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## The delayed naming task, phonological preparation time, and the three-syllable stress window in Spanish

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**Abstract:** The current study presents the delayed naming task as an effective tool for testing the robustness of phonotactic constraints. A delayed naming task was employed to test for quantity sensitivity among nonwords in Spanish. Results reveal a robust effect of stress modulation by syllable weight as evidenced by differential rates of error between penultimate diphthongs and monophthongs in nonwords marked for antepenultimate stress. Items containing phonotactically illicit diphthong/stress combinations were also shown to improve significantly over time, showing that the cognitive constraints on proscription can be overcome with sufficient preparation time. Rising and falling diphthongs were also shown to restrict antepenultimate stress differentially, replicating the findings of Shelton et al. (2012) and revealing sensitivity to gradient weight distinctions in the lexicon. These findings offer further evidence in favor of nuanced quantity sensitivity in Spanish and demonstrate the utility of the delayed naming task to view phonotactic processing over time.

**Keywords:** Spanish phonotactics, Spanish stress, syllable weight, quantity sensitivity, delayed naming task, diphthongs

### 1. Introduction

How best to characterize the Spanish stress system is a contentious topic in the Hispanic linguistics literature that resurfaces frequently with shifts in theoretical paradigms. Despite substantial disagreement on the specific nature of the system, on which this paper seeks to shed light, there is general consensus that stress placement is restricted to one of the last three syllables of nonverbals in Spanish (Harris 1983; Roca 1991; Lipski 1997; Eddington 2000), and this so-called three-syllable window serves as the starting point for most studies on Spanish stress. However,

challenges arise regarding the role that internal syllable structure plays in modulating stress placement within the three-syllable window. Certain structures within the final and penultimate syllables restrict stress placement to one of the last two syllables of a word. Specifically, putatively “heavy” syllables in the penult or the ultima have been argued to prohibit antepenultimate stress, reducing the window for stress placement to the final two syllables (Harris 1983; Roca 1991; Lipski 1997). This apparent modulation of stress placement by syllable weight has been adduced as evidence that Spanish is a quantity-sensitive language (Harris 1983, 1992; Núñez Cedeño 1988, 1994), in which stress is computed from the right edge of the word, skipping light and stressing heavy syllables. However, the attested stress patterns in the Spanish lexicon are less consistent than a simple quantity-sensitive account would predict. For example, not all heavy final syllables are stressed (e.g., *lápiz*), and there are exceptional cases in which antepenultimate stress surfaces with both heavy penultimate and final syllables (e.g., *Wáshington*). Such forms have led other researchers to argue against quantity sensitivity in the synchronic analysis of stress placement (Roca 1988, 1991, 1997, 2016; Bárkányi 2002; Alvord 2003; Martínez-Paricio 2013; Piñeros 2016). More recently, experimental studies examining the interaction of Spanish stress and syllable structure from a processing perspective have suggested that Spanish is quantity sensitive, while at the same time questioning the binary distinction between “heavy” and “light” syllables in traditional phonological representations (Shelton 2013; Shelton, Gerfen, and Gutiérrez Palma 2012a, 2012b).

The present paper builds upon previous processing studies in an attempt to extend their findings to a new behavioral task, which may shed further light on how syllable-internal structure interacts with stress placement when native speakers process novel forms. Specifically, we will explore the behavior of rising and falling diphthongs in the penultimate syllable and how they modulate stress placement in Spanish nonwords. When native speakers are asked to read them aloud, theoretically licit and proscribed patterns should arguably provoke differential patterns of error rates and variable improvement over time. Observing these differences may inform our understanding of the nature of these interactions within the phonotactic system. In the following sections we review the specific nature of the three-syllable window and diphthongs in Spanish, report on an experiment that further tests the restrictions that syllable structure places on stress placement, and discuss the implications of the findings for theoretical approaches to Spanish stress assignment.

## 2. The three-syllable window

Stress is assigned to one of the last three syllables of nonverbals in Spanish<sup>1</sup> (e.g., Contreras 1977; Hooper and Terrell 1976; Harris 1983, 1992; Roca 1991; Hualde 2014), allowing for stress on the ultima (e.g., *café*, *perfil*), on the penult (e.g., *tetera*, *carcel*), or on the antepenult (e.g., *silaba*, *musica*). Nonverbals in Spanish are never stressed farther to the left in the word. Of the existing patterns, penultimate stress is the most frequent across the Spanish lexicon. Núñez Cedeño et al.

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<sup>1</sup> This paper focuses on stress placement among nonverbal forms in order to explore the nature of the three-syllable window and its vagaries, which do not apply to verbal stress, which is relatively straight-forward but also influenced by multiple morphosyntactic factors such as mood, tense, person and number. For a discussion of stress in Spanish verbs and accounts that consider both substantive and verbal forms, we refer the reader to Harris (1989, 1995) and Roca (1990).

(2014) calculate that 64% of all Spanish words carry penultimate stress, 28% have final stress, and only 8% have antepenultimate stress. Pons & Bosch (2010) note that 60% of disyllabic words are stressed penultimately, and in trisyllabic words 70% have penultimate stress. Penultimate stress is clearly the canonical stress pattern in the language, and the relatively low percentage of words with antepenultimate stress is arguably attributable to the large number of disyllabic nonverbals, together with syllable phonotactics in the final and penultimate syllables that restrict stress placement to the final two syllables of the word.

Distributional evidence suggests that heavy penults may modulate stress placement by reducing the three-syllable window to two syllables from the right edge (Harris 1983; Roca 1991). Specifically, penults closed by a consonant or that contain a diphthong allow penultimate stress but proscribe antepenultimate stress<sup>2</sup>. In the final syllable, a similar pattern emerges, as illustrated in Table 1.

**Table 1. Reduced three-syllable stress window**

	<i>Licit stress pattern</i>	<i>Illicit stress pattern</i>
Closed penult	<i>gigante</i> [xi.'ɣan.te]	* <i>gígante</i> *['xi.ɣan.te]
Diphthong in penult	<i>mosaico</i> [mo.'saj.ko]	* <i>mósaico</i> *['mo.saj.ko]
	<i>curioso</i> [ku.'rjo.so]	* <i>cúrioso</i> *['ku.rjo.so]
Closed ultima	<i>festival</i> [fes.ti.'βal]	* <i>féstival</i> *['fes.ti.βal]
	<i>canibal</i> [ka.'ni.βal]	* <i>cánibal</i> *['ka.ni.βal]
Diphthong in ultima	<i>Paraguay</i> [pa.ra.'ɣwaj]	* <i>Páraguay</i> *['pa.ra.ɣwaj]
	<i>comercio</i> [ko.'mer.θjo]	* <i>cómercio</i> *['ko.mer.θjo]

The patterns in Table 1 can be interpreted as evidence of quantity sensitivity in Spanish under the view that heavy penultimate and final syllables reduce the Spanish stress window from three syllables to two. However, upon closer examination of both the distributional data and experimental evidence, some have challenged the conclusion that Spanish is sensitive to syllable weight. Roca (1988, 1991, 1997, 2016) argues that Spanish is not quantity sensitive, because simply accenting heavy syllables fails to account for the full range of patterns in the language. For example, words containing heavy final syllables are oftentimes not stressed on the ultima (a pattern expected under a quantity-sensitive approach), but rather surface with penultimate stress (e.g., *árbol*, *mártir*). Furthermore, antepenultimate stress is in some cases also attested in words ending in a consonant, as in the native word *régimen*, or borrowings such as *Washington* or *Mánchester*

<sup>2</sup> While no native forms allow antepenultimate stress when they contain a penultimate diphthong, some borrowings with this word shape have entered the language. As an anonymous reviewer commented, toponyms of Mexican origin, such as *Pátzcuaro* and *Tócuaro*, and the variable proparoxytonic vs. oxytonic *vóleibol* and *voleibol*, which vary by dialect, suggest that speakers of Spanish are at times amenable to exceptions to this rule.

