An Analysis of Frequency as a Factor Contributing to the Diffusion of Variable Phenomena: Evidence from Spanish Data

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1. Introduction

The role of frequency[1] effects in the diffusion of variable linguistic phenomena has been the subject of recent study in the linguistic literature. Bybee (2002, 2003) argues that physiologically-driven phonetic change is subject to a pattern of lexical diffusion, tending to occur in high frequency lexical items first and then spreading to less frequent ones. In the case of Spanish, analyses of syllable-final /ɾ/ (Díaz-Campos 2005, 2006, Ruiz-Sánchez 2007, Díaz-Campos and Ruiz-Sánchez 2008), vowel coalescence in New Mexican Spanish (Alba 2006), intervocalic /d/ in New Mexican Spanish (Bybee 2002), and syllable-final /s/ (Brown 2009, File-Muriel 2009, Minnick-Fox 2006) have been proposed. However, the recent surge in research has lead to considerable debate regarding the role of frequency of usage in language change. For example, while Bybee (2002) and Jurafsky, Bell, Gregory, & Raymond (2001) have found a significant effect for frequency of use as a factor affecting /t,d/ deletion in Chicano English and amongst monolingual American English speakers, respectively; Bayley, Loudermilk, and Li (2006) find that frequency does not have an effect in regularly inflected past tense/past participle forms in Mexican American English as would be predicted by Bybee's model. Bayley, Loudermilk and Li's, results show that monomorphemes such as *just*, *first* and *most* are affected by frequency, while regular past tense (e.g. walked) and participial forms are not. This finding, they argued, presents a problem for an exemplar model since this model assumes that frequency effects should be found in both types of forms[2]. Bayley, Loudermilk and Li propose a rule-based account that assumes that regular forms would be rule-derived and would not show frequency effects because they do not belong in the lexicon[3]. This analysis is similar in a sense to the one presented by Guy (1991a, 1991b). Guy makes a proposal, using the theory of lexical phonology, according to which /t,d/ deletion can apply at a fixed rate in different levels of grammar. For instance, monomorphemes (e.g. *just*, *must*) have three chances to undergo /t,d/ deletion, while semi-weak past tense (e.g. left) have two chances to undergo deletion and regular past tense (e.g. talked) only have one chance. In his account, it is explained that monomorphermes will show more deletion than regular past tense due to the multiple applications of the rule at different levels. Bayley, Loudermilk, and Li present an analysis within a traditional model, without addressing how current models handle frequency. It also is important to

[1] For this paper, frequency refers to the usage of lexical items or patterns (e.g. morphemes, phonotactic units) relative to a reference corpus and that of the corpus of study. For the Caracas data the Reference Corpus for Contemporary Spanish (CREA), while the Habla Culta corpus from Buenos Aires was used for the Buenos Aires data.

[2] Bybee (2002) argues that regular past tense and participles tend to occur before words that start with a vowel, a context that disfavors reduction.

[3] Bybee (2001: 20) explains "structuralist frameworks placed great emphasis on the systematicity of language, and it was thought appropriate to reduce the enormous complexity of language by extracting regularities that could be capture in general statements (i.e., rules), thereby only representing truly idiosyncratic material in a list (i.e,, the lexicon).

point out that both traditional and current generative models of phonology, such as Optimality Theory (OT), neglect frequency. This investigation contributes to the discussion by examining the behavior of intervocalic /d/ deletion in past-participle contexts versus all other instances, to determine the effect of usage in the development of intervocalic /d/ deletion in Venezuelan Spanish. In addition, we test predictions of usage-based models about physiologically-driven as well as non-physiologically-driven phenomena. An analysis of /ʒ/ devoicing is also presented, which deals with the issue of context of use independently of the occurrence in a derived environment. The following research questions guide our analysis:

1) What is the effect of frequency on two socio-phonetic processes in Spanish that have very different natures?
2) Do we find frequency effects in past participles as well as in other grammatical categories ?
3) What is the effect of context of use? Can we disentangle the context of use effects from the frequency of use effects?

2. Previous Studies

The following section presents a description of previous studies about /d/ deletion and /ʒ/ devoicing with the purpose of providing the necessary context to understand this paper's main goal of incorporating frequency as a crucial factor to understand socio-phonetic variation. The section begins with a presentation of /d/ deletion studies and continues with a description of the literature on /ʒ/ devoicing.

2.1. Spanish /d/ deletion

Descriptive literature about intervocalic /d/ deletion dates back to the 16th and 17th centuries (Lapesa 1981), and is abundant in all reference books dedicated to the history of Spanish or Spanish phonetics and dialectology, including Navarro Tomás (1999[1918]) in his seminal handbook of Spanish pronunciation. Navarro Tomás (1999 [1918]:101) states that /d/ is produced as a fricative in *-ado* participial forms in formal situations, while in spontaneous speech /d/ is weaken or deleted. Navarro Tomás argues that this phenomenon also extends less commonly to other participial forms in informal styles in varieties of Spanish spoken in Spain. These observations made by Navarro Tomás indicate that weakening of intervocalic /d/ is not new and that there is an uneven distribution across participial forms. Dialectological description of Latin American Spanish is also available. Henríquez Ureña (1921) reports intervocalic /d/ weakening in many varieties of American Spanish, but points out that Andean varieties spoken in Ecuador and Colombia do not exhibit this phenomenon.

In the specific case of Venezuelan Spanish pronunciation, Lipski (1994: 349) maintains that there is no major study, rather partial investigations from which some of the principal traits of the dialect can be considered. Lipski mentions intervocalic /d/ deletion in rapid speech among the relevant traits to describe this variety.

