

# Accounting for Variability in the Production of Spanish Vowel Sequences

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## 1. Introduction

*Hiatus* refers to the occurrence of heterosyllabic adjacent vowels either at the word boundary, e.g., *la-escuela* ‘the school’, or at the syllable boundary, e.g., *re-al* ‘real/royal’. Like many languages, Spanish favors a regular vowel-consonant-vowel alternation, and thus, hiatus is commonly resolved in some way in speech. Possible resolution types include deletion of one of the two vowels (e.g., /a+/e/ > [e]), creation of a diphthong (e.g., /a+/e/ > [ai]), coalescence of the two vowels into a different one (e.g., /a+/e/ > [ɛ]), and insertion of a consonant (e.g., /a+/o/ > [ayo]). Although adjacent vowels are most often resolved in one of these ways, it is also possible for hiatus simply to be maintained.

Because vowel-final and vowel-initial words are frequently juxtaposed in Spanish, hiatus at the word boundary is very common. The question of precisely how such sequences are resolved in any given case has long been a topic of interest among linguists, from phoneticians and structuralists to those working within the various frameworks of both linear and non-linear generative theories of phonology. Consistent with the goals of these approaches, previous accounts have typically sought to specify the structural (e.g., phonological) properties relevant to determining how hiatus is resolved and present lists of predictions or rules meant to determine and explain the outcome of hiatus in any particular case. For instance, Jenkins (1999:52-53) gives the following list of predictions for the resolution of vowel sequences between words in New Mexican Spanish<sup>1</sup>:

- (a) Stressed elements are never altered in resolution, unless adjacent to another stressed element.
- (b) Diphthongization occurs in situations where a [-low] unstressed vowel appears before a [-high] (non-identical) vowel. The result is always a rising diphthong.
- (c) If a [-low] unstressed vowel appears before a non-homorganic high vowel (i.e., /eu/ or /oi/), the result is also a rising diphthong.
- (d) V<sub>1</sub> [first vowel] deletion occurs before a homorganic high vowel (i.e., /ei/ or /ou/).
- (e) V<sub>1</sub> deletion also occurs when a low vowel precedes an unstressed mid or high vowel.
- (f) V<sub>2</sub> [second vowel] deletion occurs when a stressed element precedes /e/.
- (g) Hiatus is maintained when a stressed vowel precedes a vowel other than /e/.

In particular, two phonological factors are critical in any such account, which are (a) the quality of the two vowels, and (b) whether these vowels are stressed or unstressed. In addition, various authors cite a number of other factors as important to the resolution of hiatus between words, which include whether the second vowel occurs in an open or a closed syllable (Monroy Casas 1980), whether the words involved are content or function words (Casali 1997, 1998, Causley 1999, Jenkins 1999), whether there has been mention of the string in the preceding discourse (Jenkins 1999), and the frequency with which the string occurs in language use (Jenkins 1999), among others.

While previous accounts have been very valuable to our understanding of the types of factors that may influence the outcome of hiatus between words, they have been problematic for a number of reasons. One issue is a lack of agreement about what factors are important, as different authors have proposed different sets of factors to explain the same phenomenon. In most cases, no means of actually measuring the contribution of the proposed factors have been employed; i.e., with few exceptions, no quantitative studies have been done and no statistical analyses have been performed<sup>2</sup>. Thus, the

importance of these factors has yet to be confirmed empirically. A related problem is that even when two accounts do concur that a certain factor plays a role, they may yet disagree about precisely how this factor affects the outcome of hiatus. For instance, while vowel quality and stress are both fundamental in any account, different sets of rules involving these factors sometimes predict contradictory outcomes for the same vowel sequence. To illustrate, below we compare rules given by two different authors to explain what happens to vowel sequences between words in Chicano (Martínez-Gil 2000) and New Mexican Spanish (Jenkins 1999)<sup>3</sup>:

- a mid vowel (stressed or unstressed) is elided when followed by a high vowel with the same tongue retraction (Martínez-Gil 2000:517).  
*compré higuitos* [kom.prí.ýí.tos] ‘buy-1SG.PRET figs’ (é # i > í).
- Stressed elements are never altered in resolution, unless adjacent to another stressed element; also, hiatus is maintained when a stressed vowel precedes a vowel other than /e/ (Jenkins 1999:52–53).  
*compré higuitos* [kom.pré.i.ýí.tos] ‘buy-1SG.PRET figs’ (é # i > é # i).

As we can see, for the string *compré higuitos*, Martínez-Gil predicts that the second vowel will be deleted, while two rules proposed by Jenkins prohibit this possibility.