(Roca 1991). A further complication in this debate concerns which level of representation should constitute the domain of stress assignment. Those adhering to quantity-insensitive accounts tend to view the stem as the domain of stress placement in Spanish, while those who argue in favor of quantity sensitivity believe the word is the appropriate level. Harris (1995) attempts to take both approaches into account, differentiating between the “morphological word” and the “phonological word”, concluding that “some generalizations of stress assignment in Spanish clearly hold over the domain of the entire word while others seem to require reference to the subword stem constituent” (p. 871). Moreover, the stress system likely has separate projections for assigning stress among verbs and nonverbals (p.884). In short, despite the apparent modulation of stress placement by syllable weight, there nevertheless remains no consensus regarding quantity sensitivity in the generative literature on Spanish stress. If the system is quantity sensitive, the nature of the interaction between stress assignment and syllable weight is not a straightforward one.

Experimental studies examining nonverbal stress in Spanish are also not conclusive in their findings. In an oft-cited and important early study, Aske (1990) presented native speakers with a series of nonwords in contexts in which they would be interpreted as either adjectives or nouns. Participants were asked to mark where they felt stress should fall in each item. The task tested whether participants would follow the traditional generative stress algorithm, stressing heavy syllables from the right leftward, or if they would be sensitive to extant patterns in the lexicon, which, if so, would lead them to assign stress analogically in the novel forms. For example, words ending in “*n*” should be assigned final stress, as the final consonant closes the last syllable rendering it heavy. This is the case for most Spanish words of this shape, with the exception of those ending in “*en*”, which show penultimate stress 62% of the time. Similarly, words ending in “*ico*” would be predicted to be assigned penultimate stress, as it is the default stress pattern in words ending in -CVCV. However, extant words ending in “*ico*”, such as *clásico*, most often carry antepenultimate stress in Spanish. Results revealed that in general participants did assign stress to heavy syllables following the default stress patterns, which may be interpreted as evidence of quantity sensitivity. However, in those cases in which they did not, the findings suggested that speakers attended to subregularities in the lexicon and assigned stress analogically (Aske 1990). Extending Aske's work, Eddington (2000, 2004) found similar results. Tested on the 4,970 most frequent words in the Alameda and Cuetos (1995) corpus, his computational model assigned stress correctly approximately 94% of the time. Interestingly, the words to which the model incorrectly assigned stress were often those that traditional approaches have also treated as exceptional (Eddington 2000). In the case of “*ico/a*”, the model produced accurate stress placement patterns in 99 out of 107 words, despite the marked status of the antepenultimate stress pattern. These results suggest again that the Spanish stress system is sensitive to differences in syllable weight, but that the system must also consist of subtler patterns than a simple distinction between “heavy” and “light” syllables would predict. Further evidence of analogical processing of stress has also been found among second-language (L2) learners of Spanish. Bullock and Lord (2003) present the results of an experiment with L2 speakers of Spanish that suggest that early learners quickly understand that penultimate stress is the default pattern in the language, and when they encounter novel forms, they first search for similar exemplars in their L2. If none are available, they then resort to analogy within the native lexicon. Furthermore, as their proficiency grows, so too does their use of analogy in their L2.

Other experimental work has argued against sensitivity to syllable weight. Face (2000) examined the role syllable weight plays in the perception of stress by native Spanish speakers. In his study, nonwords were synthesized so that no syllable was more prominent than any other syllable in the word. Participants listened to the stimuli and marked what they interpreted as the stressed syllable. Quantity sensitivity appeared to play a strong role in the listeners' stress preferences, as heavy syllables were typically perceived as stressed. However, in a later paper, Face (2004) disputes his earlier findings, identifying problems in the stimuli synthesis that may have cued participants to stressed syllables after all. Specifically, cues to stress had been neutralized by controlling the duration of the vowels across the word. However, the duration of the overall syllables had not been manipulated. In Face (2004), this error was corrected and no effect of syllable weight was found.

Two pencil-and-paper tests offer further possible support to the argument against weight sensitivity. Bárkányi (2002) asked participants to mark where stress should be placed in a list of nonwords. Results revealed that heavy penults did not impede antepenultimate stress assignment in many cases. In a slightly different experiment, Alvord (2003) marked a list of nonwords for stress diacritically and asked participants to judge the words as possible or impossible words in Spanish. His results corroborate those of Bárkányi (2002) in that words marked for antepenultimate stress were accepted overwhelmingly despite the presence of heavy penults.

In sum, both generative and experimental studies have yielded conflicting accounts of the Spanish stress system. Descriptive observation of extant forms and some experimental studies support a view in which native speakers are sensitive to the distinction between heavy and light syllables. However, subsequent experimental work has shown this perspective to be problematic, particularly in tasks probing native speaker intuitions regarding stress placement in nonwords. These findings motivated further work of a behavioral nature, with the goal of exploring whether a processing approach involving speech production might illuminate from a different perspective the role or non-contribution of syllable weight in the Spanish stress system.

One limitation of the previously cited experimental studies is their reliance on metalinguistic judgments. Speakers' conscious intuitions, while potentially important, may not always match the cognitive representation of linguistic patterns. The presentation of a well-pronounced word in a perception task, especially when the stimuli are designed well to sound as native-like as possible, may bias listeners toward acceptability, especially upon repeated exposure to a pattern. Similarly, binary forced decisions regarding the possibility or acceptability of written forms do not necessarily require the speakers to prepare the word phonologically. Although they may phonologically encode the form, it is possible to make decisions of acceptability in written tasks based on the appearance of the item alone. More generally, multiple methodologies and converging evidence are needed to increase our understanding of the complex relationship between syllable structure and stress in Spanish. We argue that behavioral tasks that force production can provide a particularly useful window on the ability of native speakers to prepare and articulate putatively proscribed forms. This may be especially true in those tasks in which the speakers are not expected to make any judgments about the forms at all, but rather simply produce them. The results of such a task can provide a perspective on the syllable structure/stress relationship that is arguably less mediated by metalinguistic reflection. With this in mind, we turn our attention to behavioral studies that examine more closely the patterning of rising and falling diphthongs in Spanish.

