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Prosodically-conditioned Sibilant Voicing in Balkan Judeo-Spanish*

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1. Introduction

Much work in the recent phonetics-phonology interface literature argues that the low-level phonetic realization of words is influenced by higher-order prosodic structure. For instance, articulatory gestures located at prosodic boundaries "get longer, larger, and farther apart" (Byrd and Saltzman 2003: 159, inter alia). The degree of edge-adjacent effects correlates with the strength of the prosodic boundary. Researchers have also argued that *phonetic underspecification* provides a descriptively adequate approach to patterns of obstruent voicing neutralization (Ernestus 2003, Hsu 1996, Steriade 1999). In this approach, non-contrastive obstruents are marked by the phonology as neutral, or [0voice], and remain that way into the phonetics, where they are subject to gradient and variable voicing as a function of prosodic context.

In this paper, I show that phonetic underspecification provides a natural account of prosodically-conditioned sibilant voicing in Balkan dialects of Judeo-Spanish (henceforth, JS). A quantitative analysis of corpus data from Crews (1935) indicates that word-final prevocalic sibilant voicing varies across different prosodic contexts, with lower rates of voicing observed before stronger boundaries. I develop an account in Optimality Theory (Prince and Smolensky 1993/2004) of the phonological distribution of sibilant voicing categories. The phonetic implementation of word-final [0voice] sibilants is modeled in Articulatory Phonology using prosodic, or π-gestures, which produce greater slowing of oral constriction gestures across stronger prosodic boundaries (Byrd and Saltzman 2003). Longer sibilant duration favors aerodynamically driven devoicing, which explains the negative correlation between voicing rates and boundary strength.

This paper is organized as follows. Section 2 describes sibilant voicing patterns in JS. Section 3 presents a study of word-final prevocalic sibilant voicing based on Crews (1935). Section 4 develops a phonological and phonetic account of the observed patterns. Section 5 summarizes and concludes.

2. Sibilant Voicing Contrast and Neutralization in JS

Modern JS exhibits a phonological contrast between voiceless and voiced sibilants in word-medial intervocalic position, but neutralizes the contrast elsewhere (Penny 1992, 1993: 80-81, 2000: 181-182, 185-186, Sala 1971). The following data exemplify the pattern on the basis of dental sibilants.[1]

(1)		aβɾasaɾ	'to hug'	aβɾazaɾ	'to scorch'
		pasaɾ	'to pass'	pazaɾ	'bazaar'

(2)	a.	sapatu	*zapatu	'shoe'
		sodɾu	*zodɾu	'deaf'
	b.	alsaɾ	*alzar	'to raise'
		kansaɾ	*kanzar	'to fatigue'

(3)	maz o menos	'more or less'
	doz o tɾes	'two or three'

In syllable-initial position, both word-initially (2a) and after a heterosyllabic consonant (2b), only the voiceless [s] appears. Sala (1971: 142-143) observes that in Bucharest JS, [z] is limited to intervocalic position in words inherited from Spanish, while [z] appears in initial position only in words borrowed from Hebrew or Turkish. In word-final position, /s/ and /z/ are neutralized to [z] before a following vowel-initial word and to [s] before pause, as shown in (3). (Regressive voicing assimilation applies in preconsonantal contexts, not discussed here.) Penny (1992, 1993: 80-81, 2000: 182) views word-final prevocalic voicing as a similarity that JS shares with modern varieties of Catalan, Portuguese, and by extension, Old Spanish.

Bradley and Delforge (2006a) examine patterns of sibilant voicing in modern JS based on experimental data elicited from a multilingual, elderly female speaker residing in Istanbul. Results indicate that the contrast between voiced and voiceless sibilants is maintained word-internally but that voicing in word-final prevocalic position is more variable than has been indicated in previous descriptions of JS. Acoustic analysis of data from a text reading task shows that 73% of word-final prevocalic sibilants show some degree of phonetic voicing, which generally supports the descriptive observations of Penny (1992, 1993). However, the results also suggest that voicing in this context should be described as a variable process rather than as a categorical phenomenon. Evidence of variability comes from a sentence reading task in which carrier phrases present word-final prevocalic sibilants in different syntactic contexts, as in (4). (Note that word-final sibilants are represented as orthographic <*s*> regardless of their phonetic realization.)