Beyond the pure dialectological descriptions, there have also been sociolinguistic studies of intervocalic /d/ deletion in varieties of Spanish spoken in Spain (Samper Padilla 1996, Hernández-Campoy and Jiménez-Cano 2003, Blas Arroyo 2006) and, most relevant for our study, in Venezuelan Spanish (D'Introno and Sosa 1986). Samper Padilla (1996) examined the weakening of intervocalic /d/ in the educated norm of Las Palmas de Gran Canaria. He found that deletion was not widespread in educated speakers and that the most favoring context involves the past participle *-ado*. The phenomenon also shows conditioning according to gender: men favor deletion; women[4] disfavor it.

The work of Hernández-Campoy and Jiménez-Cano (2003) shows the influence of the standard dialect of northern Spain on Murcian Spanish, a variety dialectically associated with southern Spain. In an analysis of radio speech, they found a tendency for politicians and non-politicians to eliminate features associated with vernacular Murcian Spanish including deletion of intervocalic /d/. Blas Arroyo (2006) examines the influence of structural and stylistic factors in intervocalic /d/ deletion. His

[4] Sociolinguistic variation implies tendencies that cannot be considered categorical.

findings indicate that the bilingual background of the speakers (i.e. Catalan vs. Spanish) influences rates of deletion with Spanish dominant speakers favoring deletion as in other areas of Spain. His results also show that the rate of deletion in past participles ending in *–ado* is much higher than in any other lexical categories, including nouns and non-participial adjectives. Blas Arroyo argues that stylistically colloquial items are more likely to have instances of /d/ deletion than formal items in the Spanish dominant population.

The study of D'Introno and Sosa (1986) is the only sociolinguistic study of intervocalic /d/ deletion in Venezuelan Spanish. These scholars distinguish three variants of intervocalic /d/: retention, transition (a weakened or approximant production), and deletion. They found that in formal styles upper and middle class speakers favored retention more so than the lower socioeconomic group. They also found that deletion occurs in the lower socioeconomic class more than in any other socioeconomic group. Their data also show a trend according to which males favor deletion.

These previous investigations focused their analysis on sociolinguistic aspects of the variable use of intervocalic /d/, but they do not offer any insight as to why the reduction is more advanced in the participle *-ado* than in any other context. These studies also do not provide any answers as to why intervocalic /d/ deletion behaves differently in derived versus non-derived contexts. Bybee (2002) argues that type frequency[5] is the main reason to explain the widespread deletion in participial *-ado* as is evident in her data from New Mexican Spanish. Since Bybee's model has proven to be useful predicting frequency effects in variation phenomena in language, it is warranted to extend this frequency analysis to other varieties of Spanish.

2.2. Buenos Aires /ʒ/ devoicing

The devoicing of /ʒ/ has been described as a salient feature of the Rio de la Plata region, where the phenomenon began as a production of an assibilated variant, the voiced palato-alveolar fricative /ʒ/. Schwegler, Kempff, and Ameal-Guerra (2010: 398) report that the voiced palato-alveolar fricative is also found in Andalusia, Extremadura, and areas of Chile and Mexico, though in these varieties assibilation is less prominent. The phenomenon has been the subject of sociolinguistic study. Fontanella de Weinberg (1979: 13) reports that various investigators have noted this phenomenon at least since the 1930s[6]. Fontanella de Weinberg (1979) herself finds that in Bahía Blanca, in the province of Buenos Aires, the sound was pronounced differently depending on style and the social characteristics of the informant. The devoicing was characteristic only of the younger age groups (15-49 years), with a greater rate of devoicing amongst the youngest speakers. Additionally, women used the devoiced variants more than men of the same age. Finally, the devoicing was found to occur more amongst the most educated in the 35-49 age group, but this trend reversed amongst the youngest speakers with the least educated showing the greatest rate of devoicing in the youngest group.

During the same time period Wolf & Jiménez (1979) conducted a study of the same phenomenon in the speech of the city of Buenos Aires. These scholars arrived at similar conclusions to what Fontanella de Weinberg (1979) found, in this case highlighting the opposition between the upper class and the remainder of the population, with the upper class showing considerably less devoicing. Wolf (1984) later conducted a real time study that included many of the same informants that were included in the previous study. Almost all upper-class informants showed more devoicing in 1975 than in 1970, although the differences varied widely. Her analysis of other aspects of the variation showed numerous inconsistencies, leading her to believe that devoicing would never reach its conclusion and that a situation of stable variation existed.

More recently, Chang (2008), in a study of the variable production of /ʒ/, has come to the conclusion that the variation in pronunciation of /ʒ/ is now primarily correlated with age and that the sound change is now complete, contra the predictions of Wolf (1984).

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[5] Bybee (2001:10) defines type frequency as follows: "Type Frequency refers to the dictionary frequency of a particular pattern (e.g., stress, an affix, or a consonant cluster)."

[6] The reader is directed to the first chapter of Fontanella de Weinberg (1979) for a detailed review of these observations. Fontanella de Weinberg (1985, 1987, and 1989) has also written extensively about the evolution of Río de la Plata Spanish.

