. I., Davis, C., & Krolikowski, S. (1998, November). *Prelexical processes in masked priming.* Paper presented at the 39th Annual Meeting of the Psychonomic Society, Dallas, TX.

Forster, K. I., Davis, C., Schoknecht, C., & Carter, R. (1987). Masked priming with graphemically related forms: Repetition or partial activation? *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 39*(A), 211–251.

Forster, K. I., Mohan, K., & Hector, J. (in press). The mechanics of masked priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: State of the art.* Hove, England: Psychology Press.

Forster, K. I., & Taft, M. (1994). Bodies, antibodies, and neighborhood density effects in masked form priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 844–863.

Forster, K. I., & Veres, C. (1998). The prime lexicality effect: Form-priming as a function of prime awareness, lexical status, and discrimination difficulty. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 498–514.

Grainger, J. (1992). Orthographic neighborhoods and visual word recognition. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning* (pp. 131–146). Amsterdam: Elsevier.

Grainger, J., Colé, P., & Segui, J. (1991). Masked morphological priming in visual word recognition. *Journal of Memory and Language, 30,* 370–384.

Grainger, J., & Ferrand, L. (1996). Masked orthographic and phonological priming in visual word recognition and naming: Cross-task comparisons. *Journal of Memory and Language, 35,* 623–647.

Grainger, J., & Jacobs, A. M. (1996). Orthographic processing in visual word recognition: A multiple read-out model. *Psychological Review, 22,* 696–713.

Hinton, J., Liversedge, S. P., & Underwood, G. (1998). Neighborhood effects using a partial priming methodology: Guessing or activation? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 1294–1305.

Jacobs, A. M., & Grainger, J. (1992). Testing a semistochastic variant of the interactive activation model in different word recognition experiments. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 1174–1188.

Justicia, F., Santiago, J., Palma, A., Huertas, D., & Gutiérrez, N. (1996). La frecuencia silábica del español escrito por niños: Estudio estadístico [The syllabic frequency in Spanish written by children: A statistical study]. *Cognitiva, 8,* 131–168.

Lane, D. M., & Ashby, B. (1987). PsychLib: A library of machine language routines for controlling psychology experiments on the Apple Macintosh computer. *Behavior Research Methods, Instruments and Computers, 19,* 246–248.

Levelt, W. J. M., Roelof, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences, 22,* 1–75.

Marslen-Wilson, W. D., & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. *Cognitive Psychology, 10,* 29–63.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375–407.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review, 76,* 165–178.

Paap, K. R., & Johansen, L. S. (1994). The case of the vanishing frequency effect: A retest of the verification model. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 1129–1157.

Paap, K. R., Johansen, L., Chun, E., & Vonnahme, P. (2000). Neighborhood frequency does affect performance in the Reicher task: Encoding of decision? *Journal of Experimental Psychology: Human Perception and Performance, 26,* 1691–1720.

Pallier, C., Sebastián-Gallés, N., Felguera, T., Christophe, A., & Mehler, J. (1993). Attentional allocation within the syllabic structure of spoken words. *Journal of Memory and Language, 32,* 373–389.

Perea, M., & Carreiras, M. (1995). Efectos de frecuencia silábica en tareas de identificación [Effects of syllable frequency in speeded identification tasks]. *Psicológica, 16,* 302–311.

Perea, M., & Carreiras, M. (1998). Effects of syllable frequency and neighborhood syllable frequency in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 1–11.

Perea, M., Paap, K. R., Gotor, A., Hooper, D., & Algarabel, S. (1995, April). *Some neighbors are more equal than others.* Paper presented at the Sixty-Fifth Annual Convention of the Rocky Mountain Psychological Association, Boulder, Colorado.

Perea, M., & Rosa, E. (2000). Repetition and form priming interact with neighborhood density at a brief stimulus-onset asynchrony. *Psychonomic Bulletin & Review, 7,* 668–677.

Perea, M., & Rosa, E. (2002). Does the proportion of associatively related pairs modulate the associative priming effect at very brief stimulus-onset asynchronies? *Acta Psychologica, 110,* 103–124.

Peretz, I., Lussier, I., & Beland, R. (1998). The differential role of syllabic structure in stem completion for French and English. *European Journal of Cognitive Psychology, 10,* 75–112.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles. *Psychological Review, 103,* 56–115.

Pollatsek, A., Perea, M., & Binder, K. (1999). The effects of neighborhood size in reading and lexical decision. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 1142–1158.

Pollatsek, A., & Well, A. (1995). On the use of counterbalanced designs in cognitive research: A suggestion for a better and more powerful analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 785–794.

Prinzmetal, W., Hoffman, H., & Vest, K. (1991). Automatic processes in word perception. *Journal of Experimental Psychology: Human Perception and Performance, 17,* 902–923.

Prinzmetal, W., Treiman, R., & Rho, S. H. (1986). How to see a reading unit. *Journal of Memory and Language, 25,* 461–475.