(4)

		Diga ___ por favor.	'Say ___ please.'
a.	Determiner + Noun	*las amigas*	'the friends'
b.	Noun + Adjective	*flores ermozas*	'beautiful flowers'
c.	Verb + Adverb	*estamos aki*	'we are here'
d.	Noun + Conj + Noun	*diyas i semanas*	'days and weeks'

As shown in Table 1, rates of sibilant voicing differ across syntactic boundary types, following the hierarchy Det + N > N + Adj > V + Adv > N + Conj + N. Fully voiced realizations are favored in the Det + N context (54.8%), and voiceless realizations are most frequent in the N + Conj + N context (84.6%).

	Det + N	**N + Adj**	**V + Adv**	**N + Conj + N**
Voiceless	15 (35.7%)	17 (42.5%)	22 (52.4%)	33 (84.6%)
Partially voiced	4 (9.5%)	9 (22.5%)	9 (21.4%)	1 (2.6%)
Fully voiced	23 (54.8%)	14 (35%)	11 (26.2%)	5 (12.8%)
TOTALS	42 (100%)	40 (100%)	42 (100%)	39 (100%)

Table 1: Word-final prevocalic sibilants by syntactic context:
χ^2 (df 6, n 163) = 30.02, $p<0.005$

3. A Corpus-based Study of Sibilant Voicing in Balkan JS

3.1 Hypothesis, method, and data collection

An alternative hypothesis is that word-final prevocalic sibilant voicing is dependent not on syntactic structure but on prosodic boundaries. It is generally agreed that syntax has a non-isomorphic relationship to prosodic structure (Nespor and Vogel 1986, Selkirk 1984, 1996, Zec and Inkelas 1990). Syntactic structure determines prosodic structure, but the two are not identical. I assume that prosodic structure above the foot level is constructed in accordance with the Prosodic Hierarchy in (5).

(5) Utterance (U)
|
Intonational Phrase (IP)
|
Phonological Phrase (PP)
|
Prosodic Word (PW)

Languages build prosodic structure in systematic ways, and phonological processes are often restricted to apply within a particular prosodic domain or at the juncture between domains. Recent studies have shown that the low-level phonetic realization of words is influenced by higher-order prosodic structure, such as the presence of phrase boundaries. In particular, articulatory gestures are known to increase in both duration and magnitude according to the strength of an adjacent prosodic boundary (Beckman et al. 1992, Byrd 2000, Byrd and Saltzman 1998, 2003, inter alia). Since longer constriction duration favors sibilant devoicing (Kirchner 1998, Widdison 1997), it is plausible that the distribution of voiced and voiceless sibilants in word-final prevocalic contexts might vary according to prosodic boundary strength. The present study explores the following hypothesis:

(6) Hypothesis: The rate of word-final prevocalic sibilant voicing decreases as the strength of the intervening prosodic boundary increases.

In order to test this hypothesis on a larger data set, tokens were drawn from Crews's (1935) corpus of phonetically transcribed oral narratives produced in the early 1900s by 11 native speakers of JS residing in Bucharest, Romania and in Bitola and Skopje of what is now the Former Yugoslav Republic of Macedonia. The speakers included three males and eight females, ranging from 13 to 75 years in age. The advantage of using Crews's transcriptions is that they constitute a speech sample of JS prior to its classification as a dying language, at a time when proficient speakers were greater in number. (See Crews 1935: 9-14 for specific details about the informants.)

All tokens of word-final prevocalic sibilants were identified in the corpus and classified according to four prosodic contexts, illustrated by the examples in (7) and (8). Crews's segmental transcriptions are adapted here to standard IPA.

(7)
a. i luz intʃo lus kantarikus
   'and she filled up the little jugs'
b. poɾke ti βaz a ʝiɾ?
   'why are you going to go?'
c. i li stan kaʝendu las kaɾnis a piðasus
   'and pieces of his skin are falling off'
d. «im pas ki toɾnis.» i se fwe.
   '«May you return in peace.» And she left.'

