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Naming pseudowords in Spanish: Effects of syllable frequency☆

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Abstract

Three naming experiments were conducted to examine the role of the first and the second syllable during speech production in Spanish. Facilitative effects of syllable frequency with disyllabic words have been reported in Dutch and Spanish (Levelt & Wheeldon, 1994; Perea & Carreiras, 1998). In both cases, the syllable frequency effect was independent of—and additive to—the effect of word frequency. However, Levelt and Wheeldon (1994) found that words ending in a high-frequency syllable were named faster than words ending in a low-frequency syllable, whereas Perea and Carreiras (1998) found a facilitative effect of syllable frequency for the initial syllable. In Experiments 1–2, we manipulated the frequency of the first and the second syllable of disyllabic CV.CV pseudowords. In Experiment 3, participants named CVC disyllabic pseudowords for which only the frequency of the first syllable was manipulated. The experiments showed a facilitative effect of frequency of the first syllable. The findings are discussed in terms of the current models of speech production.

1. Introduction

The syllable has been considered an important unit of language from both a linguistic (e.g., see Kenstowicz, 1994) and a psycholinguistic perspective (see Levelt, Roelofs, & Meyer, 1999). Indeed, there is a considerable amount of empirical evidence that suggests that syllables are functional units during speech perception in French and Spanish (e.g., Mehler, Dommergues, Frauenfelder, & Segui, 1981; Sebastián, Dupoux, Segui, & Mehler, 1992; however, see Content, Meunier, Kearns, & Frauenfelder, 2001). French and Spanish speakers tend to use syllables as a cue for speech segmentation, although this is not the case in other languages (e.g., English speakers seem to rely on stress as the segmentational cue; see Cutler, Mehler, Norris, & Segui, 1986, 1989).

Evidence for syllabic processing during reading has also been obtained in Spanish and French. In a recent study, Carreiras and Perea (2002) found syllabic priming effects in a series of lexical decision experiments with the masked priming procedure (Forster & Davis, 1984). More specifically, Perea and Carreiras (2002; Experiment 3) used monosyllabic (*ZINC*) and CV.CV disyllabic words (*RA.NA*) as targets. Monosyllabic words were preceded by monosyllabic pseudowords that either shared the first two letters with the target (related condition: *ziel*), or did not (unrelated condition: *flur*). Similarly, CV.CV disyllabic words were preceded by related (*ra.jo*) or unrelated pseudowords (*cu.fo*). Thus, in the two related conditions, primes and targets shared the two first letters, but only in the case of disyllabic words did these letters form the first syllable. The results showed a significant syllabic priming effect for the disyllabic but not for the monosyllabic words. Likewise, Álvarez, Carreiras, and Perea (2004) found significant priming effects for disyllabic prime–target pairs that shared the first three letters and the first CV syllable (e.g., *ju.nas*-*JU.NIO*) relative to disyllabic pairs that shared the first three letters but not the first syllable (*jun.tu*-*JU.NIO*). Taken together, these findings support

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the view that sublexical input phonology is structured syllabically, at least for languages with clear syllable boundaries (see also Colé, Magnan, & Grainger, 1999, for syllabic effects in French with a syllable monitoring technique).

Another important piece of evidence for the existence of syllabic processing in Spanish has been obtained by manipulating syllable frequency (e.g., Álvarez, Carreiras, & Taft, 2001; Carreiras, Álvarez, & de Vega, 1993; Perea & Carreiras, 1995, 1998): words composed of high-frequency syllables are responded to more slowly than words composed of low-frequency syllables, both in lexical decision and progressive demasking tasks. This inhibitory effect of syllable frequency has been interpreted in terms of competition among word units in an interactive activation model (see Carreiras et al., 1993; Perea & Carreiras, 1998). It is worth noting that a number of other potential explanatory factors of the syllable frequency effect have been discarded: neither bigram frequency (Carreiras et al., 1993), orthographic neighborhood density/frequency (Álvarez et al., 2001; Perea & Carreiras, 1998), or morpheme frequency (Álvarez et al., 2001) can account for the previous findings. One further proof of the reliability of this finding is that the inhibitory effect of syllable frequency has been replicated in other languages (e.g., French: Mathey & Zagar, 2002; German: Conrad & Jacobs, 2004). Thus, the syllable frequency effect in lexical decision suggests that the syllable is a fundamental processing unit in visual word recognition in Spanish (and probably in other languages as well).