## 2.1 The differential patterning of rising vs. falling diphthongs in Spanish

As Table 1 illustrates, syllables with falling diphthongs tend to pattern with closed syllables in that they both attract stress to the syllable which contains them and block antepenultimate stress (Lipski 1997). Rising diphthongs, however, interact with stress in a slightly different way. In one sense rising and falling diphthongs pattern together, as antepenultimate stress is impossible if the penult or the ultima contains either type of diphthong. Curiously, however, in contrast to falling diphthongs, rising diphthongs do not, themselves, systematically attract stress, as seen in forms such as *comércio* in Table 1. Here the rising diphthong in the final syllable fails to attract stress, allowing for penultimate stress in the word. This is, in fact, a common pattern in the Spanish lexicon, as very few final rising diphthongs are stressed. Alameda and Cuetos (1995) list over seven hundred nonverbal words of this type, such as *sitio*, *ambigua*, and *especie*. Words such as these exemplify a divergence between rising and falling diphthongs and how they affect stress placement in Spanish.

This observation adds another layer of complexity to the issue of quantity sensitivity in Spanish. If Spanish is sensitive to syllable weight, the system might be expected to stress both diphthong types equally, as both are considered heavy by traditional standards<sup>3</sup> (e.g., Harris 1983). However, if native speakers are sensitive to subtler subsyllabic phonotactic patterns in the lexicon, it is possible that the interaction between syllable structure and stress placement is more finely grained than a binary heavy-light distinction permits.

Shelton et al. (2012a) examined this possibility by means of a carefully controlled behavioral task. Specifically, participants were asked to read aloud nonwords of the shape CV.CGV.CV, such as *fátiago*, and CV.CVG.CV, as in *fáraiga* (where 'G' is a palatal glide). Stimuli were counterbalanced across participants with and without diacritic accent marks over the first syllable, rendering segmentally identical items in two conditions of antepenultimate and penultimate stress. A set of monophthong control stimuli (CV.CV.CV, e.g., *fátaga*) was included as a baseline comparison. Traditional accounts of Spanish stress would predict that all stimuli should pattern equally in the penultimate stress condition, as stress assignment to the penult of any of these items is licit (*fatiágo*, *faráiga*, *fatága*). By contrast, in the antepenultimate stress condition, one would expect differences to arise. While monophthong controls are theoretically licit with either antepenultimate or penultimate stress (*fátaga* – *fatága*), diphthong stimuli are expected to be permissible with penultimate stress (*fatáigo*, *faráiga*) but proscribed in the antepenultimate stress condition (*\*fátiago*, *\*fáraiga*). This prediction derives from the putatively heavy nature of diphthongs in Spanish stress theory. If traditional accounts of Spanish stress hold true, both rising and falling diphthongs in the penult reduce the three-syllable stress window, limiting stress to one of the last two syllables.

Shelton et al. (2012a) thus predicted higher rates of error among both diphthong stimuli sets compared to monophthong controls in the antepenultimate stress condition. From a processing perspective, it is common to view higher or lower error rates as evidence of higher or lower processing costs associated with particular patterns. This was the result found in the experiment. In their study, an error consisted of not producing the item as it was written, be it by shifting stress

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<sup>3</sup> Another matter of substantial debate in the literature is the underlying representation from which surface-level diphthongs derive. There is a lack of consensus on the phonemic status of the Spanish glide. As such a discussion is out of the scope of this paper, the reader is directed to Roca (2016), which discusses this topic in great detail.

to another syllable, by changing segments in the (pseudo)word, or by means of disfluency. When pooled together, diphthong stimuli provoked significantly higher rates of error than monophthong controls in the antepenultimate condition (45.4% vs. 14%) (Shelton et al. 2012a). More interestingly, however, when the two diphthong types were compared, an unexpected split in behavior between falling and rising diphthongs was revealed. Falling diphthongs (e.g., *fátaigo*) elicited significantly more errors (55.2%) than did rising diphthongs (e.g., *fátiago*) (35.5%) in the antepenultimate condition. This finding is striking, as traditional accounts of Spanish stress treat both diphthongs as heavy. The authors interpreted these results as indicative of gradient effects of syllable phonotactics on the availability of stress placement. That is, while the general comparison between diphthongs and monophthong controls reveals a pattern that is compatible with binary, quantity-sensitive accounts of Spanish stress assignment, the subtler difference between rising and falling diphthongs suggests that the internal structure of syllables modulates stress assignment in more finely-grained ways than previously recognized.

In a second experiment, Shelton et al. (2012b) explored the syllabification of Spanish on-glides, in an attempt to understand better the “lighter” nature of the rising diphthongs evidenced in their previous study. Reviewing developmental work from the clinical literature, the authors identified studies which argue that at least during early stages of acquisition some learners of Spanish appear to syllabify on-glides within the onset of the syllable, rather than with the vowel in the nucleus as traditionally assumed. For example, one study identified a similarity in patterning between prevocalic consonant+liquid (CLV) and consonant+glide (CGV) sequences among replacement and deletion errors as well as in coalescence effects in the speech of five Spanish-speaking children (Kehoe et al. 2008). Given that CLV sequences are clear examples of complex onsets, similar patterning of CGV may suggest an equivalent syllabification. Another study described a language game commonly played in Central and South America known as *jerigonza* or *hablando de ‘p’* (Piñeros 1998). In some varieties, an infixation process inserts an epenthetic syllable of the shape [-pV-] after each syllable of the word, with the rime of the new syllable surfacing as a copy of the previous rime. For example, *libro* becomes *li.pi.bro.po*. It is important to note that not only the vowel appears in the epenthetic syllable, as coda consonants and off-glides are also maintained. However, interestingly, onset segments and on-glides are not carried over to the new syllable. As examples, compare *estoy* and *también*. In the former, the off-glide appears in the added syllable, *e.pes.to.poy*, but the on-glide of the latter is omitted in *ta.pam.bie.pen*. Based on these observations, one might predict that the rising diphthongs pattern as lighter than falling diphthongs in the results reported in Shelton et al. (2012a) because they are syllabified outside of (or at least bound less tightly to) the syllable nucleus.

Also employing a naming task, Shelton et al. (2012b) compared nonwords containing penultimate on-glides, such as *lótiega*, with nonwords containing complex penult onsets, as in *lótrega*. Here the prediction was as follows. If on-glides are syllabified outside the syllable rime, on-glide and complex onset stimuli might pattern together, as the penultimate syllable in both categories consisted of a vowel preceded by two onset segments, CV.CGV.CV and CV.CCV.CV. However, if the on-glides are syllabified in the nucleus, then the two word types should pattern distinctly. Results revealed that on-glide stimuli provoked more than double the amount of errors induced by complex onsets (52% vs. 24%) (Shelton et al. 2012b). In the penultimate condition no significant differences surfaced. These data thus suggest that the varying degrees of syllable weight evidenced in the previous paper cannot be attributed to segmental differences among the data. That is to say, the extra segment in the diphthong (CV.CGV.CV vs. CV.CV.CV) is not the cause of the

significant difference between diphthongs and their monophthong controls. The addition of another segment that is clearly syllabified to the onset does not alter the effect. In short, the results of this study are strongly consistent with the position that native adult speakers of Spanish syllabify the on-glide into the syllable nucleus. These results, in tandem with the previous findings, further support a gradient effect of syllable weight on stress assignment in the language, given a task that allows for the manifestation of the effect.