Another problem for rule-based accounts of hiatus is the variation evident in natural language use. Some recent studies, e.g., Jenkins 1999, Alba 2002, and Hualde & Prieto 2002, have found variability in the pronunciation of vowel sequences occurring in or between certain words, even in the speech of a single individual. For instance, in a quantitative study of hiatus resolution between words in a corpus of New Mexican Spanish (cf. Bills & Vigil 1999), Jenkins (1999) found that the most common outcome for the sequence /a+/e/ in the string *la escuela* was the coalescence of the two vowels into a different vowel (e.g., [lɪs.kwé.la], [lɛs.kwé.la], or [lɪs.kwé.la]). However, he also found that it was possible for either the first or second vowel to be deleted, giving [lɛs.kwé.la] or [lɪs.kwé.la] respectively. In addition to these possibilities, Alba’s (2002) study of hiatus in this same language variety found that in the production of *la escuela* a diphthong could be formed ([lajs.kwe.la]), or hiatus might even be maintained ([la.ɛs.kwé.la]). What is more, both Jenkins and Alba observed that a single speaker might employ more than one of these strategies for the same lexical item. Although most authors do acknowledge such variation to some degree and propose a variety of explanations for its occurrence, in their concentration on the abstract structure of language they have systematically excluded it from their formal accounts of hiatus.

The usage-based model of phonology (cf. Bybee 2000, 2001, 2002a, 2002b), proposes that language use plays a key role in shaping the form and content of the sound systems of languages. Unlike structuralist and generative theories, which hold that the structure of a language is an abstract, idealized system separate from its actual use in real time, usage-based functionalists maintain that a language’s structure and its actual use for communication are intimately connected; i.e., language use creates and continually shapes language structure. In this view, each token of a given lexical item experienced in use is stored as an *exemplar* of that item, along with all of its particular features (e.g., phonetic, semantic, pragmatic, and morphosyntactic) in memory, and as this happens, its phonetic and other details become part of its mental representation. Thus, instead of positing separately a lexicon and a system of abstract sound units (e.g., phonemes) that undergo transformation to surface forms by phonological rules, the usage-based model argues for the direct, detailed representation of words and frequent phrases in memory.

A factor crucial to determining how structure is affected by use is the frequency with which different items occur. In fact, in a usage-based functionalist approach to language, repetition is seen as the mechanism that creates linguistic structure (Bybee & Scheibman 1999:593). There are several ways in which the frequency of occurrence of words and collocations in running discourse—or their *token frequency*—can affect phonological structure and thus contribute to the type of variation seen in hiatus resolution. First, a number of studies have shown that phonetic changes such as reduction and deletion often progress faster in higher-frequency items than in lower-frequency ones. Every time an item is used in speech it is ‘exposed to the reductive effect of articulatory automation’ (Bybee 2000:252), and the more often it is used, the more ‘opportunity’ it has to be affected (Bybee 2001:11–

12). Because each token of use (including the reduced forms of a word) is stored in memory, the frequency of occurrence of a particular word plays an important role not only in the variable production of that word (or its own phonetic variation), but also in the rate at which a particular phonetic process affects different items in the lexicon (or lexical variation). Bybee (2002b) found evidence for this type of frequency effect in her study of the variable deletion of Spanish intervocalic /d/ (e.g., *lado* ‘side’) in Spanish. She found that the rate of deletion was greater for higher-frequency words such as *lado* ‘side’ than for lower-frequency words like *adecuado* ‘adequate’.

Another effect of token frequency is that frequently occurring collocations may be processed and stored by the speaker as single units or chunks rather than as combinations of individual words. The more often speakers string words together, the more fluent they become in doing so. For example, with frequent use over time, Spanish speakers could become very fluent in combining *la* and *escuela* so that, eventually, if the string is frequent enough, they might process, store, and access the two words as a chunk rather than individually as *article* and *noun*. Such chunks facilitate sound change between words to a greater extent than when the words are processed separately, since fluency in stringing words together leads to the smoothing of the transition between them and the overlapping of articulatory movements in production (Bybee 2001:15). And, as with reduced forms of single words, the reduction of strings has an effect on their mental representation, since the reduced strings are also stored in memory. Evidence for these types of effects has been provided by a number of studies, including Krug 1998, 2001, Bybee and Scheibman 1999, Boyland 2001, Bush 2001, Smith 2001, and others. Krug (1998) investigated the effects of *string frequency* (the token frequency of a multiword sequence) on the formation of English contractions and found that there was a correlation between the frequency of a given string and its rate of contraction in speech. For instance, he found that both *is* and *has* tend to contract to ‘s (e.g., *he is* to *he’s*) at a higher rate with more frequently co-occurring items like *it*, *that*, *he*, and *she*, than with less frequent items like *everybody*, *somebody*, *nobody*, and *anybody*, and that the rate of contraction is lower still with even less-frequent items like *everything*, *something*, *nothing*, and *anything*.

Based on previous findings about frequency effects, we hypothesized that hiatus resolution involving reduction or syllable merger would occur more often in items with relatively high token frequencies than in those with relatively low frequencies. However, we must emphasize that despite the importance placed on frequency effects, a usage-based approach would not discount the role played by the phonological and other factors cited in previous accounts, as such factors might well be very important. Yet, the current study departs from traditional accounts by taking as its object of investigation the variability evident in the pronunciation of vowel sequences between words, and by investigating the contribution of the potential factors empirically. This study does not attempt to determine which resolution will be chosen whenever two vowels are juxtaposed, but rather, to discover patterns in the relative frequency of the resolution versus maintenance of hiatus and the co-occurrence of the various factors that condition their selection. Specifically, it seeks to answer the following questions: (a) of the factors previously proposed, which truly affect the outcome of hiatus, and how? (b) do frequency effects play a significant role? and (c) how does the role of frequency effects compare to that of the other factors involved, particularly structural properties like vowel quality and stress?