Rohena-Madrazo (2008a, 2008b) also has studied the variable production of /ʒ/, coming to a similar conclusion to Chang's (2008) that in the younger generation the males have caught up to the females in their rate of devoicing, although he still finds that upper-class speakers disfavor the devoicing. Another recent study (King 2009) examined the language attitudes of porteños from 18 to 30 years of age towards voiced and voiceless variants, finding that even in that generation there is still an association of voiced variants with Recoleta and Barrio Norte, in general. The author examined the productions of her informants and found very high rates of devoicing in all except one speaker, from Belgrano, who expressed a negative attitude toward the voiceless variant.

Finally, in a departure from the studies that have looked at the considerable social aspect of devoicing in Buenos Aires, Gradoville (2007a, 2007b) examined lexical effects, context of use, and frequency of use in the devoicing of /ʒ/ in the speech of speakers from the neighborhoods of Belgrano, Palermo, and Recoleta. Gradoville (2007b) showed that tokens following a pause show a much higher rate of devoicing than tokens in intervocalic position, especially word-medially. Also, in intervocalic contexts high frequency words showed a lower rate of devoicing than low frequency words. In addition, Gradoville (2007a) showed that different collocations involving the word *yo* showed different rates of devoicing.

3. The usage-based model

A usage-based model of language proposes that our mental representation is based on linguistic experience (Bybee 2003, 2006). As such, the cognitive representation is affected by the frequency with which individual units of language are used. Bybee (2006) delimits three effects of token frequency, defined as the number of instances of use of individual words or constructions. These effects are the *reducing effect*, the *conserving effect*, and *autonomy*. The reducing effect refers to the tendency for high frequency words and constructions to undergo phonetic reduction at a faster rate than lower frequency items. This reducing effect is considered to drive physiologically-motivated sound changes. Examples of sound changes where this has been found to be true include English unstressed vowel reduction (Hooper 1976), English /t,d/ deletion (Bybee 2002; Gregory, Raymond, Bell, Fosler-Lussier, & Jurafsky 1999), English word-boundary palatalization (Bush 2001), Spanish final /s/ reduction (Earl Brown 2009, Esther Brown & Torres Cacoullos 2003, File-Muriel 2009, Minnick-Fox 2006), Spanish initial /s/ reduction (Esther Brown & Torres Cacoullos 2003), Spanish /d/ reduction (Bybee 2002), syllable-final /ɾ/ reduction (Díaz-Campos 2005, 2006, Ruiz-Sánchez 2007, Díaz-Campos and Ruiz-Sánchez 2008), and others cited by Phillips (2006). The conserving effect refers to the tendency for high-frequency sequences to retain forms that do not conform to the regular paradigms. This concept has primarily been applied to morphosyntactic structure (e.g. English past tense forms, Hooper 1976; Romance future forms, Gradoville 2008a, 2008b, 2009), although Phillips (2006: 76-95) lists numerous apparently gradual phonetic changes where the low-frequency words were affected first. For instance, Hooper (1976) mentions the case of pairs such as *weep/wept, leap/lept* vs *keep/kept, sleep/slept* where *weep* will tend to regularize to *weeped* and *leap* to *leaped* due to their low frequency and weak cognitive representation. In Spanish we also have examples of analogical change that fit the same generalization. For instance, the preterit first person form *andar* 'to go' may regularize to *andé* instead of *anduve*. The explanation behind this change is that speakers are modeling the form based on the general paradigm for the preterit. Furthermore, *andar* is subject to change due to its low frequency and weak cognitive representation. Regarding gradual phonetic changes that affect the least frequent words first, Phillips (2006: 94) attributes a required "deeper level of analysis during [the sound change's] production" instead of physiological motivation. She goes on to state that "[i]n production, infrequent forms are accessed more slowly and memory traces are weaker. These properties give speakers the time and motivation to access other levels/components … when producing these forms."

Another important notion that is key to the understanding of the model is autonomy. Autonomy refers to the notion that "morphologically complex forms (or strings of words) of high frequency can lose their internal structure as they become autonomous from etymologically related forms" (Bybee 2006: 715). This means that highly frequent combinations in speech can transform into new

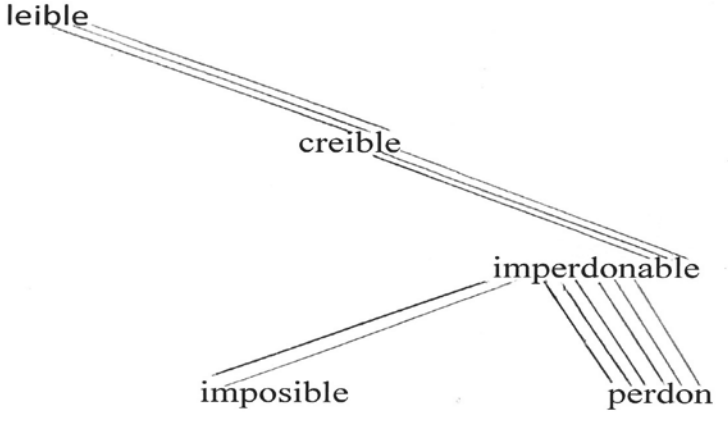
independent chunks. For instance, Bybee and Scheibman (1999) found evidence that *I don't know* can be considered autonomous. Their findings reveal that speakers do not independently access *I*, *do*, *not*, and *know* but that the combination is accessed as a whole.

In applying this model, we need a definition of phonetic reduction. In developing her conceptualization of the usage-based model, Bybee (2003) turns to the articulatory gesture-based account of reductive processes argued for by Pagliuca and Mowrey (1987), who divide reductive processes into two categories, substantive reduction and temporal reduction. Substantive reduction involves a decrease in the magnitude of an articulatory gesture. Temporal reduction involves an increase in the overlap of articulatory gestures. In our view, Spanish intervocalic /d/ falls in the former category, given that the change can be viewed as the gradual decrease in the magnitude of the tongue's gesture. "Deletion" processes are also classified as weakenings in Lavoie's (2001) sonority-based account.