Motivated by these studies, in this paper we present a behavioral experiment, the goal of which is to extend the findings of Shelton et al. (2012a) in order to test the strength and persistence of the phonotactic constraints that these subsyllabic patterns impose on the stress system. We propose the use of the delayed naming task, a methodology which has been used in the psychology literature to probe the time course of phonological preparation (Monsell et al. 1989; Murphy 2012; Laganaro and Alario 2006). For our purposes, the appropriation of this tool for linguistic inquiry is promising as a metric of the cognitive validity and robustness of an observed phonotactic effect. We describe the delayed naming task in more detail in the following section.

### **3. The delayed naming task**

The delayed naming task is an adaptation of the standard naming task. As in regular naming, participants performing a delayed naming task read aloud words presented one at a time on a computer screen, and behavioral data in the form of reaction times and/or error rates are collected for subsequent analysis. However, in the delayed naming task, participants are instructed to withhold articulation until cued to speak. This small difference is beneficial in that it allows the experimenter to control the amount of preparation time before articulation (Laganaro and Alario 2006). In psycholinguistics, the task has been used widely to examine effects of word frequency and semantic relationships on lexical activation. Oldfield and Wingfield (1965), for example, found that naming latencies are generally slower for low-frequency words than for high-frequency words. However, this effect disappears when speakers are provided with sufficient time to prepare words prior to articulation (Monsell et al. 1989). Similarly, lexical activation has been shown to be facilitated if a semantically-related word is presented first (Meyer and Schvaneveldt 1971). However, if articulation is sufficiently delayed, this semantic priming effect disappears (Murphy 2012). More generally, differential effects attributed to the processing of patterns encoded in the lexicon, such as phonological preparation, word frequency, or semantic associations, are expected to disappear with longer delays (and therefore more preparation time) in the task.

The delayed naming paradigm is advantageous here for the examination of the processing of rising vs. falling diphthongs, and the interaction of stress and syllable structure in Spanish broadly, as it yields clear predictions for our data. Given the Shelton et al. (2012a) findings, we again predict that a high error rate will arise from the proscription on antepenultimate stress when there is a diphthong in the penultimate syllable, as compared to licit monophthong controls. This effect, due to the modulation of stress placement by syllable structure, should diminish as the speaker has more time to prepare the forms for articulation. The time-course data from the delayed naming task also allow us to track the processing of the two diphthong types individually. The variable strength of the constraints that each diphthong type imposes on antepenultimate stress may be manifest in the amount of preparation time necessary for speakers to be able to overcome the proscription. Arguably, participants may overcome weaker restrictions on the system earlier,

as evidenced by significant improvement in a given category at earlier delays. That is, forcing articulation before enough preparation time has occurred results in higher production errors. Potentially, if less preparation time is required, fewer errors will occur, indicating a weaker proscription in the system.

### 3.1 Participants

Fifty-five adult speakers of Spanish participated in this study. Participants were undergraduate students at the University of Jaén, Spain, of which 44 were female (mean age = 19, SD = 1.51), and 11 were male (mean age = 21, SD = 4.52). All university students in Spain have had some exposure to other languages, such as English, which does permit antepenultimate stress in words containing putatively heavy penults and ultimas. However, the participants in this experiment were functionally monolingual, given that they were not sufficiently fluent in any language other than Spanish to the extent that one would predict changes in their processing of phonotactic patterns in their native language.

### 3.2 Materials

Critical stimuli consisted of 28 trisyllabic nonwords containing a rising diphthong (CV.CGV.CV) and 28 nonwords with a falling diphthong (CV.CVG.CV) in the penultimate syllable. Orthographically, rising diphthongs were represented by *ia* or *ie* (e.g., *fátiago* or *fáriena*), and falling diphthongs by *ai* or *ei* (*fáraiga* or *fáteiga*). The segmental makeup of the stimuli was controlled so that all consonants and vowels in the antepenultimate and final syllables appeared equally across all conditions. For comparison to the diphthong stimuli, a set of monophthong control stimuli was also included. These items matched the diphthong stimuli segmentally, with the exception of the penultimate syllable, which contained a monophthong instead of the diphthong (e.g., *fátaga*).

All critical and control items were presented both with and without a diacritic accent mark on the antepenultimate syllable. Given that stress is overtly marked in the Spanish spelling system, a written accent over the initial syllable of a three-syllable word always indicates antepenultimate stress. If a Spanish word ends in a vowel and contains no accent mark, penultimate stress is always assigned. This orthographic convention permits a perfectly controlled comparison of otherwise segmentally identical stimuli in two stress conditions. In addition, in order to avoid the repetition of identical syllable sequences, the presentation of items with and without orthographic accent marks was counterbalanced. For example, if participant #1 read *fátiago*, then participant #2 would read *fatiago*. In total, 112 critical items and controls were presented to each participant.

Participants also saw 168 filler forms comprised of both real words and nonwords. The nonword fillers consisted of 28 CV.CV.CV items that were segmentally distinct from the critical items, and 140 real-word fillers were chosen from Alameda and Cuetos (1995). These were sampled from all three possible stress patterns: antepenultimate, penultimate, and final stress. Overall, participants were exposed to a balanced list of 140 nonword items and 140 real words over the course of the experiment.

Table 2 provides examples of the critical nonword stimuli (i.e., target diphthongs and controls) with quantities of each listed in parentheses. Of central importance are the rising and falling diphthong stimuli in the antepenultimate condition. Recall that such forms are theoretically

proscribed, because the diphthongs in the penultimate syllable should constrain stress placement, limiting it to one of the final two syllables of the word. That is, overtly marking the first syllable of our stimuli for stress (e.g., *fáteiga*) renders these forms illicit. The stimuli presented with penultimate stress are phonotactically licit, because stress is always permitted on the penult, regardless of its weight. Similarly, given that all syllables in the monophthong controls are light, stress is permissible in Spanish on either the antepenultimate or penultimate syllable. This design allows us to make two critical comparisons. First, we can compare the behavior of the putatively proscribed forms containing diphthongs with antepenultimate stress and the remaining stimuli. A second, more important comparison between the items containing rising diphthongs and falling diphthongs is motivated by the ambiguous patterning of the rising diphthongs in the lexicon. That is, the design allows us to test both for the synchronic strength of the ban on antepenultimate stress in words containing a diphthong in the penult, while at the same time replicating the subtler difference between the rising and falling diphthongs and their interaction with stress placement in the language.

**Table 2. Critical stimuli**

	<i>Antepenultimate stress</i>	<i>Penultimate stress</i>
Rising diphthongs	fátiago (28)	fatiago (28)
Falling diphthongs	fáteiga (28)	fateiga (28)
Monophthong controls	fátaga (56)	fataga (56)

### 3.3 Procedure

Stimuli were presented in a delayed naming task using E-Prime, a software package commonly used in psychology for computerized experiment design, data collection, and analysis (Schneider, Eschman, and Zuccolotto 2002). Participants were tested in a quiet room, seated before a computer screen and microphone. The microphone was connected to a digital recorder (Marantz PMD600 sampling at 48 kHz) that was connected to a PST Serial Response Box. The button box was connected to the computer and served as a voice key to cue the presentation of the next stimulus when the participants spoke. The digital recorder recorded the experimental sessions for subsequent coding of response accuracy.