The role of the syllable in speech production has also been the focus of theoretical and empirical interest in recent years. Current models of speech production propose that syllables exist either in the word-form lexicon (the phonological syllables, see Dell, 1986, 1988) or in the form of articulatory programs (e.g., Crompton, 1981; Levelt, 1989; Levelt & Wheeldon, 1994; Levelt et al., 1999). According to Levelt's influential model of speech production, syllables are articulatory motor units. Levelt's model incorporates a library of articulatory routines for syllables (a mental 'syllabary') that is accessed during the process of speech production. The rational for this assumption is that access to these precompiled syllabic motor programs would greatly reduce the computational load on the speech production system. Alternatively, in the framework of an interactive activation model of visual word recognition and naming, Ferrand, Segui, and Grainger (1996) proposed the presence of syllable-sized units both in the sublexical input phonology and in the sublexical output phonology. Similarly to Levelt et al.'s model, the syllable-sized output units in Ferrand et al.'s model can facilitate the articulatory response in a mental 'syllabary.'

Empirical evidence supporting the role of the syllable in speech production is, however, rather mixed. Using the masked priming paradigm, Ferrand et al. (1996) showed that both word naming and picture naming in French were facilitated when there was a syllabic congruency between primes and targets. Specifically, they presented words such as *ba.lance* and *bal.con*, preceded by primes such as *ba%%%%* and *bal%%%%* (i.e., syllable primes could be either congruent or incongruent with the first syllable of the words). They found that CV targets were responded to faster when preceded by CV primes as compared to CVC primes, and CVC targets were responded to faster when preceded by CVC primes as compared to CV primes. Ferrand, Segui, and Humphreys (1997) replicated this pattern of data with English stimuli. Nonetheless, several experiments have failed to replicate the syllable congruency effect in word naming in Dutch (Schiller, 1998), Spanish (Carreiras, Grainger, & Perea, unpublished data; Schiller, Costa, & Colomé, 2002), French (Brand, Rey, & Peereman, 2003), and English (Schiller, 2000).

Another strategy that may provide empirical support for the syllable as a speech unit comes from experiments manipulating syllable frequency (Levelt & Wheeldon, 1994; Perea & Carreiras, 1998). Levelt and Wheeldon (1994) used a two-phase production task in which they manipulated the syllable- and word-frequency of stimuli. In the "study" phase, participants learned to associate symbols with response words: for instance, the symbol &&&&&& with the response word *giraffe*. On each trial of the "test" phase, one of the learned symbols was presented (e.g., &&&&&&), and the participant's task was to produce the corresponding response word (*giraffe*) as quickly as possible. Levelt and Wheeldon found a facilitative effect of syllable frequency for words in this production task. This syllable frequency effect was independent of the word frequency effect, and only occurred for the second syllable. Levelt and Wheeldon (1994) proposed that speakers have access to a store of articulatory-phonetic syllable programs called the mental syllabary: Accessing a syllable in the mental syllabary that is frequently used in the language will be faster than accessing a syllable that is less frequently used (see also Levelt et al., 1999).[1] However, there have been failures to replicate this syllable frequency effect for the second syllable when the initial sound was controlled for (see Hendriks & McQueen, 1996). In Spanish, Perea and Carreiras

[1] Levelt and Wheeldon (1994) suggested that the syllable frequency effect could be present only in the second syllable because the retrieval of first and second syllable are independent processes but initiation of articulation will not start until both syllables have been accessed from the syllabary. They argued that any frequency effects of the first syllable, though occurring during retrieval from the syllabary, might not be captured by naming latencies.

(1998) found a facilitative effect of syllable frequency that was additive to the word frequency effect in a word naming task. This facilitative syllable frequency effect also appeared in pseudoword naming (Perea & Carreiras, 1996). However, unlike Levelt and Wheeldon (1994), the facilitative effect of syllable frequency occurred for the first syllable. In particular, Perea and Carreiras (1998) reported that disyllabic words with an initial high-frequency syllable were pronounced more rapidly than disyllabic words with an initial low-frequency syllable. They interpreted this effect of syllable frequency in terms of faster access of high-frequency syllables to the mental syllabary involved at the level of the sublexical phonological output. Nonetheless, it could be argued that sublexical input phonology might also have contributed to the syllabic effect, since they used a word naming task. In any event, the fact that Levelt and Wheeldon (1994) obtained facilitative effects of syllable frequency for the second syllable, whereas Perea and Carreiras (1996, 1998) found facilitative effects for the first syllable merits further research.