## 2. Data and Methods

The methodology employed in this study is variationist (cf. Labov 1972, 1984, Sankoff 1988a, 1988b). Both usage-based functionalists and variationists maintain that in order to adequately explain language phenomena we must study them empirically, which has important implications for appropriate data and procedures. First, the data should come from real language use. Also, the analysis of these data should be quantitative, involving some means of measuring tendencies or patterns occurring in use. Without such measurements, we cannot truly test our hypotheses nor come to any real conclusions about the particular forms or processes we are interested in.

The data for our study are from a corpus of approximately 29 hours of tape-recorded sociolinguistic-style interviews conducted with 38 native speakers (male and female) of New Mexico/Southern Colorado Spanish as part of the *New Mexico–Colorado Spanish Survey (NMC OSS)* (Bills & Vigil 1999). These interviews have two parts: (a) guided conversations between the

interviewer and the consultant, and (b) lexical identification tasks. We used only data from the guided conversation portions of the recordings in an effort to ensure that examples of vowel sequences were taken from speech that (a) most nearly represented natural discourse, and (b) was more fluid rather than hesitant and uneven, which was characteristic of much of the speech in the identification tasks.

To facilitate coding the outcome of hiatus and to help ensure that all tokens in question represented the same phenomenon, we defined the variable context for this study as all cases of hiatus between /a/ and any vowel at the word boundary (i.e., /a#a/, /a#e/, /a#i/, /a#o/, /a#u/). We also carefully excluded a number of items for which it was impossible to reliably determine how the vowel sequence was produced. These included all cases in which (a) one of the two vowels was part of a presumed diphthong (e.g., *familia en* ‘family in’), (b) either vowel was adjacent to one of the palatal consonants /ñ/ or /j/ (e.g., *niña en* ‘girl in’; *una olla* ‘a pot’), (c) deletion of an intervocalic consonant created a sequence of more than two vowels (e.g., *nada hasta* > *na’a hasta* ‘nothing until’), (d) there was any type of pause or stumbling between the two words in question, among others. In adherence to the principle of accountability (cf. Labov 1972), we extracted all cases of hiatus from our corpus conforming to these criteria, yielding a total of 1,912 tokens, which represent 808 *types* or different two-word strings.

These 1,912 tokens were then coded for the outcome of hiatus as well as for each of the factors we considered, which included (a) the quality of the second vowel ( $V_2$ ) (/a/, /e/, /i/, /o/, or /u/), (b) the stress of each vowel (stressed or unstressed), (c) the type of syllable in which the  $V_2$  occurred (open or closed), (d) the class of each word in the string (content or function), (e) the class of the string (article+noun, verb+preposition, or other), (f) whether there was previous mention of the string in the preceding discourse (mention or no mention), and (g) string frequency (high vs. low)<sup>4</sup>. In coding the outcome of hiatus we chose only to distinguish between resolution and maintenance, rather than each of the different types of resolution listed in section 1; i.e.,  $V_1$ , deletion,  $V_2$  deletion, coalescence, or diphthongization (no instances of consonant insertion occurred). This is primarily because reliably distinguishing between these various resolution types by the impressionistic method we employed was not possible<sup>5</sup>. However, the basic distinction between resolution and maintenance was sufficient to assess the relative contribution of each of the factors we were evaluating.

Once the data were coded for all of the variables under consideration, we performed several types of analyses to assess the contribution made by each factor. These included (a) looking at each factor one-by-one to see which ones appeared to produce an effect individually, (b) performing cross-tabulations between factors to discover any interactions occurring between them, and (c) performing a multivariate analysis of the factors to evaluate their relative magnitude of effect as they operated simultaneously.

### 3. Results

Table 1 shows the number of tokens of hiatus that were resolved vs. those that were maintained.

Table 1. Distribution of the 1,912 Tokens of Hiatus by Resolution vs. Maintenance

Outcome of Hiatus	N	%
Resolved	1,424	74
Maintained	488	26
<b>TOTAL</b>	<b>1,912</b>	<b>100</b>

As we can see, hiatus was resolved in our data nearly three times as often as it was maintained (74 vs. 26%). These results are consistent with previous findings for New Mexican Spanish (Jenkins 1999, Alba 2002) in showing that, overall, resolution of hiatus is highly favored over maintenance. Our results are also consistent with the widespread notion that there is a strong tendency towards the resolution of hiatus in Spanish generally (cf. Navarro Tomás 1918, Stockwell & Bowen 1965, D’Introno et al. 1995). And, our findings support Casali’s (1998) more universal claim that, while maintenance of hiatus does indeed occur in many languages, it is not readily tolerated.