The devoicing of /ʒ/, on the other hand, is a little more complicated. In the intervocalic environment, there is a clear decrease in gestural overlap since the vocal cords have to stop vibrating to produce the fricative before restarting for the following vowel. Devoicing in the intervocalic environment is an uncommon sound change in the languages of the world, as Lavoie's (2001) survey only found four examples of devoicing, all of which were tied to initial position[7]. On the other hand, in her sample she found 17 examples of voicing, 13 of which were intervocalic and 4 of which occurred in some other medial position. As a result, we can say that typologically, in intervocalic positions voicing is the favored direction of change, while in initial positions devoicing seems to be favored. We take the stance that in intervocalic position the devoicing should be classified as a strengthening due to the decreased gestural overlap that results from the devoicing in this position. In this context, therefore, devoicing is motivated by something other than physiological factors, since physiological motivation would lead to weakening.

Finally, as Bybee (2002) found, tokens of sounds in favorable environments for reduction in morphemes of high type frequency (the morpheme occurs in many words) are subject to higher rates of reduction due to the lexical connections between the individual forms. Bybee's model proposed that lexical items relate to others whether it is based on form or whether it is based on both form and content. For example in Figure 1 we can see the connections between forms such as *leible, creible, imperdonable* and *increible*. This figure represents a simplified way of illustrating some of the lexical connections among the forms selected.

Figure 1: Representation of Lexical Connections



In her New Mexican Spanish data, intervocalic /d/ reduction occurred at a higher rate in the past participle than in other environments. These findings show that regular forms, such as the past

[7] Lavoie's (2001) references to these four sound changes are somewhat ambiguous. There are no examples of affected words and it is unclear as to whether these devoicings occur in the intervocalic environment.

participle, can be subject to frequency effects. We expect to find similar results in our corpus from Caracas Spanish since the usage-based model, as a general theory, should explain the same phenomenon in any variety.

4. Methodology

This study makes use of recorded interview data. Thirty-six speakers were selected from the corpus *Estudio Sociolinguistico de Caracas* (Bentivoglio and Sedano 1993) with equal representation of socio-economic level (upper class, middle class, and lower class), age (14-29, 30-45, 61 and older), and sex (male and female). The data from Buenos Aires come from interviews performed by the second author in Buenos Aires in 2008. Nine participants are included, all native speakers of Spanish who lived in the neighborhoods of Belgrano, Palermo, or Recoleta. These neighborhoods were chosen since, based on previous studies, it was believed that there would be greater likelihood of variation in these neighborhoods than in other areas of the capital.

All tokens of intervocalic /d/ were extracted and coded for lexical frequency using the online CREA corpus from the Royal Academy (Corpus de Referencia del Español Actual 'Reference Corpus of Contemporary Spanish'). The data were also coded for corpus frequency by counting the number of occurrences of lexical entries used from the actual corpus of Caracas. The criteria for the definition of frequency were based on the nature of the data coded. For the CREA frequency tokens were considered in the high category when the lexical count was between 5,365 and 49,112. In the case of the corpus frequency, the high category was considered between 100 and 1,658. Roughly, the items defined as high frequency according to CREA and corpus frequency were consistent. Since we had to come up with categories as VARBRUL analysis assumes categorical variables, a division between highly frequent items and infrequent ones was decided. Items considered highly frequent in the corpus of study fall into the same category as they do in the CREA corpus. For example, the word *de* 'of" had a CREA frequency of 49,112 while in the Caracas corpus it had 1,658 classifying *de* in the same level of high frequency according to both corpora. We recognize that there was some arbitrariness in the division of the categories, but such categorization adequately models the similarity in pattern of behavior for both the CREA and the corpus frequency. As it will be clear in the results, we found patterns of behavior in the data indicating the relevance of the criteria employed. All tokens of /ʒ/ were extracted from the interviews. Loan words were excluded since they exhibited no variation. Additionally, tokens were excluded where an acoustic disturbance (e.g. tapping on the microphone, overlap of voices) occurred that would prevent the accurate identification of the variant. The coding of the dependent variable was determined auditorily, with the additional examination of the sound on the spectrogram using Praat (Boersma & Weenink 2009) for confirmation. Four independent variables were coded: previous context, position within the word, word frequency, and string frequency. Previous context was defined with the following values: pause (includes hesitation noises, since they behaved the same as the pause), non-sibilant consonant, sibilant consonant (includes all realizations of /s/), and vowel[8]. Position within the word was coded with the values word-initial and word-medial according to orthographic conventions. Word frequency was coded using the frequency in the corpus of study (14 or more tokens for high frequency, 11 or fewer for low frequency) and the frequency in the Buenos Aires Habla culta corpus (more than 2 tokens per 10,000 words for high frequency, fewer than 2 for low frequency; Barrenechea 1987)[9]. The words *yo* and *ya* were considered separate

[8] Devoiced vowels were not included in the analysis of previous context. Particularly in strings where the previous consonant is /s/ (e.g. *se llama*), there is a tendency to produce the entire sequence /seʒ/ as either totally voiced or totally voiceless. Devoiced vowels only affected six tokens, five fricatives of which were also voiceless.