Instructions appeared on the screen in Spanish. Participants were informed that they would see words one-by-one, and were asked to speak the words aloud as quickly and accurately as possible, when cued by a tone to speak. The tone sounded either immediately as the stimulus appeared on the screen (0 ms delay), 600 ms after stimulus presentation, or 1200 ms after the stimulus. The three delay cues sounded randomly across the stimuli sets. After a response, a blank screen appeared for 1000 milliseconds until the following trial began. If participants committed an error, the experimenter cued the computer to present an error message. The word “Error” appeared in red letters in the upper left-hand corner of the screen to alert participants that they had committed an error and to focus them on the task, cuing them to pay closer attention to the orthography of the items.

The delayed naming task is useful in that delaying the presentation of the cue to speak for varying intervals offers controlled amounts of time for phonological preparation and processing. Before the experimental items were presented, participants performed a practice session consisting

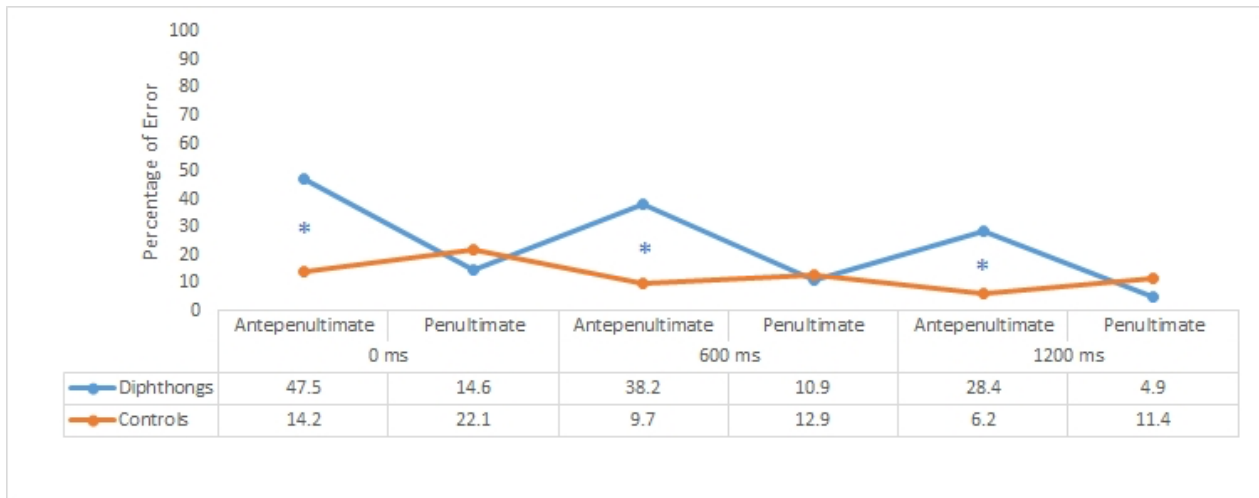
of 12 items (6 words and 6 nonwords), none of which contained the critical structures under examination. Following the practice, the experimental stimuli were randomly presented in two experimental blocks with a 30-second break between them.

### 3.4 Results

Before submitting the data to statistical analyses, errors were coded manually by listening to the digital recordings of the experimental sessions. A response was coded as an error if participants misspoke the stimulus. Three types of errors were identified among the critical stimuli: stress shifts to another syllable (e.g., *rámaino* > *ramáino*), changes in the segmental makeup of the word (*sóreiga* > *sóriega*, *náteiga* > *nátiga*), or disfluencies in which participants did not finish producing or in which they paused during the production of the item (*rámiena* > *rá...miéna*). The first author coded all data, 40% of which were then spot-checked by the second author. As the errors were robust and easily identifiable by proficient speakers of the language, there were no discrepancies.

Technical errors in which microphone sensitivity failed to register a response were eliminated from all analyses. Error rates were submitted to separate repeated measures ANOVAs by participants ( $F1$ ) and by items ( $F2$ ) using the software STATISTICA 6.0. Main effects and interactions were followed by Tukey's HSD post-hoc tests to identify independent effects across the experimental categories and conditions.

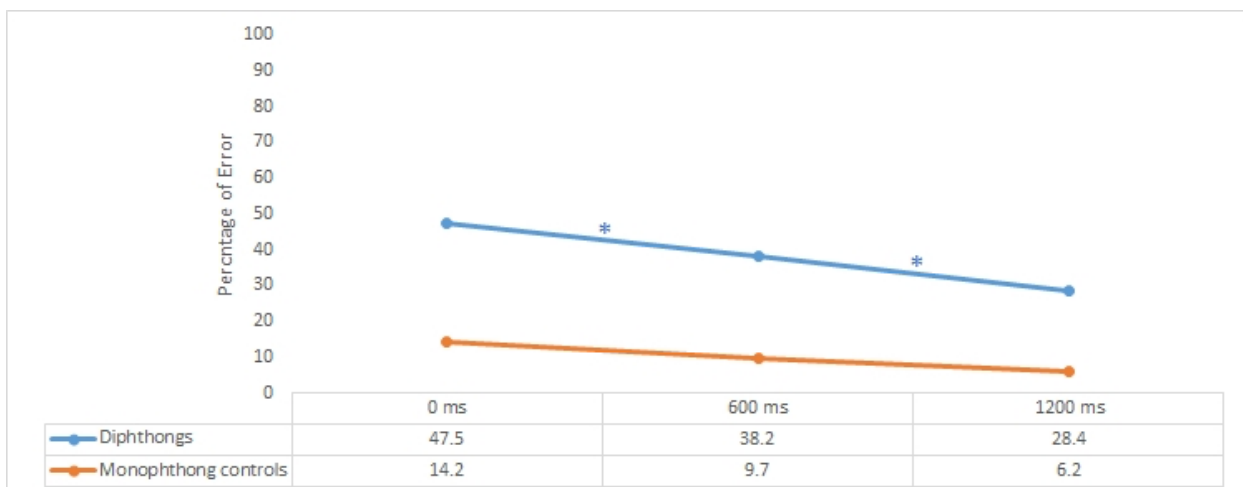
Our first comparison examines error rates for the diphthong and monophthong stimuli in all three delay conditions. ANOVAs revealed a significant main effect of word type (diphthongs vs. monophthongs),  $F1(1, 54) = 67.84, p < .001$ ;  $F2(1, 110) = 61.96, p < .001$ , a significant main effect of stress type (antepenultimate vs. penultimate),  $F1(1, 54) = 34.64, p < .001$ ;  $F2(1, 110) = 91.05, p < .001$ , and a significant main effect of delay (0ms vs. 600ms vs. 1200ms),  $F1(2, 108) = 42.68, p < .001$ ;  $F2(2, 220) = 32.83, p < .001$ . Analyses also revealed a significant interaction of word type and stress type,  $F1(1, 54) = 90.24, p < .001$ ;  $F2(2, 220) = 187.88, p < .001$ , a significant interaction of stress type and delay by items,  $F1(2, 108) = 1.20, p > .30$ ;  $F2(2, 220) = 3.16, p < .05$ , a significant interaction of word type and delay,  $F1(2, 108) = 4.08, p < .02$ ;  $F2(2, 220) = 5.44, p < .01$ , and, most important for the present study, a significant interaction of stress type, word type, and delay,  $F1(2, 108) = 3.98, p = .02$ ;  $F2(2, 220) = 2.88, p = .058$ . Figure 1 lists the percentage of error for diphthongs and their monophthong controls in each stress condition across the three delay conditions.