The main goal of the present paper is to gather additional empirical evidence on the role of the syllable on speech production. In particular, we will examine the role of the syllable frequency of *each* syllable for disyllabic items during speech production. In Experiments 1–2, participants named CV.CV pseudowords. We opted for pseudowords rather than words as experimental stimuli because of the impossibility of controlling all relevant variables with word stimuli. In Experiment 3, to tease apart syllable frequency from bigram frequency, we used CVC disyllabic pseudowords in which the frequency of the initial bigram was kept constant while the frequency of the first syllable was manipulated (e.g., *mis.cun* vs. *min.cun*).

2. Experiment 1

Experiment 1 addressed whether syllable frequency effects are limited to the initial syllable in speech production in Spanish. Perea and Carreiras (1996, 1998) only manipulated the frequency of the first syllable, for which they found a facilitative syllable frequency effect. Levelt and Wheeldon (1994), however, found a syllable frequency effect for the second but not the first syllable. In the present experiment, we manipulated the syllable frequency of the first and the second syllable in disyllabic pseudowords.

2.1. Method

2.1.1. Participants

A total of 40 psychology students from the University of La Laguna took part in the experiment to fulfill a course requirement. All of them either had normal vision or vision that was corrected-to-normal and were native speakers of Spanish.

2.1.2. Materials

The targets were eighty-four pseudowords, all of them of four letters. The pseudowords were created by combining two variables (syllable frequency of the first syllable: low vs. high; syllable frequency of the second syllable: low vs. high) in a 2×2 within-participants but between-items design. We selected syllables according to their token positional frequency in the dictionary of frequency of syllables in Spanish (Cobos et al., 1995). We considered syllables to be of high frequency when they had a minimum frequency of occurrence of 237 per million in the database and to be of low frequency when they had a maximum frequency of occurrence of 125. The positional frequency of each syllable refers to the number of times that the syllable (weighted by lexical frequency) appeared in that word position (first, second, final, etc.). All pseudowords had a CV.CV syllabic structure and were matched across conditions for the number of orthographic neighbors (overall mean: 2.8, range: 1–7). The log of the frequency of the initial bigram in the Spanish database (Sebastián, Martí, Carreiras, & Cuetos, 2000) was virtually the same in the four conditions (3.0). Pseudowords in the four experimental conditions were also matched for initial sound on an item-by-item basis: all items that began with the sound /r/ were equated across conditions (e.g., High Frequency–High Frequency: *repa*; Low Frequency–High Frequency: *ruse*; High Frequency–Low Frequency: *rapi*; Low Frequency–Low Frequency: *ruli*). In all cases, lexical stress occurred in the first syllable, which is the usual stress pattern in Spanish for disyllabic words. The stimuli are shown in Appendix A.

2.1.3. Procedure

Participants were tested individually in a quiet room. Presentation of stimuli and recording of latencies were controlled by a PC. Naming latencies were collected by a microphone connected to a voice-activated key interfaced with a digital I/O port of the computer. Standard speeded naming procedures were applied. Pseudowords were presented one at a time in the center of the screen and participants were instructed to read the pseudoword aloud as rapidly and as accurately as possible. When the participant responded, the stimulus disappeared from the screen. After an inter-trial interval of 1500 ms, the next trial was presented. Both mispronunciations and hesitations were considered as errors. The whole session, including 10 practice trials, lasted approximately 10 min.

2.2. Results and discussion

Incorrect responses (2.3%) and naming times less than 250 ms or greater than 1000 ms (3.8%, mostly caused by an error of the voice key) were omitted from the latency analysis. Mean naming times and percentages of error were then submitted to separate analyses of variance (ANOVAs), with frequency of the first syllable (low vs. high) and frequency of the second syllable (low vs. high) as within-participants but between-items factors. The ANOVAs were performed for participants ($F1$) and for items ($F2$). The mean naming time and error rate in each condition are shown in Table 1.