[9] We initially attempted to use the Corpus de Referencia del Español Actual for the Buenos Aires data. However, during the analysis we noted issues that led us to doubt the validity of the oral Argentine portion of the corpus (for example, the word *proyecto* had 4192 tokens versus 935 for *yo*, the most frequent word by far containing the sound according to many other corpora). We decided to use the *Habla culta* corpus from Buenos Aires since that appears to be the only other corpus of spoken Argentine Spanish readily available. Given its caveat of only including 54,048 words (a comparable amount of speech to the corpus of study, which

frequency categories due to their overwhelmingly high frequency compared to the rest of the data[10]. The divisions above categorized high frequency and low frequency word tokens to create approximately equally sized groups of tokens. Where the two measurements of frequency of use disagreed regarding the frequency category the word was excluded from the frequency analysis[11]. String frequency was defined as the number occurrences of a two-word string involving the word before the token of /ʒ/ and the word with the token of /ʒ/ (e.g. *se llama, y ya*). The following values were defined for this variable: high frequency (7 or more occurrences in the corpus of study), low frequency (5 or fewer occurrences), not in a string (applied to tokens after a pause, hesitation, etc.).

Each set of data was analyzed using GoldVarb X (Sankoff, Tagliamonte, & Smith 2005), a program that uses a form of logistic regression to provide a model with corrected probabilities accounting for interactions between different independent variables and determines the statistical significance of said independent variables in predicting the dependent variable. In the tables we present, the factor groups are presented in order based on the range (difference between the highest and lowest weights), which in general indicates the relative magnitude of effect of the factor groups. Weights closer to 1 are said to favor the application value, whereas weights closer to 0 are said to disfavor the application value.

5. Results from Caracas

The present section is dedicated to the discussion of the results of the analysis of intervocalic /d/ deletion and the role of frequency effects in the diffusion of the pattern of variation. The first part is dedicated to the independent effect of CREA frequency and corpus frequency in the whole data. Next, a description of the variation affecting intervocalic /d/ deletion by grammatical category is presented. We also observe if variation behaves in the same way in all participial forms as well as the effect of frequency without participial forms.

The analysis of the perceptually-gathered data is based on 7,200 tokens where 6,473 tokens were cases of retention (89.9%), while 727 tokens were cases of deletion (10.1%). We have defined our dependent variable as binary where retention is the perceptual presence of sound and deletion means the perceptual absence of sound. This decision of defining a binary dependent variable is consistent with the requirements to perform a logistic regression with VARBRUL. Future investigations might observe the behavior of intermediate categories that for the purpose of our analysis were limited to two categories. D'Introno and Sosa (1986:142)[12] find that the most relevant distinction between the variants of intervocalic /d/ was to consider the retained dental fricative versus the total deletion of it. An analysis of frequency effects was performed by studying independently CREA frequency and then corpus frequency. Table 1 presents the results of intervocalic /d/ deletion according to CREA frequency.

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is seven hours of speech), it was decided that for Buenos Aires a combined definition would be more reliable than taking the two separate definitions of frequency.

[10] The five most frequent words in the Buenos Aires *Habla culta* with /ʒ/ are *yo* (89.37 tokens per 10,000 words) *ya* (32.01 tokens per 10,000 words), *allí* (9.62 tokens per 10,000 words), *ella* (8.33 tokens per 10,000 words), and *ellos* (5.92 tokens per 10,000 words).

[11] Given its caveat of only including 54,048 words (a comparable amount of speech to the corpus of study, which is seven hours of speech), it was decided that for Buenos Aires a combined definition would be more reliable than taking the two separate definitions of frequency.

[12] D'Introno and Sosa (1986:142) argue the following; "Estas observaciones nos permiten concluir que la transición es, desde el punto de vista sociolingüístico, menos pertinente que la dental y la elisión. En otros términos, las variantes que corresponden a los extremos de la escala de debilitamiento de la /d/ son las que reciben una función y un valor social más definido e importante." "These observations allow us to conclude that the transitional variant is, from a sociolinguistic point of view, less pertinent than the dental fricative and deletion. In other words, the variants corresponding to the two extremes of the weakening scale of /d/ are the ones that receive a function and a more definite and important social value. "

Table 1: Multivariate analysis of the contribution of CREA frequency to intervocalic /d/ deletion

Log likelihood			-2351.52
Total N			7,200
	Factor weight	%	N
CREA frequency			
High	.55	12.1	200/1658
Low	.49	9.5	527/5542
Range	*6*		

Table 1 shows that high frequency lexical items favor deletion (weight = .55). Tokens from low frequency words disfavor deletion (weight = .49).

Table 2: Multivariate analysis of the contribution of corpus frequency to intervocalic /d/ deletion

Log likelihood			-2352.77
Total N			7,200
	Factor weight	%	N
Corpus frequency			
High	.53	11.3	298/2642
Low	.48	9.4	429/4558
Range	*5*		

Table 2 shows that corpus frequency yields similar results to those shown for CREA frequency. High frequency tokens in the corpus slightly favor deletion (weight = .53), while low frequency lexical items disfavor deletion (weight = .48). Table 3 shows the distribution of intervocalic /d/ cases according to grammatical category[13] to examine if the behavior of /d/ deletion is consistent across categories or if we find similarities with the results reported for other dialects of Spanish.