**Figure 1. Percentage of error – diphthongs vs. controls – across delays**

Figure 1 reveals a clear pattern across the three delays. All comparisons in the antepenultimate stress condition are statistically significant ( $p < .01$ ). In the penultimate condition, the difference between word types was not significant in any of the three delays. These results suggest that diphthongs and monophthongs are processed similarly when stress is assigned to the penultimate syllable. However, when stress is assigned to the antepenult, the diphthong stimuli provoke higher error rates.

Figure 2 focuses specifically on the patterning of diphthong and monophthong controls in items marked for antepenultimate stress across the three delay conditions.

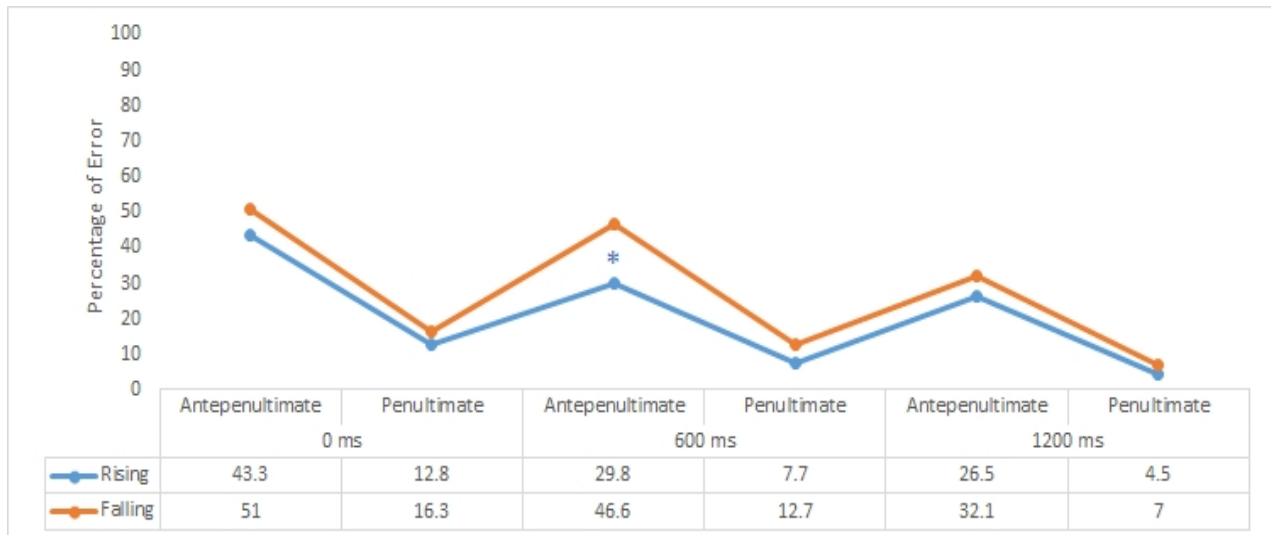


**Figure 2. Percentage of error – diphthongs vs. controls in the antepenultimate condition – across delays**

Interestingly, in the antepenultimate stress condition, where diphthong stimuli are theoretically proscribed, we observe a significant improvement with each delay (0 ms – 600 ms =  $p < .01$ , 600

ms – 1200 ms =  $p < .01$ ), as marked by the steeper slope for diphthong stimuli. However, as preparation time is added, the differences among control stimuli are not statistically significant (0 ms – 600 ms =  $p > .72$ , 600 ms – 1200 ms =  $p > .94$ ).

Given the findings of Shelton et al. (2012a), in which significant differences in error rates were found for rising vs. falling diphthong critical items, a second analysis of the data examines whether this effect is replicated when participants have additional time to prepare forms for production. Specifically, to examine whether our participants evidenced sensitivity to these subtler patterns within the lexicon, the error rates of the two diphthong types were also submitted to statistical analyses. ANOVAs revealed a significant main effect of word type (rising vs. falling diphthongs),  $F(1, 54) = 15.15, p < .001$ ;  $F(1, 54) = 22.72, p < .001$ , a significant main effect of stress type (antepenultimate vs. penultimate),  $F(1, 54) = 73.57, p < .001$ ;  $F(1, 54) = 496.28, p < .001$ , and a main effect of delay (0ms vs. 600ms vs. 1200ms),  $F(2, 108) = 28.19, p < .001$ ;  $F(2, 108) = 34.27, p < .001$ . A significant interaction of stress type and word type for items,  $F(1, 54) = 3.42, p > .06$ ;  $F(1, 54) = 16.86, p < .001$ , a significant interaction of stress type and delay,  $F(2, 108) = 4.23, p < .02$ ;  $F(2, 108) = 7.65, p < .001$ , no significant interaction of word type and delay,  $F(2, 108) = 2.53, p > .08$ ;  $F(2, 208) = 2.67, p > .07$ , and no significant interaction of stress type, word type, and delay,  $F(2, 108) = 0.89, p > .41$ ;  $F(2, 108) = 2.39, p > .09$  were also found. Figure 3 identifies the patterning of the rising and falling diphthongs in both stress conditions in each delay.



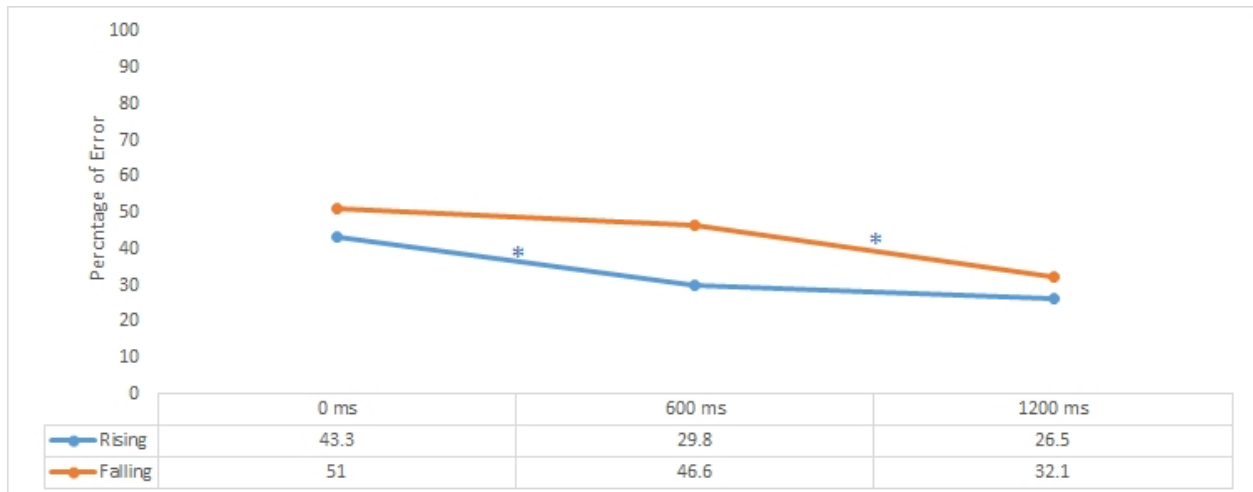
**Figure 3. Percentage of error – rising vs. falling diphthongs – across delays**

As we have seen previously, and congenial with a weight-sensitive account of Spanish stress, in the penultimate stress condition, where both rising and falling diphthongs are licit, the analyses revealed no significant differences in any delay condition. In the antepenultimate condition, post-hoc analyses revealed a significant difference between the two diphthongs types in the effect of delay on error rates in the 600 ms condition ( $p < .01$ ).

