Voice and aspiration: Evidence from Russian, Hungarian, German, Swedish, and Turkish[1]

OLGA PETROVA, ROSEMARY PLAPP, CATHERINE RINGEN AND SZILÁRD SZENTGYÖRGYI

Abstract

The purpose of this article is to investigate a variety of languages with laryngeal contrasts that have usually been characterized in the literature of generative phonology as having a two-way [voice] contrast and to show that by adopting a narrower interpretation of [voice] to cover only those languages which exhibit prevoicing in word-initial stops, a better understanding of the laryngeal contrasts and assimilation of laryngeal features in these languages is possible. We consider Hungarian, Russian, German, Swedish, and Turkish, which have all been analyzed as having a two-way [voice] contrast for stops. We suggest that the feature [voice] is indeed appropriate for Hungarian and Russian, that the feature of contrast in German is [spread] and that, in Swedish and Turkish, both [voice] and [spread] occur in underlying forms. Analyses are provided for these stop systems in the framework of Optimality Theory.

1. Authors' names are listed in alphabetical order. Earlier versions of parts of this article were presented at the 2000 LSA Meeting in Chicago, Jan. 2000, the Workshop on Voice in Stuttgart, June 2000, the Typology Workshop, Utrecht, the Netherlands, June 2000 and the Budapest Phonology Circle, Eötvös Loránd University of Science, Budapest, Nov. 2000. We are especially indebted to Jill Beckman, who started us thinking about laryngeal features and whose advice and discussions have helped us in the preparation of this manuscript. We also gratefully acknowledge the help we have received from Judit Balassa, Karen Baertsch, Sylvia Blaho, Greg Dogil, Olle Engstrand, Pétur Helgason, Richard Hurtig, Michael Jessen, Elena Kallestinova, Péter Rebrus, Jerzy Rubach, Péter Siptár, and Otto Sohn as we prepared this article. We also wish to thank members of the audiences at the various presentations for their comments, especially Paul Boersma and René Kager. Finally, we have benefited from the comments of two anonymous reviewers. This does not mean that all of these people necessarily endorse any or all of what we say here. This research was supported, in part, by an SSFI grant (2002-03) and an AHI grant (1999) from the University of Iowa to C. Ringen and by grant No D042210 from the Hungarian National Scientific Research Fund to S. Szentgyörgyi.

The Linguistic Review 23 (2006), 1–35 0167–6318/06/023-01
DOI 10.1515/TLR.2006.001

1. Introduction

Discussions of what features can best describe the variety of laryngeal contrasts and the types of voice assimilation that are found in the world's languages have persisted in the literature of generative phonology for several decades, including the discussions by Cho (1990, 1994), Iverson and Salmons (1995, 2003), Keating (1984, 1996), Kingston and Diehl (1994), Lisker and Abramson (1964), Lombardi (1991, 1999), Westbury and Keating (1986), and Wetzels and Mascaró (2001). Yet, in spite of this attention, there are many unanswered questions and unsolved problems. Most phonologists have assumed, following Lisker and Abramson (1964), that the feature [voice] should be used to cover languages with two-way laryngeal contrasts involving any two of the following: negative Voice Onset Time (VOT) (prevoicing), short-lag VOT, long-lag VOT.[2] Analyses based on this assumption include those of Lombardi (1991, 1999), Cho (1990, 1994), Wetzels and Mascaró (2001). The alternative view, represented by Anderson and Ewen (1987), Iverson and Salmons (1995, 1999, 2003), Jessen (1989, 1996, 1998, 2001), Jessen and Ringen (2002), van Rooy and Wissing (2001) among others, is that [voice] should be more narrowly construed and not be used to characterize the contrast between short and long-lag VOT.

In languages such as Hungarian, Russian, French, and Spanish (henceforth, true voice languages), so-called "voiced stops" are produced with vocal cord vibration during closure, including in word-initial position.[3] No vocal fold vibration occurs with voiceless stops, and there is no aspiration. However, in many Germanic languages, for example German and English, so-called "voiced stops" are not produced in the same way as they are in true voice languages. In German, for example, the vocal cords do not vibrate for so-called "voiced stops" except between vowels – or, more accurately, between sonorants; hence, phonetically, they are actually [p], [t], and [k] (except between sonorants). Another difference is that the voiceless stops are (usually) produced with aspiration in Germanic languages.[4] Although these differences have been