Table 3: Multivariate analysis of the contribution of grammatical category to intervocalic /d/ deletion

Log likelihood			-2274.52
Total N			7,200
	Factor weight	%	N
Grammatical category[14]			
Participles	.73	21.7	180/831
Prepositions	.57	11.8	218/1853
Adverbs	.56	11.6	31/267
Pronouns	.49	9.1	62/681
Adjectives	.46	8.1	58/720
Verbs	.43	7.1	106/1491
Nouns	.32	5.3	72/1357
Range	*41*		

The findings according to grammatical category reveal that participles favor deletion, which is consistent with other dialects of Spanish such as New Mexican Spanish (Bybee 2002), Canary Island Spanish (Samper Padilla 1996), etc. The pattern found in participles indicates that it is in this context where intervocalic /d/ reduction is most advanced. We come back to this issue in the discussion section. Table 4 shows the distribution of intervocalic /d/ deletion according to type of past participle.

[13] Since our analysis is based on frequency, Table 3 shows that each category is affected by intervocalic /d/ deletion to a different extent. Previous analyses observing phonetic context reveals that a previous central vowel and a following middle back vowel favor deletion. This apparent phonological effect is confounding the fact that deletion occurs more often in in *-ado* participles. This is a clear example of the need to include an analysis of grammatical category to uncover the frequency effect of participial forms.

[14] Examples for the categories found are as follows: participles: *llegado*, prepositions: *o desde*, adverbs: *y despues*, pronouns: *nada* , adjectives: *toda esa* 'all that', verb: *te digo*, nouns: *vida.*

Table 4: Multivariate analysis of the contribution of type of past participle to intervocalic /d/ deletion

Log likelihood			-2281.235
Total N			7,200
	Factor weight	%	N
Past participle ending			
ADO	.81	30.4	117/385
IDO	.69	19.0	35/184
Elsewhere	.47	8.7	575/6631
Range	*34*		

Table 4 shows that past participles in general favor deletion, but particularly strong is deletion found in *-ado* forms with a weight of .81 in comparison to the elsewhere condition, which disfavors deletion with a weight of .47. This finding can be seen as an effect of type frequency, an issue that we discuss below.

Given that we found more deletion in the past participles, the next step was to observe the effect of frequency in the rest of the data without past participles. Table 5 shows the effect of CREA frequency on /d/ deletion excluding tokens in past participles[15].

Table 5: Multivariate analysis of the contribution of CREA frequency to intervocalic /d/ deletion without past participles

Log likelihood			-1849.416
Total N			6,369
	Factor weight	%	N
CREA frequency			
High	.60	12.1	200/1658
Low	.47	7.4	347/4711
Range	*13*		

Table 5 indicates that frequency effects increase in magnitude when excluding past participles with the range increasing from 6 to 13, relative to Table 1. This finding indicates a pattern of lexical diffusion, which is consistent with Bybee's (2003:11) description according to which "phonetic change often progresses more quickly in items with high token frequency". Table 6 shows the effect of corpus frequency on intervocalic /d/ deletion, when past participles are excluded.

Table 6: Multivariate analysis of the contribution of corpus frequency to intervocalic /d/ deletion without past participles

Log likelihood			-1844.827
Total N			6,369
	Factor weight	%	N
Corpus frequency			
High	.58	11.3	298/2637
Low	.44	6.7	249/3732
Range	*14*		

Consistently, magnitude of frequency effects also increases according to corpus frequency with the range increasing from 5 to 14 between Tables 2 and 6. Again, this pattern indicates more erosion of intervocalic /d/ in high frequency tokens in a fashion that shows lexical diffusion.

6. Results from Buenos Aires

As was found in a previous study of Buenos Aires Spanish (Gradoville 2007b), previous phonetic context is of great importance in the devoicing of /ʒ/, being the only factor selected as significant by

[15] Some of the tokens included nouns such as *radio* 'radio', vestido 'dress', *apellido* 'last name', verbs in cases such as *me dejaba* 'he/she let me', *te doy* 'I give you', among other examples.

GoldVarb X when the dataset is taken as a whole (see Table 7). Tokens occurring after a pause or hesitation noise most favor voicelessness (weight = 0.74). Tokens occurring after a vowel –in other words, intervocalic tokens– disfavor voicelessness (weight = 0.45). Tokens occurring after a consonant account for a very small portion of the data (6.0% of the data).

Table 7: Multivariate analysis of the contribution of previous context to the devoicing of /ʒ/

Log likelihood			-475.280
Total N			723
	Factor weight	%	N
Previous Context			
Pause/Hesitation	.74	81.0	81/100
Non-Sibilant Consonant	.59	68.4	13/19
Sibilant	.51	60.9	14/23
Vowel	.45	54.7	308/563
Range	*29*		

It must be noted that word frequency was not included in the execution of GoldVarb X shown in Table 7 because it interacted with previous context. The two variables are not entirely independent in practice. Specifically, only *yo* and *ya* occur in non-intervocalic contexts with any frequency (91% of non-intervocalic tokens are *yo* or *ya*, whereas only 35% of intervocalic tokens are *yo* or *ya*). That *yo* and *ya*, by far the two most frequent words in Spanish with /ʒ/, occur in different contexts than the remainder of the data reveals serious asymmetries. As such, another analysis was performed excluding tokens of *yo* and *ya*. We can see in Table 8 that without *yo* and *ya*, position in word (range = 17) and word frequency were selected as significant (range = 4). It must be noted that previous context could not be included in this execution of GoldVarb X because it interacted with position in word. Specifically, only intervocalic tokens occur in word-medial position and 95% of tokens without *yo* and *ya* occur in intervocalic position, so other contexts almost do not occur.