Raaijmakers, J. G. W., Schrijnemakers, J. M. C., & Gremmen, F. (1999). How to deal with "the language-as-fixed-effect fallacy": Common misconceptions and alternative solutions. *Journal of Memory and Language, 41,* 416–426.

Rapp, B. C. (1992). The nature of sublexical orthographic organization: The bigram through hypothesis examined. *Journal of Memory and Language, 31,* 33–53.

Rastle, K., & Coltheart, M. (2000). Lexical and nonlexical print-to-sound translation of disyllabic words and nonwords. *Journal of Memory and Language, 42,* 342–364.

Rouibah, A., & Taft, M. (2001). The role of syllabic structure in French visual word recognition. *Memory & Cognition, 29,* 373–381.

Rumelhart, D. E., & McClelland, J. L. (1982). An interactive activation model of context effects in letter perception: Part 2. The contextual enhancement effect and some tests and extensions of the model. *Psychological Review, 89,* 60–94.

Sánchez-Casas, R. M. (1996). Lexical access in visual word recognition: The contribution of word form. In M. Carreiras, J. E. García-Albea, & N. Sebastián-Gallés (Eds.), *Language processing in Spanish* (pp. 21–59). Mahwah, NJ: Erlbaum.

Schiller, N. O. (1998). The effect of visually masked syllable primes on the naming latencies of words and pictures. *Journal of Memory and Language, 39,* 484–507.

Sebastián-Gallés, N., Dupoux, E., Segui, J., & Mehler, J. (1992). Contrasting syllabic effects in Catalan and Spanish. *Journal of Memory and Language, 31,* 18–32.

Segui, J., & Grainger, J. (1990). Priming word recognition with orthographic neighbors: Effects of relative prime–target frequency. *Journal of Experimental Psychology: Human Perception and Performance, 16,* 65–76.

Seidenberg, M. S. (1987). Sublexical structures in visual word recognition: Access units or orthographic redundancy. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 245–263). Hillsdale, NJ: Erlbaum.

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96,* 523–568.

Sereno, J. A. (1991). Graphemic, associative, and syntactic priming effects at a brief stimulus onset asynchrony in lexical decision and naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 459–477.

Tabossi, P., Collina, S., Mazzetti, M., & Zopelo, M. (2000). Syllables in the processing of spoken Italian. *Journal of Experimental Psychology: Human Perception and Performance, 26,* 758–775.

Taft, M. (1979). Lexical access via an orthographic code: The basic orthographic syllabic structure (BOSS). *Journal of Verbal Learning and Verbal Behavior, 18,* 21–39.

Taft, M. (1991). *Reading and the mental lexicon.* Hillsdale, NJ: Erlbaum.

Taft, M. (1992). The body of the BOSS: Subsyllabic units in the lexical processing of polysyllabic words. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 1004–1014.

Taft, M., & Forster, K. I. (1976). Lexical storage and retrieval of polymorphemic and polysyllabic words. *Journal of Verbal Learning and Verbal Behavior, 15,* 607–620.

Taft, M., & Radeau, M. (1995). The influence of the phonological characteristics of a language on the functional units of reading: A study in French. *Canadian Journal of Experimental Psychology, 49,* 330–346.

Tousman, S., & Inhoff, A. W. (1992). Phonology in multisyllabic word recognition. *Journal of Psycholinguistic Research, 21,* 525–544.

Treiman, R., Mullennix, J., Bijeljac-Babic, R., & Richmond-Welty, E. D. (1995). The special role of rimes in the description, use, and acquisition of English orthography. *Journal of Experimental Psychology: General, 124,* 107–136.

van Heuven, W. J. B., Dijkstra, T., Grainger, J., & Schriefers, H. (2001). Shared neighborhood effects in masked orthographic priming. *Psychonomic Bulletin & Review, 8,* 96–101.

Westall, R., Perkey, M. N., & Chute, D. L. (1986). Accurate millisecond timing on the Apple Macintosh using Drexler's millitimer. *Behavior Research Methods, Instruments and Computers, 18,* 307–311.