(8)

a.	(luz (intʃo))$_{PW}$	PW-internal
b.	(ti (βaz))$_{PW}$ (a (ʝiɾ))$_{PW}$	Inflected verb + a + infinitive
c.	(las (kaɾnis))$_{PW}$ (a (piðasus))$_{PW}$	Across PW boundary
d.	(im pas ki toɾnis)$_{MajP}$ (i se fwe)$_{MajP}$	Across a MajP boundary

An unstressed function word was analyzed as a proclitic that adjoins to the following PW to form an outer PW. Such proclitics included determiners, pronouns, and prepositions, as seen in (8a-c).[2] In (8a), the sibilant-vowel sequence is internal to the outer PW domain. In both (8b,c), the sequence spans across two distinct PWs, where the word containing the sibilant is stressable, but the following vowel-initial word need not be. Based on previous informal observations of frequent sibilant voicing in periphrastic future forms, (8b) was treated as a category separate from (8c). In (8d), 'Major Phrase" is a cover term subsuming Phonological Phrase, Intonation Phrase, and Utterance.[3]

3.2 Results

The corpus provided a total of 1427 tokens of word-final prevocalic sibilants. Tokens were categorized as either voiced or voiceless, and the rate of voicing was calculated for each of the four prosodic contexts. Table 2 gives frequency counts by geographic region. According to the totals for all 11 subjects combined, [z] appears most often within the PW and in periphrastic future forms, with a combined frequency of 98.6%. In contrast, [s] appears most often across major prosodic boundaries at a rate of 96%. Sibilant voicing is more variable across PW boundaries, with [z] appearing more often than [s] (62% versus 38%). In the texts representing Bitola and Skopje, voiced sibilants are more than two times as frequent as voiceless ones in the PW boundary context, while the difference is negligible for Bucharest.

		PW-internal		**V + *a* + Inf**		**Across PW**		**Across MajP**	
Bucharest	[s]	6%	4/64	4%	1/25	53%	72/135	96%	66/69
	[z]	94%	60/64	96%	24/25	47%	63/135	4%	3/69
Bitola	[s]	3%	2/59	0%	0/99	36%	91/250	95%	151/159
	[z]	97%	57/59	100%	99/99	64%	159/250	5%	8/159
Skopje	[s]	0%	0/58	0%	0/115	31%	84/267	97%	122/126
	[z]	100%	58/58	100%	115/115	69%	183/267	3%	4/126
TOTALS	[s]	3%	5/181	0%	1/240	38%	247/652	96%	339/354
	[z]	97%	176/181	100%	239/240	62%	405/652	4%	15/354

Table 2: Distribution of word-final prevocalic sibilant allophones (n=1427)

The prosodic structures in (8b,c) predict similar voicing rates for the periphrastic future and the PW boundary contexts. The fact that periphrastic future forms pattern instead with PW-internal contexts suggests that forms like (8b) may have been prosodically restructured: ((ti (βaz)) a)$_{PW}$ (ʝiɾ)$_{PW}$. If the preposition *a* of the periphrastic future patterns as an enclitic to the preceding inflected verb, then the following generalization can be maintained: word-final prevocalic sibilant voicing is bound to the PW domain. In contrast, voicing is more variable across PW boundaries and virtually absent across major boundaries. These results confirm the hypothesis in (6): sibilant voicing rates decrease as the strength of the intervening prosodic boundary increases.

4. Formal Analysis

4.1 Sibilant voicing contrast and neutralization

In approaches to obstruent voicing neutralization that assume phonetic underspecification, a distinction is posited between obstruents that are specified as either [+voice] or [–voice] in the input and output of the phonological component and others that are completely unspecified, or neutral, with regard to voicing, represented as [0voice] (Bradley 2005, Bradley and Delforge 2006a,b, Ernestus 2003, Hsu 1996, Steriade 1999). Phonologically voiced or voiceless obstruents require specific articulatory gestures designed to ensure that they will be perceived in accordance with their underlying voicing specification. The production of voiced obstruents always involves a reasonable degree of articulatory effort, and the realization of voiceless obstruents also necessitates specific glottal adjustments when these sounds are adjacent to sonorants. Neutral obstruents, conversely, do not have perceptual targets and do not entail any specific articulatory gestures. They are marked as [0voice] by the grammar and remain unspecified into the phonetic implementation component (hence the term *phonetic underspecification*). Such sounds adopt the laryngeal configurations of contiguous sounds and can therefore be expected to exhibit gradient and variable voicing as a result of the interpolation of contextual glottal activity.