Table 8: Multivariate analysis of the contribution of factors to the devoicing of /ʒ/, *yo* and *ya* excluded

Log likelihood			-283.946
Total N			422
	Factor weight	%	N
Position in Word			
Initial	.63	67.3	70/104
Medial	.46	51.6	164/318
Range	*17*		
Word Frequency			
Low	.52	60.0	105/175
High	.48	53.8	84/156
Range	*4*		

Returning to the results in Table 8, tokens in word-initial position, the context most favorable to variation[16], favor voicelessness (weight = .63), while word-medial position disfavors voicelessness (weight = .46). It makes sense that the alternating environment would favor voicelessness because, while these words do not occur in other environments very often, they can occur in environments that favor devoicing. As a result, the voicelessness may become part of the lexical representation when these words occur in favoring environments (especially, after a pause) and then occur in the disfavoring environment (intervocalic). We will return to the discussion of this effect later.

The other factor group that was selected as significant is word frequency. Low frequency words

[16] Bybee (2000: 251) makes reference to the notion of 'alternating environments', where "a sound in a particular word or morpheme is sometimes in the environment for a change to take place and sometimes not." Tokens of /ʒ/ in word-initial position, for example, sometimes occur after a pause which favors devoicing and sometimes in an environment not favorable to devoicing.

such as *playa*, *belleza*, or *llevar* favor voicelessness (weight = .52), while high frequency words such as *llama*, *ellos*, or *allá* disfavor voicelessness (weight = .48). Since the magnitude of effect is so small (range = 4), we can definitely say that the effect is subordinated to the context of use effects. Nevertheless, there is an effect for frequency of use.

Returning to the issue of the alternating environment, an additional run of GoldVarb X was performed with all and only the word-initial tokens. Due to space restrictions those results will not be presented in a table, but they were similar to the first analysis with previous context being the only variable selected as significant. That analysis revealed an interaction between word frequency and string frequency: no low frequency words formed high frequency chunks and almost all tokens of the high frequency word (i.e. *llama*) occurred in the high frequency chunk *se llama*. Since in the word-medial context, high frequency words and low frequency words have been found to behave basically identically according to the frequency definitions that have been used (54.5% and 54.2%, respectively), the frequency effect found in Table 8 must be due to the word-initial tokens. However, it is impossible to tease this word frequency effect apart from string frequency. On the other hand, *yo* and *ya* have basically the same rate of devoicing in high frequency and low frequency strings.

We can observe in Figure 2 the distribution of word-initial tokens according to lexical type and previous context. As we can see, in the data the only high frequency word *llama* with word-initial /ʒ/ always appears in intervocalic environments. *Yo* and *ya* on the other hand appear in non-intervocalic environments more than 40% of the time. Likewise, low frequency words also appear in non-intervocalic environments nearly 30% of the time. Figure 3 shows the rates of voicelessness of word-initial tokens according to lexical type and previous context. We can observe that all three lexical categories show about an 80% rate of voicelessness after a pause, so there is no detectable effect for lexical type in this environment. We can also see that these three lexical categories, which can occur after a pause, have higher rates of voicelessness than high frequency words, which do not occur after a pause, thereby supporting the notion that the voiceless pronunciation of the word that started after a pause lexicalized and began occurring in disfavoring environments.

Figure 2: Distribution of word-initial tokens of /ʒ/ in Buenos Aires Spanish according to lexical type and previous context.

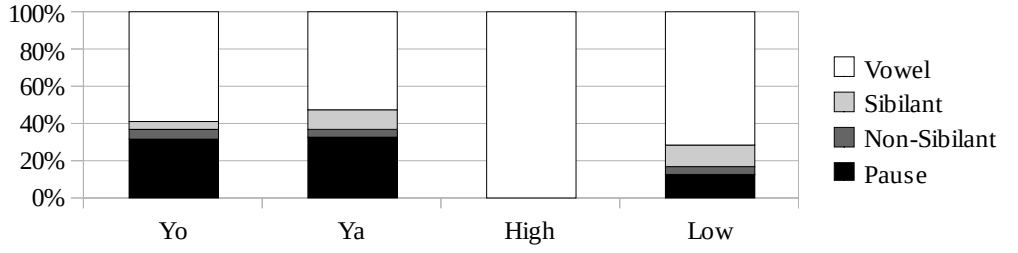
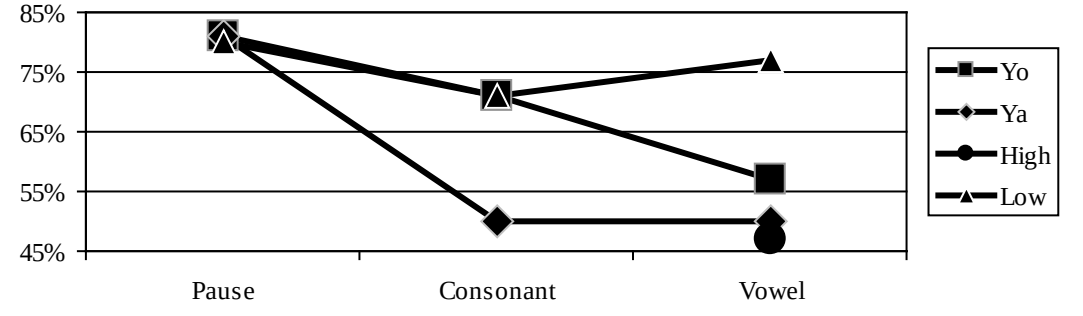


Figure 3: Rates of voicelessness of word-initial /ʒ/ in Buenos Aires Spanish according to lexical type and previous context



We return now to the word-medial tokens. Recall from the discussion above that, using the predefined word frequency categories, the behavior of high frequency and low frequency words was virtually identical in this environment. A *post hoc* examination of the most frequent words with word-medial /ʒ/ can be found in Table 9. As we can see, the two most frequent words in the analysis, *ella* 'she' and *ellos* 'they (masc)' have the least rate of voicelessness (31% together). This rate is significantly different from the remainder of the word-medial tokens included in the analysis (62% voiceless as a group; $\chi^2 = 19.284$, degrees of freedom = 1, $p \leq 0.0001$).