The ANOVA on the latency data showed that, on average, participants named pseudowords with a high-frequency first syllable 14 ms faster than the pseudowords with a low-frequency first syllable, $F1(1,39) = 15.46$, $MSE = 482.3$, $p < .001$; $F2(1,80) = 4.06$, $MSE = 502.7$, $p < .05$. The effect of the frequency of the second syllable was not significant, both Fs < 1. There were no signs of interaction between the two factors (both ps $> .15$).

The ANOVA on the error data did not reveal any significant effects. Only the effect of frequency of the first syllable approached significance, $F1(1,39) = 3.46$, $MSE = 9.21$, $p = .070$; $F2(1,80) = 2.13$, $MSE = 7.87$, $p > .10$.

To examine whether the frequency of the initial bigram and/or the number of orthographic neighbors (N) played a role in the obtained syllable frequency effect, we computed the correlation coefficient between the item mean RT and the log of the syllable frequency of the initial syllable when the influence of N and the log of the frequency of the initial bigram was partialed out. The partial correlation coefficient was highly significant, $r(80) = -.30$, $p < .007$. It is worth noting that the Pearson coefficient between the log of the frequency of the initial bigram and the item mean RT was negligible ($r = .01$). Thus, the facilitative effect of syllable frequency was not due to bigram frequency, but rather to syllable frequency.

The results are clear-cut. We found a facilitative effect of syllable frequency only for the initial syllable, replicating the results of Perea and Carreiras (1998). In addition, we found no signs of any effect of syllable frequency for the second syllable. In the present experiment we controlled for a number of potential confounds (e.g., initial sound, orthographic neighborhood, bigram frequency, or structural complexity of syllables, among others); however, it could be argued that the chances of obtaining the frequency effect for the first syllable were maximized because stress assignment occurred always in the first syllable. To examine this possibility, stress was always marked in the second syllable in Experiment 2.

Table 1
Mean naming times (in ms) and percentage of errors (in parentheses) on pseudowords in Experiment 1

	Frequency of the first syllable		
	Low	High	Syllable frequency effect (1st)
Frequency 2nd syllable			
Low	629 (2.4)	618 (1.8)	11 (1.6)
High	633 (3.2)	616 (2.0)	17 (1.2)
Syllable frequency effect (2nd)	−4 (−0.8)	2 (−0.2)	

3. Experiment 2

Experiment 2 is parallel to Experiment 1 except that stress assignment was located, in all cases, in the second syllable. The issue here is whether the syllable frequency effect in the initial syllable can be replicated when stress is placed on the second syllable or, alternatively, whether stress assignment was driving the syllable frequency effect in the initial syllable. To assign lexical stress in the second syllable of CV.CV items in Spanish, it is necessary to use orthographic accent marks on the second syllable. For instance, *repa* was an item in Experiment 1, and *repá* was an item in Experiment 2. If the process of stress assignment and the process of retrieving syllables from the syllabary (or the computation of syllables) correspond to two different stages in speech production (see Levelt et al., 1999), syllable frequency effects should not interact with stress.

3.1. Method

3.1.1. Participants

A total of 40 psychology students from the University of La Laguna took part in the experiment to fulfill a course requirement. All of them either had normal vision or vision that was corrected to normal and were native speakers of Spanish. None of them had participated in Experiment 1.

3.1.2. Materials

The materials were the same as in Experiment 1, except that all items had an accent mark on the second syllable. In this way, lexical stress always occurred in the second syllable (e.g., *rusé* instead of *ruse*).

3.1.3. Procedure

The procedure was the same as in Experiment 1.

3.2. Results and discussion

Incorrect responses (7.5%) and naming times less than 250 ms or greater than 1000 ms (2.9%, usually caused by an error of the voice key) were omitted from the latency analysis. The mean naming time and error rate in each condition are shown in Table 2.