Patterns of sibilant voicing neutralization can be analyzed as the interaction of faithfulness and markedness constraints within Optimality Theory (henceforth, OT; Prince and Smolensky 1993/2004). I assume the constraints shown in (9). (For other work on Ibero-Romance sibilant voicing in OT, see Bermúdez-Otero 2001, Bradley 2005, Bradley and Delforge 2006b, Colina 2006.)

(9)
a. MAXSIB(voi/V_V) — Let SIB be an intervocalic output sibilant. A [voice] feature in the input correspondent of SIB has an output correspondent in SIB.
b. MAXSIB(voi) — Let SIB be an output sibilant. A [voice] feature in the input correspondent of SIB has an output correspondent in SIB.
c. ${}_{\sigma}$[s — A sibilant in syllable-initial position is [–voice].
d. *[αvoi] — No obstruent has a [voice] feature.
e. MAXSIB(voi/V_V) » ${}_{\sigma}$[s » *[αvoi] » MAXSIB(voi)

The MAXSIB(voi) constraints in (9a,b) ensure that sibilant voicing specifications in the input are realized faithfully in the output. (9a) is relativized to intervocalic position, while (9b) is a context-free constraint. The positional markedness constraint in (9c) requires sibilants in syllable-initial position to be voiceless. Context-free (9d) assigns one violation per positive or negative voicing specification, thereby favoring [0voice] sibilants in the output. The ranking in (9e) accounts for sibilant voicing patterns in Balkan JS. Generally speaking, output sibilants are phonetically underspecified for voicing with two exceptions: (i) [s] occurs in syllable-initial position, and (ii) [z] contrasts with [s] in syllable-initial position between vowels.

The analysis of word-medial intervocalic sibilants is shown in tableau (10). In output candidates, periods indicate syllable boundaries, with syllabification determined by constraints not shown here. Uppercase [S] in (c,f) denotes a sibilant that is neutral in [voice]. High-ranking MAXSIB(voi/V_V) maintains input voicing specifications when sibilants appear between vowels in the output. The optimal candidates (a) and (d) correspond to examples such as the minimal pairs shown in (1).

(10) Maintenance of sibilant [voice] contrast word-medially between vowels[4]

	MAXSIB(voi/V_V)	$_{\sigma}$[s	*[αvoi]	MAXSIB(voi)
☞ a. /VsV/ V.sV			*	
b. V.zV	*!	*	*	*
c. V.SV	*!	*		*
☞ d. /VzV/ V.zV		*	*	
e. V.sV	*!		*	*
f. V.SV	*!	*		*

The same ranking produces neutralization to [s] in word-initial and syllable-initial postconsonantal contexts. Since MAXSIB(voi/V_V) is irrelevant in non-intervocalic position, the next lowest constraint $_{\sigma}$[s would map potential inputs such as /sapatu/ and hypothetical /zapatu/ to [sapatu] 'shoe' (2).

In syllable-final position, both MAXSIB(voi/V_V) and $_{\sigma}$[s are irrelevant. In tableau (11), lower-ranked *[αvoi] eliminates candidates (a,b) and (d,e) because they have sibilants that are phonologically specified for [voice]. The result is neutralization to [0voice] in (c) and (f).

(11) Neutralization to [0voice] in syllable codas

	MAXSIB(voi/V_V)	$_{\sigma}$[s	*[αvoi]	MAXSIB(voi)
a. /Vs/ Vs.			*!	
b. Vz.			*!	*
☞ c. VS.				*
d. /Vz/ Vz.			*!	
e. Vs.			*!	*
☞ f. VS.				*

In analyzing the phrasal behavior of word-final sibilants, I assume a distinction between lexical and postlexical rankings in OT (Itô and Mester 2001, Kiparsky 1998, and McCarthy and Prince 1993, inter alia). While Richness of The Base holds of inputs to the lexical phonology, the input to the postlexical phonology is necessarily the output of the lexical phonology. Candidates (11c,f) show that word-final sibilants are [0voice] in lexical outputs: [VS]. Let us assume /VS#V/ as the postlexical input representing the context of a word-final prevocalic sibilant. Since input /S/ has no [voice] specification, the MAXSIB(voi) constraints are irrelevant. $_{\sigma}$[s incorrectly generates a [–voice] sibilant in this context—contrary to the variation observed in Table 2. Following Colina (2006) and Ernestus (2003), I solve this problem with the constraint in (12), which forbids the insertion of [voice] features in the output.[5]

(12) DEPSIB(voi)
Let SIB be an input sibilant. A [voice] feature in the output correspondent of SIB has an input correspondent in SIB.