While our results thus substantiate a strong tendency toward resolution of hiatus in New Mexican Spanish, they also show that maintenance is more common than previously proposed. Indeed, these findings largely contradict the basic claims made in previous accounts of New Mexican and Chicano Spanish about hiatus resolution in the specific context examined here, i.e., /a#V/ (cf. Espinosa 1930, Hutchinson 1974, Reyes 1978, Clements & Keyser 1983, Schane 1987, Martínez-Gil 2000). Such generalizations almost universally predict that hiatus in this context will always be resolved, yet hiatus in our data was maintained more than a fourth of the time.

Table 2 presents the distribution of the 1,912 tokens of hiatus by stress.

Table 2. Distribution of the 1,912 Tokens of Hiatus by Stress

Stress	N	N Resolved	% Resolved	% of all Data
VV	1,431	1,183	83	75
V̇V	71	53	74	4
VV̇	379	184	49	20
V̇V̇	31	4	13	1
<b>TOTAL STRESSED</b>	<b>481</b>	<b>241</b>	<b>50</b>	<b>25</b>
<b>GRAND TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

The four stress categories:  $p \leq 0.001$ , Chi-square = 246.3955; Stressed vs. unstressed:  $p \leq 0.001$ , Chi-square = 200.8439

Here we see that the context which most favored resolution in our data was that in which both vowels were unstressed, with resolution occurring 83% of the time. In sharp contrast, when both vowels were stressed, hiatus was resolved only 13% of the time. Moreover, when we combine the three contexts in which at least one of the two vowels was stressed (i.e., V̇V, VV̇, and V̇V̇), we find that hiatus was resolved at a significantly lower rate in such cases (50% of the time) than when both vowels were unstressed<sup>6</sup>. These results provide strong support for the widespread assumption that stress plays a crucial role in the outcome of hiatus between words, with unstressed items being much more susceptible to alteration overall than stressed items.

Table 3 shows the distribution of the 1,912 tokens of hiatus by the quality of the  $V_2$ .

Table 3. Distribution of the 1,912 Tokens of Hiatus by Quality of the  $V_2$

Vowel Quality ( $V_2$ )	N	N Resolved	% Resolved	% of all Data
/a/	570	498	87	30
/e/	846	661	78	44
/o/	111	69	62	6
<b>TOTALS</b>	<b>1,527</b>	<b>1,228</b>	<b>80</b>	<b>80</b>
/u/	206	107	51	11
/i/	179	89	49	9
<b>TOTALS</b>	<b>385</b>	<b>196</b>	<b>51</b>	<b>20</b>
<b>GRAND TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

The five vowels:  $p \leq 0.001$ , Chi-square = 177.3838; Low and mid vowels vs. high vowels:  $p \leq 0.001$ , Chi-square = 140.8631

The results for this factor show some interesting trends. First, two of the five vowels favored resolution (i.e., were resolved at a higher rate than the average of 74%), which were /a/ and /e/ (87 and 78% resolved respectively). With a resolution rate of 62%, the other mid vowel (/o/) was more resolved than either of the high vowels (/u/ and /i/), which were both maintained about half the time. As we can see, of the two vowels that favored resolution, the low vowel (/a/) favored it the most. This is certainly no surprise given the fact that the  $V_1$  was always /a/ in our data. Yet, while previous accounts of hiatus predict that identical adjacent vowels will *always* be reduced to one, this simply was not the case here, as hiatus was maintained in this context nearly a fourth of the time (23%). Overall, we see that hiatus was resolved at a significantly higher rate when the  $V_2$  was either a low or mid vowel (80% of the

time) than when it was a high vowel (51% of the time). As with stress, our results for vowel quality support the claims that vowel quality is an important factor in hiatus resolution between words. The fact that both stress and vowel quality would be important is not unexpected in a usage-based account, given that phonetic processes such as reduction and deletion are thought to result (initially) from articulatory adjustments made on-line during speech. With regard to vowel quality, it appears that hiatus resolution was more likely to occur when the  $V_2$  was more similar in height to the  $V_1$  (which again was always /a/). In the case of /e/ vs. /o/, the difference in roundness between a final /a/ and an initial /o/ might partly account for the lower rate of resolution found for /o/ in terms of articulation.

The next factor we will discuss is syllable type. According to Monroy Casas (1980), the  $V_2$  in hiatus position can only be deleted when it occurs in a closed syllable. However, Monroy Casas does not specify whether syllable type comes into play at the word or phrase level. When the second word in the string is polysyllabic (e.g., *la hija*), this is a mute point, since the distinction does not affect the type of syllable in which the  $V_2$  occurs. However, when the second word is monosyllabic, it often does. For instance, if we were to syllabify each word individually in the string *era un* ‘be-3SG.IMP a’, the  $V_2$  would always occur in a closed syllable (*e.ra.un*). However, if we were to syllabify *era un* at the phrase level, we would have to consider the broader context (following word), as this affects syllabification. For example, when syllabified at the phrase level, the initial /u/ in the string *era un estado* ‘be-3SG.IMP a state’ occurs in an open syllable (*e.ra.u.nes.ta.do*). However, if *era un rancho* ‘be-3SG.IMP ranch’ is syllabified at the phrase level, the /u/ is in a closed syllable (*e.ra.un.ran.cho*). For this study we chose to code and assess syllable type both at the word and phrase levels to see if either had an effect. As it turned out, we found syllable type was not a significant factor either way. Table 4 presents the distribution of the 1,912 tokens of hiatus by the type of syllable in which the  $V_2$  occurred, with syllable type coded at the phrase level.