Appendix

Word Targets and Primes for Experiments 1–4

Table A1

List of Word Targets for Experiments 1–3

Related	Unrelated	Word target
	Experiment 1	
alto	esto	ALGA
arte	esto	ARPA
bajo	rojo	BABA
baño	peso	BAZA
boca	caja	BONO
cabo	rojo	CANA
cama	nube	CAZO
cena	dama	CEBO
cola	masa	COCO
cosa	debe	COPO
cura	dama	CUÑO
dado	vivo	DAGA
doña	luna	DOTE
duro	beso	DUNA
fama	debe	FARO
gato	humo	GASA
hija	base	HIPO
hora	vida	HOYO
jefe	vivo	JETA
lado	cuyo	LAPA
modo	nube	MOTA
malo	pero	MAYA
mano	solo	MAZA
mesa	casa	MEMO
mito	doce	MIGA
loco	masa	LOTE
nada	pero	NAZI
paso	niño	PALA
pelo	humo	PEÑA
pena	suma	PETO
piso	tomo	PIRA
poco	leve	POPA
raro	cuyo	RANA
rato	doce	RAJA
rico	lujo	RIMA
sala	leve	SAPO
tipo	beso	TIÑA
toda	cine	TOPO
tono	cine	TOGA
vale	solo	VARA
vino	suyo	VIGA
zona	pura	ZOCO
	Experiment 2	
alco	usto	ALGA
arle	usto	ARPA
bamo	rono	BABA
baxo	pejo	BAZA
bopa	caya	BONO
cado	ropo	CANA
cafa	nufe	CAZO
cema	dapa	CEBO
coga	mada	COCO
coxa	defe	COPO
cuma	dapa	CUÑO
dapo	vimo	DAGA
doga	luva	DOTE
dubo	bepo	DUNA
fapa	befe	FARO
gabo	dere	GASA
hiba	nuce	HIPO
	Experment 2 (*continued*)	
hopa	bape	HOYO
jege	vime	JETA
lapo	vico	LAPA
momo	cufo	MOTA
mafo	nufe	MAYA
mabo	pepo	MAZA
mepa	luya	MEMO
mifo	caxo	MIGA
lono	mada	LOTE
nava	pepo	NAZI
pamo	nigo	PALA
pemo	huco	PEÑA
pefa	sufa	PETO
pigo	tobo	PIRA
pobo	cise	POPA
rapo	cufo	RANA
rado	dobe	RAJA
ripo	luvo	RIMA
saha	lete	SAPO
tigo	bepo	TIÑA
toba	cile	TOPO
tofo	cile	TOGA
vame	sopo	VARA
vipo	suno	VIGA
zota	pula	ZOCO
	Experiment 3: Monosyllabic words	
blan	fraz	BLOC
clup	bies	CLAN
clab	fism	CLON
chig	tong	CHEF
dier	crez	DIAL
fied	tuez	FIAR
fren	tiel	FRAC
goom	bues	GOLF
liel	snon	LIAR
piet	muez	PIAR
ruey	tals	RUIN
vinc	zoon	VIAL
buir	cric	BUEY
clen	duez	CLIP
cres	gogs	CRIN
chaf	fror	CHIP
duen	fosk	DUAL
flir	grit	FLAN
fuar	gron	FUEL
hiar	rong	HIEL
nual	tros	NUEZ
plic	tict	PLUS
siar	plar	SIEN
ziel	flur	ZINC
	Experiment 3: Disyllabic words	
alco	usto	ALGA
bamo	rono	BABA
cuma	dapa	CUÑO
fapa	bepe	FARO
momo	cuge	MOTA
mabo	pepo	MAZA
mifo	coxo	MIGA

(*Appendix continues*)

Table A1 (*continued*)

Related	Unrelated	Word target
Experiment 3: Disyllabic words (*continued*)		
pemo	huco	PEÑA
rapo	cufo	RANA
ripo	dobe	RIMA
tigo	bero	TIÑA
vizo	suno	VIGA
arle	usto	ARPA
baxo	pejo	BAZA
cema	dapa	CEBO
dapo	vimo	DAGA
dubo	bepo	DUNA
gafo	dere	GASA
hosa	bape	HOYO
mepa	luya	MEMO
pobe	cige	POPA
saha	lete	SAPO
vame	sopo	VARA
zota	pula	ZOCO

Note. Words repeated in the unrelated condition were assigned to different lists so that participants did not ever see the same prime twice.

Table A2
List of Word Targets for Experiment 4 (CV and CVC Structure in the First Syllable)

Word Targets	
CV	CVC
SEGURO	BALCÓN
BONITO	VIRTUD
MOLINO	VULGAR
PUREZA	RINCÓN
CORONA	NORMAL
BARATO	PERDÓN
PESADO	SECTOR
DOCENA	CARMÍN
PENOSO	MARFIL
RECELO	FERVOR
BASURA	BASTÓN
CELOSO	CARTEL
GORILA	CURSOR
MALETA	DESLIZ
PARADO	MALDAD
RESACA	POSTAL
SALADO	REPTIL
SENADO	SARTÉN
TAMAÑO	TAMBOR
VASIJA	PULGAR
MEDIDA	JARDÍN
ROMANO	PINTOR
CASINO	MENTAL
HERIDA	PASTOR
MONEDA	PERFIL
DELITO	FACTOR
GANADO	PORTAL
SALUDO	CARBÓN
PALOMA	CORTÉS
GUSANO	DESVÁN
CASETA	BOMBÓN
DISEÑO	JAZMÍN
HARINA	DELFÍN
MELENA	HALCÓN
PASIVO	PASTEL
ROSADO	PULMÓN
SALIVA	SALMÓN
SONETO	SULTÁN
RECADO	TEXTIL
VISADO	VOLCÁN

Note. C = consonant; V = vowel.

Received June 1, 2001
Revision received November 13, 2001
Accepted March 8, 2002 ■