When added above $_{\sigma}$[s in the postlexical ranking, DEPSIB(voi) correctly maintains the neutral word-final sibilant when it becomes prevocalic at the phrase level:

(13) Neutral sibilant maintained word-finally before vowels

/VS#V/	DEPSIB(voi)	MAXSIB (voi/V_V)	$_{\sigma}$[s	*[αvoi]	MAXSIB(voi)
☞ a. V.SV			*		
b. V.sV	*!			*	
c. V.zV	*!		*	*	

4.2 Phonetic implementation

Figure 1 compares the phonetic implementation of sibilant voicing in three scenarios: a neutral sibilant of relatively short duration (a), a neutral sibilant of longer duration (b), and a sibilant that is phonologically specified as [–voice] (c). Solid horizontal lines denote glottal targets corresponding to phonologically specified [voice] features, and dotted lines show interpolation between targets. Since the [0voice] sibilants have no specified target, glottal vibration is determined by gradient interpolation from the surrounding vowels. Sibilants whose constriction duration extends beyond certain thresholds tend to passively devoice for aerodynamic reasons, and voiceless fricatives are typically longer than voiced ones (Kirchner 1998: 163, 236, Widdison 1997). Shorter constriction durations in (a) increase the probability of complete voicing throughout neutral [S], whereas longer durations in (b) favor gradient degrees of voicelessness. In contrast, the intervocalic [s] in (c) has a phonologically specified [–voice] target. Interpolation from the first vowel to the sibilant and from the sibilant to the second vowel produces only transitional glottal vibration at the margins of the sibilant constriction.

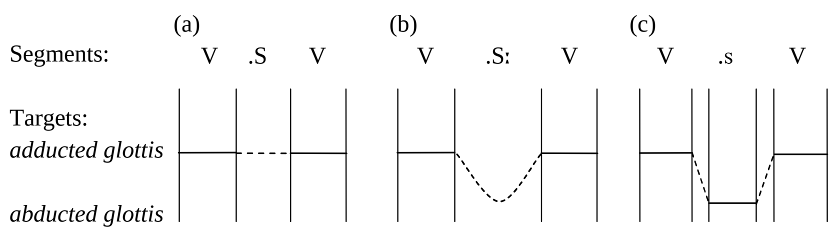

Figure 1: Sibilant voicing as interpolation between phonetic targets

In Articulatory Phonology, gestures are dynamically, spatio-temporally defined articulatory movements that produce a constriction in the vocal tract (Browman and Goldstein 1989, 1990, 1991, 1992). Articulatory gestures are known to increase in both duration and magnitude according to the strength of an adjacent prosodic boundary (Beckman et al. 1992, Byrd 2000, Byrd and Saltzman 1998, 2003, inter alia). Byrd and Saltzman (2003) propose to model boundary-adjacent lengthening and strengthening effects by way of prosodic, or π-gestures, which slow the timeflow of oral constriction gestures at phrasal junctures. The magnitude of the π-gesture correlates with prosodic boundary strength, such that stronger boundaries favor longer sibilant constriction gestures and, therefore, lower rates of sibilant voicing.

The PW-internal context is illustrated by the gestural score in Figure 2. Higher-order prosodic structure is indicated on the first tier. Prosodic and oral gestures are shown on the second and third tiers, respectively. On the oral tier, the broken lines represent the tongue body gestures of the surrounding vowels, and the solid line represents the tongue tip gesture of [S]. The fourth and final tier shows the state of the vocal folds, where the jagged line represents vibration. On the assumption that no π-gestures are present within the PW domain, the sibilant constriction does not undergo boundary-adjacent lengthening. The lack of a glottal target allows continuous vocal fold vibration throughout the shorter sibilant. This accounts for the categorical nature of sibilant voicing within PWs.