Table 4. Distribution of the 1,912 Tokens of Hiatus by Syllable Type with Syllable Type Coded at the Phrase Level

Syllable Type ( $V_2$ )	N	N Resolved	% Resolved	% of all Data
Closed	776	615	79	41
Open	1,136	809	71	59
<b>TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

$p \leq 0.001$ , Chi-square = 15.6701

Resolution did occur at a significantly higher rate with closed syllables than with open syllables (79 vs. 71%), but these results must be interpreted with some caution, since syllable type was not selected as significant when included in our multivariate analysis with all of the other factors (as we will see below). A cross-tabulation between syllable type and stress reveals why this was so (Table 5).

Table 5. Distribution of Syllable Type by Stress with Syllable Type Coded at the Phrase Level

Syllable Type	Stressed			Unstressed			Overall		
	N	% N Res.	% Res.	N	% N Res.	% Res.	% Res.		
closed (n=776)	119	15	62	<b>52</b>	657	85	553	<b>84</b>	79
open (n=1,136)	362	32	179	<b>49</b>	774	68	630	<b>81</b>	71
<b>TOTALS</b>	<b>481</b>	<b>25</b>	<b>241</b>	<b>50</b>	<b>1,431</b>	<b>75</b>	<b>1,183</b>	<b>83</b>	<b>74</b>

Stressed:  $p \leq 1$ , Chi-square = 0.2522; Unstressed:  $p \leq 2$ , Chi-square = 1.9102

While both closed and open syllables occurred at higher rates in unstressed vs. stressed contexts, this trend was stronger with closed syllables (85%) than with open syllables (68%). What is more, when we held stress constant, the effect of syllable type disappeared; that is, within each stress category, there was no significant difference between the rates at which hiatus was resolved with closed and open syllables (84 vs. 81% in unstressed contexts, and 52 vs. 49% in stressed contexts). Thus, it is clear that the difference in resolution rates obtained with closed vs. open syllables can be attributed to their respective distributions between contexts that were stressed and unstressed, rather

than to syllable type itself. A very similar result was obtained when we coded syllable type at the word level.

We move now to word class. Table 6 shows the distribution of the 1,912 tokens of hiatus by their occurrence in the four possible combinations of content and function words (i.e., function+content, function+function, content+function, and content+content). In coding this factor we followed the basic distinction traditionally drawn between so-called *lexical content words* and *grammatical* or *function words*. Essentially, content words included all *open-class* items, or nouns, verbs, adjectives and adverbs, while function words included all *closed-class* items, e.g., prepositions, conjunctions, determiners, and pronouns.

Table 6. Distribution of the 1,912 Tokens of Hiatus by Word Class

Word Class	N	N Resolved	% Resolved	% of all Data
Function+Content	851	702	82	45
Function+Function	328	234	71	17
Content+Function	568	398	70	29
<b>TOTAL FUNCTION</b>	<b>1,747</b>	<b>1,334</b>	<b>76</b>	<b>91</b>
Content+Content	165	90	54	9
<b>GRAND TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

The four word classes:  $p \leq 0.001$ , Chi-square = 70.6360; Content vs. function items:  $p \leq 0.001$ , Chi-square = 37.7404

Our results show that, overall, hiatus was resolved at a significantly higher rate when at least one of the two words was a function word (76% of the time) than when both words were content words (54% of the time), supporting the idea that function words are more susceptible to phonetic reduction/alteration than content words (cf. Casali 1997, 1998, Causley 1999, Jenkins 1999). Of the three contexts involving function words, *function+content* had the highest rate of hiatus resolution (82% vs. 71 and 70%). This difference can be partly attributed to the high proportion of article+noun strings occurring in this context (accounting for 60% of all *function+content* strings), which had a high rate of resolution in our data (84%).

Table 7 shows the distribution of the 1,912 tokens of hiatus by their occurrence in (a) article+noun strings (e.g., *la escuela*, *una escuela*), (b) verb+preposition strings (e.g., *echaba en* 'to put/throw-3SG.IMP PREP'), and (c) all other strings combined. Because article+noun and verb+preposition strings represent logically occurring, semantically coherent processing units in Spanish, we hypothesized that they would be particularly susceptible to frequency-based chunking and concurrent phonological reduction/alteration. Such strings should have a higher propensity to chunk together than strings with less semantic coherence like noun+preposition (e.g., *papá en* 'dad PREP') or pronoun+pronoun (e.g., *una usted* 'one you'), because they are already likely to be conceptualized by the speaker as a single unit. As Bybee's (2002a:112) *Linear Fusion Hypothesis* states, 'items that are used together fuse together'.