Table 9: Rates of voicelessness of word-medial /ʒ/ in Buenos Aires Spanish by lexical type[17].

Word	Frequency	%	N
ella 'she'	8.33	37	19
ellos 'they (masc)'	5.92	28	47
haya 'have (subj)'	2.78	54	14
allá 'there'	2.41	72	29
calle 'street'	2.22	93	27
low frequency	< 2	54	121

7. Discussion

Concerning intervocalic /d/ deletion, the findings of the present investigation reveal that high lexical frequency defined by CREA or corpus frequency favors intervocalic /d/ deletion as predicted by the usage-based model. This result is consistent with Bybee's (2003:11) idea that "if sound changes are the result of phonetic processes that apply in real time as words are used, then those words that are used more often have more opportunity to be affected by phonetic processes."

Frequency effects are also found in grammatical categories such as past participles (e.g. *hablado*), prepositions (e.g. *de* as in phrases such *as casa de*... 'the house of'), and adverbs (e.g. *después* as in phrases such as *o después 'or after'*). Prepositions such as *de* and adverbs such as *todo* and *después* have high lexical frequency. Deletion in past participles can be interpreted as the result of high type frequency. The *-ado* participle occurs with 269 different verbs, occurs 385 times in the data, and has the highest rate of deletion. The *-ido* participle occurs with only 74 different verbs, occurs 184 times, and has a more moderate rate of deletion, although still higher than in any other context. These findings reveal that intervocalic /d/ deletion is both influenced by token frequency as well as type frequency. The evidence analyzed shows that type frequency is more important than lexical token frequency in the past participles since deletion is more likely to happen in *-ado* forms than in *-ido* forms or in any other context. .

Concerning devoicing of /ʒ/, the results show that context of use has the greatest effect on the data, confirming findings by Brown (2009) that context of use is important in explaining variation involving socio-phonetic variables. The extreme high frequency of *yo* and *ya* and their differing distribution from other tokens of /ʒ/ explain their independent behavior. In other words, they occur in a context that favors devoicing, namely after a pause. Words that occur after a pause show more devoicing than other words, even outside of the pause context (except *ya*).

There is only a statistically significant frequency effect in the data when *yo* and *ya* are excluded from the analysis, which in effect excludes most tokens in non-intervocalic environments. More frequent words disfavor devoicing. This effect is highly localized to the very frequent words *llama* (which almost always occurs in the string *se llama*), *ella*, and *ellos*.

8. Conclusions

The findings of the analysis presented above provide some answers to the predictions regarding frequency of use based on the usage-based model. First, we examined the effect of frequency on two socio-phonetic processes in Spanish that have very different natures, namely intervocalic /d/ deletion

[17] The value in the frequency column is derived from the Habla Culta corpus for Buenos Aires. Words which were previously excluded from the frequency of use analysis because they fell into a different category in the two corpora (e.g. *allí*, *castellano*, *ellas*, *mayor*, *millones*) continue to be excluded from analysis.

and devoicing of /ʒ/. The evidence found reveals that lexical frequency and type frequency are relevant to explain rates of deletion in the case of intervocalic /d/. High frequency tokens show more deletion than less frequent ones. Past participles ending in *-ado* reflect the influence of high type frequency since this is the pattern most favorable to intervocalic /d/ deletion. Recall that *-ado* occurs with 269 different verbs, whereas *-ido* only occurs with 74.

Regarding devoicing of /ʒ/, results indicate that words that occur more in contexts favoring devoicing also devoice more in other contexts as the phenomenon is spreading from favoring contexts to disfavoring ones. When *yo* and *ya* are excluded from the analysis, a statistically significant effect for frequency is found in explaining devoicing of /ʒ/.

Another prediction concerning frequency effects dealt with past participles versus other categories. Again, the evidence shows that type frequency was a relevant factor to account for high rates of deletion in past participles, especially for past participles ending in *-ado*, which has the highest type frequency and consequently shows the highest rate of deletion. This finding supports Bybee's (2002: 281) account according to which high rates of deletion in past participles cannot be predicted by using Guy's (1991a, 1991b) model of Lexical Phonology.

The last issue was related to the role of context of use. Can we disentangle the context of use effects from the frequency of use effects? With respect to token frequency, there is only a statistical effect when we exclude *yo* and *ya*. Words that occur more frequently in contexts favoring the devoicing also devoice at a higher rate in disfavoring contexts. This pattern shows how the phenomenon spreads from favoring contexts to disfavoring ones. This effect is consistent with Bybee's (2002: 274) statement regarding the effect of alternating environments.

The evidence presented contributes to the growing body of studies regarding frequency effects on Spanish phonological processes. The analysis presented herein provides clear challenges for a priori formal accounts of language, such as Lexical Phonology, which cannot adequately address the lexically uneven distribution of phonological phenomena.

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