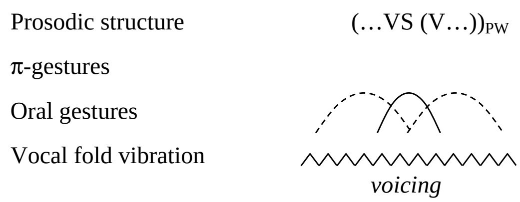

Figure 2: Lack of π-gesture within the PW favors sibilant voicing

Figure 3 compares word-final prevocalic [S] in the PW and major prosodic boundary contexts. Centered, by hypothesis, on the intersection of gestures for [S] and the following vowel, the π-gesture has the effect of slowing down the sibilant and vowel gestures with which it overlaps. Slower movement of the articulators lengthens the sibilant-vowel sequence, which favors greater degrees of aerodynamically driven sibilant devoicing. In the PW boundary context (a), the broken, jagged line on the final tier represents the greater susceptibility of vocal fold vibration to cease at some point during the longer sibilant constriction. The increased magnitude of the π-gesture appearing in the major boundary context further lengthens the sibilant constriction. Passive devoicing is even more likely, as indicated by the broken, straight line on the final tier.

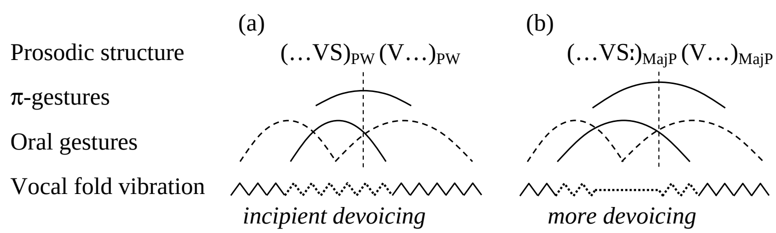

Figure 3: Variation in π-gesture strength produces longer sibilant duration and greater degrees of devoicing across higher prosodic boundaries

5. Conclusion

In the Balkan JS corpus data examined here, word-final prevocalic sibilants are less likely to be realized as voiced across stronger prosodic boundaries. By making explicit the relationship between prosodic structure and low-level phonetic implementation, the proposed analysis offers an integrated account of variability in JS sibilant voicing. Based on modern Catalan, Portuguese, and JS, Penny (1993: 80-81) hypothesizes that word-final prevocalic sibilant voicing also existed in medieval Castilian Spanish. If future research on Catalan and Portuguese were to corroborate the results of the present study, then it seems reasonable to assume that speakers of medieval Castilian would have shown similar patterns of variability in the realization of word-final sibilants.

Notes

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[1] Here I examine only the dentals /s/ and /z/. JS also has voiced and voiceless prepalatal fricatives, /ʃ/ and /ʒ/, which do not appear word-finally except in borrowings from Hebrew, Turkish, and French (Sala 1971: 144-146).
[2] Alternatively, unstressed function words can be included directly in the prosodic word domain of a following word, without the recursive structure (see Hualde, to appear). See Quilis (1988: 314-318) for a complete list of stressable and unstressable words in Spanish.
[3] Since intonation and durational cues are not recoverable from Crews’s phonetic transcriptions, it is not possible to know for sure how subjects prosodified a given utterance. Here, ‘Major Phrase’ included word-final prevocalic sibilants followed either by some punctuation mark, as in (8d), or by the coordinating conjunctions *i* ‘and’ and *o* ‘or’ without intervening punctuation.
[4] MAXSIB(voi/V_V) overgenerates a three-way surface contrast by mapping the potential input /VSV/ faithfully to the output [V.SV]. Overgeneration is not a problem in frameworks that assume constraints governing the perceptual distinctiveness of surface contrasts. In the intervocalic context, the interpolation of voicing from the surrounding vowels would produce a form that is perceptually too similar to a [+voice] sibilant between vowels. Inviolable contrast constraints effectively rule out such a contrast (see Bradley 2005 and Bradley and Delforge 2006b for further discussion).
[5] For an alternative account based on postlexical contrast preservation in Dispersion Theory, see Bradley (2005) and Bradley and Delforge (2006b). For a critique of this approach, see Colina (2006).

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