Table 7. Distribution of the 1,912 Tokens of Hiatus by String Class

String Class	N	N Resolved	% Resolved	% of all Data
Verb+Preposition	221	195	88	11
Article+Noun	512	435	84	27
<b>TOTALS</b>	<b>733</b>	<b>630</b>	<b>86</b>	<b>38</b>
All Other Strings	1,179	794	67	62
<b>GRAND TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

Verb+prep vs. article+noun vs. all other:  $p \leq 0.001$ , Chi-square = 83.1592; Constituent vs. all other:  $p \leq 0.001$ , Chi-square = 82.2886

As we can see, verb+preposition strings had the highest rate of hiatus resolution (88%), followed closely by article+noun strings (84%). In contrast, hiatus in all other strings was resolved at a significantly lower rate (67%). Combining article+noun with verb+preposition, we find that together,

these two string classes accounted for 38% of all of our data. And, comparing their combined rate of hiatus resolution with that of all other strings shows that, together, they were resolved at a significantly higher rate (86 vs. 67%).

Table 8 shows the distribution of the 1,912 tokens of hiatus by previous mention. An item was coded as having previous mention if there was at least one mention of that item by either the consultant or interviewer within the preceding five clauses of discourse. When counting clauses we included all tensed verbs produced by either speaker, whether in a main or subordinate clause (cf. Weiner & Labov 1983:46). We did not, however, include impersonal fixed expressions such as *es que* ‘the thing is that’, *quién sabe* ‘who knows’, *mira* ‘look’, *ves* ‘you see’, *digamos* ‘let’s say’, *o sea* ‘in other words’, etc. Such expressions are highly grammaticized and usually function simply as discourse markers (cf. Company Company 2004).

Table 8. Distribution of the 1,912 Tokens of Hiatus by Previous Mention

Previous Mention	N	N Resolved	% Resolved	% of all Data
Mention	211	181	85	11
No Mention	1,701	1,243	73	89
<b>TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

$p \leq 0.001$ , Chi-square = 15.9461

Here we see that when the string in question had already been mentioned within the preceding five clauses, hiatus was resolved at a rate of 85%, which was significantly higher than the rate of resolution obtained when there was no prior mention (73%). These findings concur with previous studies which have shown that once a lexical item (word or string) is introduced into discourse, it will have a shortened realization in subsequent mentions (cf. Fowler & Housum 1987, Fowler 1988, García-Lecumberri 1995). Possible explanations include (a) speakers’ tendency to shorten items in speech simply because they ‘choose to do less articulatory work when they can get away with it without sacrificing communicative efficacy’ (Fowler and Housum 1987:490), (b) speakers’ tendency to produce words in such a way that allows their listeners to distinguish between new and given information in discourse (Fowler and Housum 1987:489–490; cf. Chafe 1974), and (c) the natural reductive effects of repetition; that is, after a speaker produces an item once, his or her articulation speeds up in later mentions (cf. Bybee 2001:15).

Table 9 shows the distribution of the 1,912 tokens of hiatus by our last factor: string frequency. In coding this factor the idea was to establish the relative frequency with which each item in our data tends to be uttered in contemporary spoken Spanish. Following the procedures used in previous studies of frequency effects, we first determined the raw token frequency of each string type as it occurred in a large corpus of spoken discourse (2,778,332 words)<sup>7</sup>. Once we had raw token frequencies for every string type, we coded all 1,912 tokens accordingly. We then coded “high” vs. “low” string frequency by arranging the total list of tokens in descending order by their raw frequency values and dividing the list into two groups, designating items in the upper group as “high-frequency” and those in the lower group as “low-frequency”. Our cutoff point was to call the bottom 70% of the data “low” and the top 30% “high”, which turned out to be the best place to make the split in order to maximize the difference between “high” and “low” frequency of use.

Table 9. Distribution of the 1,912 Tokens of Hiatus by String Frequency

String Frequency	N	N Resolved	% Resolved	% of all Data
High	589	504	<b>86</b>	31
Low	1,323	920	<b>70</b>	69
<b>TOTALS</b>	<b>1,912</b>	<b>1,424</b>	<b>74</b>	<b>100</b>

$p \leq 0.001$ , Chi-square = 55.0923

Consistent with our hypothesis for frequency effects, hiatus was resolved in items with higher string frequency at a significantly higher rate than in those with lower string frequency, substantiating



the claims of the usage-based model concerning both the reductive effects of frequency and the storage of frequent strings as chunks in memory.

We now move to the results of our multivariate analysis. This was performed with GoldVarb 2001 (Robinson et al. 2001; cf. Rand & Sankoff 1990), which uses a multiple-regression procedure to determine (a) which factors have a statistically significant effect on the selection of a variant (in this case, resolution of hiatus), (b) the direction of the effect (favoring or disfavoring resolution), and (c) the relative strength of the effect when all factors are considered simultaneously (Sankoff 1988b). For any multivariate analysis to be successful, all of the factor groups that are included must be carefully set up so that they are both *orthogonal* (meaning that all of the factors within each factor group can co-occur with all of the factors in every other factor group), as well as *independent* (meaning that all of the factor groups are separate and isolable with respect to one another) (Guy 1993:241–242). In the process of performing an analysis, we may discover that certain factor groups do not satisfy these conditions as originally established, and thus need to be combined, reorganized (i.e., by merging or removing some of the factors in a factor group), or excluded altogether to facilitate a successful run. As we performed our GoldVarb analysis for the present study, we found that several adjustments of this type had to be made. For instance, several of our factor groups were not orthogonal with respect to one another, e.g., string class was not orthogonal with respect to either vowel quality or stress, and word class was not orthogonal with respect to either string class or string frequency.