#### 4. Discussion

The first goal of the present study was to test for further evidence of quantity sensitivity in the Spanish stress system. The results of this experiment extend the findings of Shelton et al. (2012a) to a new task. Consistent with the analysis that Spanish stress is sensitive to syllable weight, Figure 1 shows significant differences between diphthongs and monophthongs in the antepenultimate stress condition. The theoretical proscription on antepenultimate stress in words containing putatively heavy penults is manifest in a significant difference in patterning between the pooled diphthong stimuli and the monophthong controls. This difference is found between both word types in all delays in the antepenultimate condition. As a quantity-sensitive account might predict, there are no significant differences between stimuli types in any of the delays when the items were named with penultimate stress. Similarly, as illustrated in Figure 2, participants show significant improvement in their production of diphthong stimuli in the antepenultimate stress condition with each delay. This confirms our prediction that increasing preparation time permits speakers to improve their production of illicit structures. These results thus replicate the findings of Shelton et al. (2012a) in support of a broad view of quantity sensitivity in Spanish.

The second goal of the experiment was to replicate the subtler effect of diphthong type identified in Shelton et al. (2012a), in which rising diphthongs provoked significantly fewer errors than falling diphthongs. Here the differential behavior between rising and falling diphthongs emerges as well, although in a different way. As seen in Figure 3, a significant difference between diphthong types surfaces in the 600 ms delay ( $p < .01$ ). However, it disappears in the 1200 ms condition ( $p > .92$ ), and, perhaps most unexpectedly, it is also absent in the 0 ms delay ( $p < .57$ ), where participants had the smallest amount of time for phonological preparation. At first glance, this pattern of results may seem difficult to explain. However, if we plot the error rates for rising and falling diphthongs by delay condition, the behavior of each diphthong type when presented with antepenultimate stress becomes easier to observe.



**Figure 4. Percentage of error – rising vs. falling diphthongs in the antepenultimate condition – across delays**

Figure 4 compares rising and falling diphthongs in the antepenultimate stress condition across the three delays. Rising diphthongs evidence significant improvement in accuracy with 600 ms of preparation time (0 ms – 600 ms,  $p < .02$ ). Falling diphthongs, in contrast, require additional time to prepare, as seen in the later significant difference in accuracy after 1200 ms of delay (600 ms – 1200 ms,  $p < .01$ ). If we assume that the processing cost imposed by the two diphthongs differs, we would predict that participants need differing amounts of preparation time to produce accurate items. As the delays force articulation after controlled intervals of time following the presentation of the stimuli, we can track how increased processing time improves accuracy in the production of each word type. While we did not see significantly lower error rates for rising diphthongs as compared to falling diphthongs in every delay condition, we did find significant improvement in accuracy for rising diphthongs in an earlier delay (600 ms) than for comparable falling diphthong stimuli (1200 ms). This is to say, as seen in Figure 3, the diphthong effect still surfaces with 600 ms of preparation time, but disappears by 1200 ms, because 600 ms is arguably sufficient time for speakers to improve significantly their production of illicit forms containing rising diphthongs in the penult. Falling diphthongs, on the other hand, require more time for significant improvement. Of particular importance, our data suggest that a shorter delay of 600 ms is insufficient to eliminate the difference between how rising and falling diphthongs modulate error rates on words orthographically marked for antepenultimate stress, but after 1200 ms, the subtle weight difference between the diphthongs is no longer reflected in the error rate data. This pattern of behavior is congenial with the view that rising diphthongs impose a weaker restriction on antepenultimate stress, as demonstrated by less processing time for speakers to override the phonotactic constraint.

Another potentially interesting point of comparison raised by an anonymous reviewer is whether participants produced fewer errors as the task progressed, and if such an effect of learning across the experiment differed for rising and falling diphthongs. In response, we calculated the correlation between error rate and order of stimulus presentation for our critical stimuli. We did find a subtle effect of learning in general across all three delays. That is, the number of errors is higher in earlier trials and diminishes progressively, (0ms –  $r = -.47$ ,  $p < .01$ ; 600ms –  $r = -.30$ ,  $p < .01$ ; 1200ms –  $r = -.40$ ,  $p < .01$ ). There were, however, no significant differences in improvement between the putatively illicit items containing rising vs. falling diphthongs (0ms –  $t(87) = 1.26$ ,  $p > .05$ ; 600ms –  $t(94) = -0.77$ ,  $p > .05$ ; 1200ms –  $t(87) = 0.37$ ,  $p > .05$ ).

Thus the results of this study replicate the findings of Shelton et al. (2012a) in that the pattern of error rates reveals speaker sensitivity to the differences between the diphthong types in our stimuli, but in this case in a delayed naming task that also allows us to view accuracy across different magnitudes of preparation time. Nevertheless, as an anonymous reviewer has also pointed out, the lack of a significant difference in error rates between diphthong types in the 0 ms condition is a puzzling result. This pattern of no difference at a delay of 0 ms, significant differences at a delay of 600 ms, and no difference again at 1200 ms might be taken to suggest that our hypothesized gradient weight difference between diphthong types only emerges after a short delay, while not being present either upon immediately produced forms or forms for which speakers have a full 1200 ms to prepare for production. The challenge then is to interpret the results in a manner that explains why the difference only emerges in the 600 ms condition. While we replicate the findings of the previous study, it is unclear why in the 0 ms condition we should not find the same pattern of results that we find in the 600 ms condition. More specifically, one might argue that the results here suggest that the gradient difference in weight of the diphthongs only emerges in the

amount of delay provided to speakers to prepare them for production, and that when prompted for immediate production, they are equally phonotactically infelicitous.