The ANOVA on the latency data showed that, on average, participants named pseudowords with a high-

Table 2
Mean naming times (in ms) and percentage of errors (in parentheses) on pseudowords in Experiment 2

	Frequency of the first syllable		
	Low	High	Syllable frequency effect (1st)
Frequency 2nd syllable			
Low	575 (7.9)	568 (6.0)	7 (1.9)
High	574 (8.7)	563 (7.3)	11 (1.4)
Syllable frequency effect (2nd)	1 (−0.8)	5 (−1.3)	

frequency first syllable 9 ms faster than the pseudowords with a low-frequency first syllable, although this difference was only significant in the analysis by subjects $F1(1,39) = 5.31$, $MSE = 583.0$, $p < .03$; $F2(1,80) = 1.72$, $MSE = 556.9$, $p > .10$. The effect of the syllable frequency of the second syllable was not significant, both Fs < 1. There were no signs of an interaction between the two factors (both ps $> .15$).

The ANOVA on the error data did not reveal any significant effects, although the effect of syllable frequency of the first syllable approached significance in the by-subjects analysis:, $F1(1,39) = 3.18$, $MSE = 34.94$, $p = .082$; $F2(1,80) = 1.18$, $MSE = 49.26$, $p > .10$. The other effects did not approach significance (all Fs < 1).

As in Experiment 1, we computed the correlation coefficient between the item mean RT and the log of the syllable frequency of the first syllable when N and the log of the frequency of the initial bigram were partialed out. The partial correlation coefficient approached the classical criterion for significance, $r(80) = -.21$, $p = .057$, which reinforces the view that syllable frequency has a facilitative role in pseudoword naming.

In sum, we again found a syllable frequency effect for the first syllable but not for the second syllable. It is worth noting that a combined analysis of Experiments 1 and 2 did not reveal any signs of an interaction between lexical stress and syllable frequency (both ps $> .20$). These findings suggest that, consistent with Levelt et al.'s (1999) model, the process of stress assignment and the process of retrieving syllables from the syllabary (or the computation of the syllables) seem to occur at different stages of processing. Thus, the present results replicate and extend previous work by Perea and Carreiras (1998) and reinforce the notion of a mental 'syllabary' during speech production, at least in Spanish.

4. Experiment 3

One potential concern about Experiments 1–2 is that the initial syllable (a CV syllable) always corresponded to the initial bigram. Even though the regression analyses showed that the obtained effect was due to syllable frequency rather than bigram frequency, we believe that it is important to re-examine the effect of syllable frequency with a different manipulation. Experiment 3 was designed to disentangle the effect of the syllable frequency of the initial syllable and the effect of the frequency of the initial bigram. To that end, we created pairs of disyllabic pseudowords. All of them had an initial CVC syllable and shared all the letters *except* the third letter (e.g., *mis.cun* vs. *min.cun*) in such way that one member of the pair had a high-frequency syllable in the first syllable (*mis*) and the other had a low-frequency syllable (*min*).

4.1. Method

4.1.1. Participants

A total of 20 psychology students from the University of La Laguna took part in the experiment to fulfill a course requirement. All of them either had normal vision or vision that was corrected-to-normal and were native speakers of Spanish. None of them had participated in the previous experiments.

4.1.2. Materials

The targets were 48 pairs of disyllabic pseudowords. The first syllable always had a CVC structure. One member of the pair had a first syllable of high frequency (token positional frequency; mean: 466, range: 58–2250 per million words in the Cobos et al., 1995, count) and the other had a first syllable of low-frequency (token positional frequency; mean: 7.5, range: 1–31). Each member of the pair shared both the initial bigram and the second syllable. For instance, *mis.cun* and *min.cun*, shared the initial and the second syllable, the difference being that *mis* is a syllable with a high positional frequency, whereas *min* has a low positional frequency. The average number of orthographic neighbors was 0.8 (range: 0–6) and 0.7 (range: 0–5) for the pseudowords with an initial frequency of high- and low-frequency, respectively. The log of bigram positional frequency of the bigrams in which the two members of each pair differed (e.g., *IS* and *SC* vs. *IN* and *NC* in the previous example) was 2.2 and 2.1 for the pseudowords of high and low syllable frequency, respectively (Sebastián et al., 2000). All the pseudowords were orthographically legal in Spanish. Given the similarity between the members of each pair, we created two lists. Each list contained one member of the pair, so that each list contained 24 pseudowords with a high-frequency syllable in the initial position and 24 pseudowords with a low-frequency syllable in the initial position. Each subject received only one of the lists (e.g., half of the subjects were presented with the pseudoword *min.cun*, whereas the other half were presented with the pseudoword *mis.cun*). The stimuli are shown in Appendix A.