One major decision we made to overcome such problems was to combine factors within three of our factor groups (i.e., string class, vowel quality, and stress) so that there would be only two factors in every group. We based our decisions about which factors to combine within each factor group on two criteria: (a) we adhered to any pertinent linguistic parameters, e.g., similarities in vowel height, stress, or semantic coherence, and (b) to the extent that the first criterion allowed, we combined factors showing the most similar patterns of resolution within each group. Table 10 shows how factors in each group were combined.

Table 10. Original Factors and Combined Factors for Three Factor Groups Included in the Multivariate Analysis

Factor Group	Original Factors	% Res.		New Factors	% Res.
String Class	Verb+Preposition	88	→	semantically coherent	86
	Article+Noun	84			
	Other	67	→	other	67
Vowel Quality (V <sub>2</sub> )	a	87	→	low/mid	80
	e	78			
	o	62			
	u	51	→	high	51
	i	49			
Stress	VV	83	→	unstressed	83
	V´V	74			
	VV´	49	→	stressed	50
	V´V´	13			

For the word class factor group, combining factors was not sufficient, as word class was not orthogonal with respect to either string class or string frequency even after factors were combined. Thus, we simply had to exclude word class from our multivariate analysis. Nevertheless, cross-tabulations between word class and each of the other factor groups evaluated in our study showed that the former did indeed produce an important effect on resolution along with all of the latter, and vice versa. Table 11 shows the results of the multivariate analysis.

Table 11. GoldVarb Analysis of Variables Contributing to Reduction in the 1,912 Tokens of Hiatus

Independent Variable	N Resolved	% Resolved	% of all Data	Factor Weight
<b>Vowel Quality</b>				
Low and Mid (n=1,527)	1,228	80	80	.57
High (n=385)	196	51	20	.26 <i>range = 31</i>
<b>Stress</b>				
Unstressed (n=1,431)	1,183	83	75	.58
Stressed (n=481)	241	50	25	.28 <i>range = 30</i>
<b>String Class</b>				
Constituent (n=733)	630	86	38	.58
Other (n=1,179)	794	67	62	.45 <i>range = 13</i>
<b>String Frequency</b>				
High (n=589)	504	86	31	.59
Low (n=1,323)	920	70	69	.46 <i>range = 13</i>
<b>Previous Mention</b>				
Mention (n=211)	181	86	11	.60
No Mention (n=1,701)	1,243	73	89	.48 <i>range = 12</i>
<b>Syllable Type (Not Significant)</b>				
Closed (n=776)	615	79	41	[.51]
Open (n=1,136)	809	71	59	[.49]

$p = 0.008$ , Total Chi-square = 135.9772, Chi-square per cell = 2.4282

The *factor weights* provided by GoldVarb indicate the relative contribution of each factor within a factor group to the occurrence of the variant designated as the application value (i.e., resolution of hiatus) and are to be read here as follows: factor weights above .50 favor resolution, while factor weights below .50 disfavor (cf. Young & Bayley 1996:271). In a given GoldVarb run, the *range* between the highest and lowest factor weights within a factor group is indicative of that group's relative magnitude of effect with respect to all other groups included in the run: the higher the range, the greater the magnitude of effect.

The results of this analysis provide some very interesting insights into the relative impact that each of our independent variables had on the outcome of hiatus. Of the five variables selected as significant, the two phonological factors (i.e., vowel quality and stress) had by far the greatest magnitude of effect. This is an important finding because it shows empirically that the two principle factors which all previous accounts have claimed are critical to hiatus resolution were indeed most important in the present data. On the other hand, the third phonological factor, syllable type, was not found to be significant. We also see that string class, string frequency, and previous mention were all selected as significant, and that each had a similar magnitude of effect. The results for string frequency are especially interesting as they show that patterns of use—which previous accounts have almost universally ignored—are indeed important to hiatus resolution.

#### 4. Summary and Conclusions

The findings of this study have important implications both for an explanation of hiatus resolution between words in Spanish as well as for the notion of phonological structure set forth in the usage-based model of phonology. In contrast to the ideas proposed in previous structuralist and generative accounts, the production of vowel sequences in our data did not conform to any strict set of generalizations or rules. Instead, the outcome of hiatus was characterized by a high degree of variability. Through a quantitative empirical study we were able to assess what factors played a significant role in this variability.