While such a view is not impossible, we suggest that the specific pattern of results in this experiment, and in particular, the lack of a difference in error rates in the 0 ms condition, is more likely driven by methodological than grammatical factors. Specifically, it is important to bear in mind that Shelton et al. (2012a) presents the same result in which differences in error rates were found between diphthong types. And while that study was not carried out methodologically as a delayed naming task, speakers were instructed to pronounce items immediately upon seeing them on the screen. That is, the naming task employed in Shelton et al. (2012a) was, de facto, a naming task with a 0 ms delay, but without an auditory prompt. Why, then, are the findings of Shelton et al. (2012a) clearly replicated in the 600 ms delay here but not the 0 ms condition? We suspect that the problem lies in the way in which participants were prompted to respond in the current experiment. Anecdotally, at least, numerous participants reported being caught off-guard when the tone cueing them to speak was presented simultaneously with the visual presentation of the stimuli. Note that given the three delay conditions (0 ms, 600 ms, 1200 ms), two-thirds of the trials consisted of words that appeared on the screen followed by a delayed tone that provided participants with the opportunity to process the written form visually on screen and prepare it for production. We surmise that the simultaneous presentation of stimuli and tones may have yielded, by contrast, an unexpected, surprisal effect that resulted in more errors in the 0 ms delay, thus washing away the subtle differences between rising and falling diphthongs that would otherwise have emerged, and which did emerge in Shelton et al. (2012a). In other words, we argue that it is not unreasonable to conclude that the lack of a significant difference in error rates in the 0 ms condition was less driven by the properties of the stimuli, and more likely was an artefact of their presentation.

In this respect, a comparison to other studies which have employed the delayed naming task may prove useful. Kawamoto, Liu, Mura, and Sanchez (2008), for example, conducted a detailed, critical study consisting of three experiments that investigate whether execution-level processes in speech production are always, as had been assumed, isolated in the delayed naming task. While the specifics of their findings are not germane to our study, it is instructive to note that in their experiments four different delay conditions were employed (300, 450, 600, and 750 ms). Crucially, no stimuli were presented visually in a manner that simultaneously prompted participants to respond immediately, i.e. in a manner identical to our 0 ms delay condition. Again, this leads us to suspect that our a priori assumption that the 0 ms condition would constitute the equivalent of the immediate response condition of the prior naming tasks (Shelton et al. 2012a,b) was likely incorrect. Rather, we argue that the more likely effect of the 0 ms condition in the present experiment was to surprise participants and prompt them to respond in a rush. This, we argue, is more likely to have contributed to the lack of a significant difference between the diphthong types in the 0 ms condition, both of which were produced with high error rates. However, in the 600 ms condition, the gradient nature of the contributions of the rising vs. falling diphthongs to the proscription on antepenultimate stress does emerge, replicating the findings from the standard naming task of Shelton et al. (2012a).

The final goal of the present paper was to examine the extent to which the delayed naming task is an effective tool to probe more deeply the way in which phonotactic constraints may be modulated by preparation time in speech production. In this study, the task has proven advantageous, given the additional time-course data the delays provide. Standard naming, as

discussed in Shelton et al. (2012a), is useful in that error rates can provide behavioral data that inform our understanding of the cognitive processing of theoretically licit and proscribed forms. The delay intervals of the delayed naming task allow us to observe that processing over time. More broadly, this task has shown that it is possible to overcome some restrictions on phonotactic structure, given enough time to prepare, and, importantly, allows us to confirm in a different task that the relative modulation of stress placement as a function of the weight of rising and falling diphthongs is gradient rather than binary, with the heavier falling diphthongs requiring greater preparation time than rising diphthongs before presenting reduced error rates. The delayed naming task allows for a more nuanced view of on-going processing, which can reveal surprising results that inform our understanding of the cognitive functioning involved in the processing of phonotactic constraints.

In sum, the delayed naming data presented here continue to suggest that Spanish is a weight-sensitive language. However, this sensitivity is again revealed to be more complex than a simple distinction between light and heavy syllables would suggest. In addition, small differences in weight contribution can be overcome with sufficient preparation time, as illustrated by controlled experimentation within the delayed naming paradigm. Overall, any characterization of the Spanish stress system arguably must allow for more finely-grained phonotactic differences than have previously been assumed in theoretical analyses of the interaction of syllable structure and stress in the language.

## **5. Conclusions**

This study presents the results of an experiment that extends the findings of Shelton et al. (2012a) by means of a delayed naming task. This methodology provides snapshots of the processing of controlled stimuli across time. The results replicate the general finding that diphthongs provoke higher error rates than monophthongs when presented in the penult of a trisyllabic word marked for antepenultimate stress as well as the finding of the differential patterning of rising and falling diphthongs. These results underscore the argument put forth by Shelton et al. (2012a) that restrictions on stress assignment in Spanish are gradient, and the system must take into consideration finely-grained differences in the distribution of stress and syllable structure across the lexicon.

The delays of the delayed naming task also offered a novel perspective on the issue of phonotactic proscription. In this task, we are also able to view the progress of overcoming these costs with a sufficient amount of time to prepare the phonology. Thus, in addition to error-rate data, time-course data allow us to see that certain word categories improve in accuracy as a function of increased preparation time. We interpret the earlier improvement of the rising diphthong stimuli, or alternatively the later improvement of the falling diphthong items, as evidence of the different costs associated with processing each word type. Arguably, falling diphthongs impose a stronger effect on the possibility of antepenultimate stress in our stimuli, as indexed by the great amount of preparation time needed to produce these proscribed forms accurately (or less inaccurately). Future research may consider the implications of these results for current phonological models, such as Stochastic Optimality, which may be amenable to a more gradient approach to phonotactic constraints. From a pedagogical perspective, one might also consider the indirect implications of these findings for learning to read (aloud) in Spanish. It is

possible that metalinguistic knowledge of stress patterns, specifically the relationship between the orthographic representation and the phonological regularities, may be of aid to students who are struggling to understand the use of written accent marks in the language, a task which vexes many learners of Spanish.

A limitation of the present study was the inclusion of the 0 ms delay among the other delays in the delayed naming task. Future work could remedy this issue by eliminating the presence of a 0 ms delay and exploring the effects of delays at even more gradient intervals, such as 300, 600, 900, and 1200 ms. Nonetheless, as discussed above, we do replicate the subtler diphthong effect found in Shelton et al. (2012a) in the 600 ms delay, and we show that this effect disappears with additional time to prepare forms for production in the 1200 ms delay condition. These results continue to suggest a real and important difference in weight contribution between rising and falling diphthongs. This pattern is one that we would predict, given the distributional evidence of differential stress conditioning by rising diphthongs in the penult and ultima of trisyllabic words (as described in §2.1). When rising diphthongs appear in the penultimate syllable, they behave in a uniform fashion with falling diphthongs and block antepenultimate stress. However, when they appear in the ultima, their weight is not sufficient to stop the stress system from assigning stress to the penult. This pattern has now been borne out in a standard naming task (Shelton et al. 2012a), which forces immediate phonological preparation and articulation, and is sufficiently strong to persist with 600 ms of preparation time, as seen in the present study. The differential contributions to syllable weight by each diphthong type at 600 ms suggests that this is indeed a robust effect. After more than a half a second to prepare, speakers still evidence more difficulty processing penultimate falling diphthongs than penultimate rising diphthongs with antepenultimate stress.

Finally, the results of the present study also demonstrate that the delayed naming task can be an effective metric of the strength and persistence of phonotactic restrictions in the grammar. The findings here show that native speakers of Spanish are only able to overcome powerful cognitive constraints on stress placement when they are given a relatively long interval of time in which to prepare the words for articulation, words that are otherwise segmentally completely licit.

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