Table 3
Mean naming times (in ms) and percentage of errors (in parentheses) on pseudowords in Experiment 3

Syllable frequency of the first syllable		
Low	High	Syllable frequency effect
646 (10.3)	636 (11.4)	10 (−1.1)

4.1.3. Procedure

The procedure was similar to Experiments 1–2.

4.2. Results and discussion

Incorrect responses (10.8%) and naming times less than 250 ms or greater than 1000 ms (2.3%, mostly caused by an error of the voice key) were omitted from the latency analysis. Mean naming times and percentages of error were then submitted to separate analyses of variance (ANOVAs), with frequency of the first syllable (low vs. high) as a within-participant variable and List (list 1 vs. list 2) as a between-participant variable. The factor List was included as a dummy variable to extract the variance due to the error associated with the lists (see Pollatsek & Well, 1995). Because of the matched design, syllable frequency was treated as a within-item variable in the item analyses. The mean naming time and error rate in each condition are shown in Table 3.

The ANOVA on the latency data showed that, on average, participants named pseudowords with an initial syllable of high-frequency 10 ms faster than the pseudowords with an initial syllable of low-frequency, $F1(1,19) = 5.35$, $MSE = 193.45$, $p < .035$; $F2(1,46) = 3.59$, $MSE = 1091.4$, $p = .06$. The ANOVA on the error data did not reveal any significant effects (both $ps > .25$).

The results are again straightforward. We found a facilitative effect of syllable frequency for the initial syllable when the frequency of the initial bigram was perfectly controlled (*mis.cun* faster than *min.cun*), replicating the syllable frequency effect for the first syllable obtained in Experiments 1–2.

5. General discussion

The present experiments have shown that the effect of syllable frequency is facilitative in pseudoword naming, extending previous findings by Perea and Carreiras (1996, 1998; cf. Levelt & Wheeldon, 1994). This effect occurred independently of lexical stress, bigram frequency, and was restricted to the initial syllable. Taken together, these findings provide empirical on-line evidence for the role of syllabic units in speech production.

The three experiments showed a significant effect of syllable frequency of the initial syllable when reading aloud. However, it could be argued that reading aloud may not strictly be tapping processes of syllabic production and that the effects obtained might rather have been contaminated by the activation of orthographic and/or phonological syllabic codes during lexical access. While we cannot completely rule out this possibility with the present experiments, it is important to notice that the effect of syllable frequency is facilitative in the reading aloud task, but it is inhibitory in tasks tapping visual-word recognition processes such as lexical decision, progressive demasking, among others (e.g., Álvarez et al., 2001; Carreiras et al., 1993; Conrad & Jacobs, 2004; Perea & Carreiras, 1998; Mathey & Zagar, 2002). Therefore, it is quite unlikely that the facilitative effect of syllable frequency obtained in the reading aloud task can be attributed to input encoding. In this light, it is worth noting that, consistent with the present results, Cholin, Schiller, and Levelt (2003) recently reported the presence of a facilitative effect of syllable frequency of the first syllable (but not the second syllable) using other production tasks in Dutch.

The facilitative effects of syllable frequency are consistent with Levelt et al.'s (1999; Levelt, 1989) model. In this model there are two steps in phonological encoding where the speaker accesses stored information: the retrieving of word form information (i.e., the lexeme) and the retrieving of the articulatory syllables from a mental 'syllabary.' Syllables are not represented in the lexicon, but rather are computed or retrieved at later stages of phonological encoding as the result of a syllabification process. In particular, syllables are posited to be articulatory programs that may be retrieved or created "on the wing" when previously selected segments are associated with their corresponding metrical frames. Once syllables have been retrieved or generated from scratch, they are sent to the articulatory network for overt articulation of speech (see Levelt et al., 1999). A facilitative effect of syllable frequency in Levelt et al.'s model would result either from faster computation of high-frequency syllables or from faster access to the syllabary for high-frequency syllables. The lack of a syllable frequency effect for the second syllable could be due to the fact that the phonological translation of the second syllable takes place when articulation of the first syllable has been initiated (see Paap, McDonald, Schvaneveldt, & Noel, 1987, for a similar reasoning). That is, a speeded naming task may be insensitive to the effect of the frequency of the second syllable.