Overall, our results add to the growing body of evidence in support of an exemplar-based representation of items in memory, as frequency effects—in addition to vowel quality, stress, semantic coherence, and previous mention—were found to be significant. Our findings also corroborate previous studies which have shown that frequent collocations tend to be stored as chunks or single

units in memory. The more speakers string words together in language use, the more fluent they become in doing so, and the more they come to conceptualize the string as a chunk rather than as a sequence of individual words. The fact that items with high string frequency were resolved at a significantly higher rate than those with low string frequency is evidence that the former have been stored as whole units, and that speakers tend to access them as such rather than one word at a time. As Bybee and Hopper (2001:9) explain: ‘A major part of the evidence for the storage of multimorphemic words and multiword phrases and constructions is the fact that ... frequency effects can be demonstrated for these units. Linguistic material cannot accrue frequency effects unless the brain is keeping track of frequency in some way; frequency effects cannot be attributed to units unless they are items in storage that are affected by experience. A natural way to track frequency is to postulate that tokens of experience strengthen stored exemplars.’

The magnitude-of-effect hierarchy revealed by our multivariate analysis is also consistent with the view of phonological structure proposed in the usage-based model. The strong effects of the phonetic factors in our data suggests that the resolution of hiatus begins as a regular sound change motivated by articulatory processes that create gradual phonetic variations in the output. The more an item is used, the more it is subjected to the reductive forces of these processes. Concurrently, reduced tokens of use are added to the *exemplar cluster* for that item, building the variation encountered in the output into the phonological structure itself. High-frequency items will be more likely to have the resolved form(s) at the center of their representations, while for low-frequency items, the unresolved forms will be more central. Thus, the resolved forms of high-frequency items are stronger and more readily accessible than the unresolved forms, while for low-frequency items, the reverse is true.

## Notes

1. We cite Jenkins’ (1999) rules here because they deal specifically with observations and predictions for hiatus resolution in New Mexican Spanish, which data is the precise object of the current study. However, we note that several of these rules reflect much earlier observations for Spanish vowel sequences (cf. Navarro Tomás 1918, Dalbor 1969).

2. A notable exception is Jenkins (1999). While empirical in that it involved the quantitative study of a large number of tokens (924) from a corpus of real discourse, this study was limited in some important ways. For instance, Jenkins did not consistently employ tests of significance to determine what factors were truly significant. Moreover, while quantitative, his analysis was at best univariate. Also, while he alluded to the possibility of frequency effects, citing advanced degrees of variation in certain strings, he did not fully pursue this factor.

3. Martínez-Gil (2000:515) explains that he based his list of rules on the data and predictions of previous accounts for Chicano Spanish, i.e., Reyes (1978), Hutchinson (1974), and Harms (1977).

4. In addition to these factors, we tested a few others, including (a) the type of morpheme in which the  $V_1$  occurred (root or suffix), (b) number of previous mentions (one or more than one), and (c) producer of the previous mentions (consultant or interviewer). For brevity we do not discuss these factors in this article, as none were included in our multivariate analysis either because (a) univariate analysis showed them not to be significant (e.g., morpheme type and producer of previous mentions) or (b) they were not independent with respect to other factors tested (see below). We also tested various other frequency measures, e.g., first word frequency, second word frequency, and ratio frequency (= string frequency divided by word frequency). Separate univariate analyses showed that only string and ratio frequencies were significant, with ratio frequency having a slightly greater effect.

5. Impressionistic coding (i.e., simply listening to each token) has traditionally been a very common method of measuring phonological variation in sociolinguistic studies (Milroy & Gordon 2003:144). The use of instrumental techniques (i.e., spectral analysis) was problematic in our study because of the complexities involved in measuring vowel quality in hiatus position. Formant frequencies (F1 and F2) can vary widely over a vowel’s duration, making it very difficult in cases of hiatus to consistently determine (a) which two vowels are present, (b) where one ends and the other begins, or even (c) whether there are two vowels present vs. a diphthong or single vowel. These problems are exacerbated by the use of real discourse data, wherein it is impossible to establish consistent frequency ranges for the different vowels. Moreover, various contextual properties can interfere with instrumental analyses of adjacent vowels, including the wide array of adjoining consonants and the highly variable rate of speech characteristic of connected discourse. Still, distinguishing just between resolution and maintenance impressionistically was not always straightforward either. In many cases there was little question as to whether or not resolution had occurred: either the two vowels were clearly distinguishable or the sequence was obviously

altered in some way. In other cases, however, hiatus was neither clearly resolved nor clearly maintained, but rather, the outcome seemed to fall somewhere in between. We attribute this in large part to the fact that resolution versus maintenance of hiatus is not a binary distinction, but is instead gradient. Acknowledging this, we based our coding of each token on the *degree* of reduction or syllable merger that had occurred; in other words, whether the hiatus seemed “more maintained” or “more resolved”. Basically, if we could tell that the integrity of each vowel had remained mostly intact, we coded the hiatus as maintained, while if either vowel was missing or was markedly altered, we coded the hiatus as resolved.

6. Our criterion level of probability was 0.05 (Paolillo 2002:7–8).

7. Our frequency corpus consisted of the following materials: (a) the entire *Corpus Oral de Referencia de la Lengua Española Contemporánea (COREC)* (Marcos Marín 1992), and (b) all of the interviews conducted in nine of the cities that participated in the *Proyecto de Estudio Coordinado de la Norma Lingüística Culta de las Principales Ciudades de Iberoamérica y de la Península Ibérica (Norma Culta)*.

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