An alternative account has been offered by Ferrand et al. (1996). Ferrand et al.'s model of visual word recognition and naming involves syllable-sized units both in the sublexical input phonology and in the sublexical output phonology. The effects of syllable frequency in pseudoword naming and picture naming tasks are predicted to be facilitative because of the faster computation of the articulatory output units in the sublexical output phonology (see Ferrand et al., 1996). In other words, the syllable-sized output units can facilitate the articulatory response, so that items with higher frequency syllables can be synthesized more rapidly, and hence pronounced more rapidly than items with lower frequency syllables. What we should also note is that this model can simultaneously cope with the presence of an inhibitory effect of syllable frequency in lexical decision and identification tasks. As stated above, sublexical input phonology is thought to be structured syllabically: sublexical phonological codes (such as syllables) could receive activation from the letter level and send on activation to the word level, so that words that share one syllable can influence the process of word recognition (via lexical inhibition at the word level).

In sum, while both Levelt et al.'s and Ferrand et al.'s models assume the existence of syllabic units, the empirical evidence up to now has been sparse and, to some degree, mixed. The present findings, namely that items composed of an initial syllable of high frequency produce faster pronunciations than the items composed of an initial syllable of low-frequency, thus offer empirical support for the view that syllables are important units during speech production in Spanish. It is worth noting that a facilitative effect of the frequency of the first syllable, but not of the second syllable, has recently been obtained in a large-scale naming study with disyllabic French words (see Brand, Rey, Peereman, & Spieler, 2002). (However, Brand et al. (2002) did not find a syllable frequency effect with disyllabic English words.) Similarly to the findings in speech perception—according to which the syllable is a speech segmentation unit for some languages but not for others (e.g., syllable-timed languages; see Cutler, 1996; Mehler, Dupoux, Nazzi, & Dehane-Lambertz, 1996), it could be the case that the proposal of a mental syllabary during speech production is relevant only for some languages. In this light, the overall number of syllables in a given language may be a determining factor. Languages like Spanish, which have a manageable number of syllables (e.g., approximately 3250 syllables in Spanish, see Sebastián et al., 2000), are probably among the best candidates to provide empirical evidence for the mental 'syllabary.' It is a matter of further research to explore whether the syllable frequency effect in speech production can be generalized to other languages.

Appendix A

A.1. Materials in Experiments 1–2

HF-1st, *HF-2nd*: rore, nibe, nile, rasi, nisi, rone, fibo, nole, nine, basi, repa, fite, niba, nibo, fibe, resi, fise, gasi, nore, rede, nise; *HF-1st*, *LF-2nd* : nabu, filu, niti, nomi, fipe, ropi, nalu, fibi, rabi, nitu, fidu, bapu, nibi, rali, ribi, gami, nadu, noru, rami, rapi, natu; *LF-1st*, *HF-2nd*: nuno, buna, numa, nune, runo, nuse, ruse, nusa, nule, nusi, rute, gose, rule, nuso, fole, rune, rusi, fore, fuba, fure, nute; *LF-1st*, *LF-2nd*: fosu, nudu, goli, fubi, rudi, rupe, ruli, nubu, nupe, nuli, buli, fupe, nubi, nulu, nuti, nuni, rumi, numi, rusu, fope, rutu.

A.2. Materials in Experiment 3

HF-1st: carmus, tormi, gespa, pensus, munges, borga, boste, cinte, parbis, torben, rinto, culdus, funte, busfa, rastis, dulta, restin, fungo, simbun, desbo, gentun, marbes, santun, porbes, junquen, senfon, monfus, sombal, lenfe, larvin, forques, pinmin, fircun, nuncin, golna, tentus, conmes, sanco, rasben, tarmun, cenvo, turquin, miscun, jarpi, salpen, tambun, tancon, cergue; *LF-1st*: cadmus, tosmi, gerpa, pelsus, mulges, bonga, bonte, ciste, pambis, tolben, risto, cundus, furte, bulfa, raptis, durta, reptin, fusgo, sisbun, delbo, gertun, mambes, sartun, pombes, julquen, sesfon, molfus, sosbal, lerfe, lasvin, fosques, pilmin, fiscun, nupcin, gozna, testus, cocmes, sasco, ramben, tacmun, cesvo, tunquin, mincun, jaspi, sampen, talbun, tascon, cesgue.

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