2. An example of a language with a negative VOT – short-lag VOT contrast is Russian, which contrasts prevoiced stops (i.e., voice during closure in word/utterance initial position) and plain voiceless, unaspirated stops; an example of a language with a short-lag VOT – long-lag VOT contrast is German, which contrasts plain voiceless, unaspirated stops and aspirated stops in utterance-/word-initial position; an example of a language which contrasts negative VOT (prevoiced) stops with long-lag VOT (aspirated) stops in utterance-/word-initial position was not found in Lisker and Abramson's (1964) study, where it was suggested that such languages might not exist. However, both Swedish and Turkish are examples of such languages.
3. When voicing occurs in word-initial stops during closure, the voicing begins before the release of the closure, hence the term "prevoiced".
4. Well-known exceptions are Dutch, Yiddish, and Afrikaans, which are Germanic languages with prevoiced initial stops and no aspiration.

well known in the phonetics literature, phonologists have persisted in treating the German sound system as if the contrast is one involving the phonological feature of [voice], as in the true voice languages, rather than [spread glottis], henceforth [spread] – the phonological feature associated with aspirated stops. This persistent use of the feature [voice], even in the absence of vocal fold vibration, appears to result from the desire, following Lisker and Abramason (1964), to allow the feature [voice] to cover languages with a contrast between negative VOT (prevoicing) and short-lag VOT, between short-lag VOT and long-lag VOT, and between negative VOT and long-lag VOT. This has led to a number of unresolved problems and puzzles, and to mistaken theoretical claims.

The purpose of this article is to consider a variety of languages that have usually been characterized in the literature of generative phonology with a two-way contrast of the feature [voice] and to show that by adopting a narrower interpretation of [voice] to cover only those languages which exhibit prevoicing in initial stops, a better understanding of these systems is possible.

We start from the position that phonetics and phonology are separate, but that phonological features are phonetically grounded (Cohn 1993; Keating 1996). We assume that phonology accounts for the categorical aspects of sound structure and that phonetics focuses on the gradient or variable aspects of production and perception. We expect that if a language has a two-way contrast of the feature [voice], stops with prevoicing will be found in word-initial position. This is the case in Russian, Hungarian, and Romance languages, which are considered to be clear examples of true voice languages. Similarly, we take the fact that a language has aspirated stops to indicate that the feature [spread] is active. Where there is variation in voicing, for example, the only voiced stops that occur are found (variably) in intervocalic position, we consider that the voicing is *phonetically* conditioned and not part of the phonology. Similarly, we consider variation in the degree of aspiration which depends on stress or place of articulation has a *phonetic* explanation and is part of the phonetics, not the phonology.

Our analyses are framed in Optimality Theory (McCarthy and Prince 1993, 1995; Prince and Smolensky 1993/2002). We begin with cases of true voice languages, Russian and Hungarian, in Section 2. In Section 3, we consider German, which is a language that has often been analyzed with a [voice] contrast, but which, on the narrow interpretation of [voice], is a language with a [spread] contrast. In Section 4, we consider two languages, Swedish and Turkish, which have both aspirated stops and prevoiced stops. We suggest that in these languages, both [spread] and [voice] are underlying and show how such an account sheds light on long-standing puzzles about the correct analysis of these languages. We show how the same constraints, with different rankings, account for these different systems.

2. Russian and Hungarian

Russian and Hungarian are true voice languages with prevoicing of stops in initial position and no aspiration. Obstruent clusters agree in voicing and the voiced/voiceless quality of the cluster is always determined by the rightmost obstruent in the cluster, i.e., the one before a sonorant segment.

2.1. Russian

In Russian there is regressive voice assimilation in clusters, word-final devoicing, and no syllable-final devoicing. Examples are given in (1).

(1)	a.	vra[k]	'enemy' nom. sg.	vra[g]a	gen. sg.
	b.	bra[t]	'brother' nom. sg.	bra[t]a	gen. sg.
	c.	le[d]ok	'ice' nom. sg.	le[tk]a	gen. sg.
	d.	pro[s']it'	'to beg'	pro[z'b]a	'request'

The voiceless variant of the root-final stop (1a) is a result of word final devoicing. The forms in (1b) show that the alternative of intervocalic voicing is not a possibility. The examples in (1c)–(1d) show that there is regressive voice assimilation in Russian, as the underlyingly voiced /d/ in (1c) and the underlyingly voiceless /s'/ in (1d) assimilate when followed by an obstruent of the opposite voicing value.

As noted by Darden (1991), Zubritskaya (1995), and Steriade (1997), Russian requires strict alignment between edges of morphological and prosodic categories. This means that the left edge of a stem and the left edge of the syllable will coincide. Thus, some obstruents before sonorant consonants will be syllable final and others will not. For example, while [zl] is a possible onset in Russian, it is not a possible onset if the [z] is in a prefix and the [l] is in a stem, as in *raz+lit'*. On the other hand, in *po+zlit'*, the [zl] is the onset of the second syllable since the morphological boundary is before the [z]. In [obmɨt'], there is also an obstruent followed by a sonorant. In this case the only possible syllable boundary is between the [b] and the [m], between the prefix and the stem, since [bm] is not a possible onset in Russian.

(2)	a.	raz+lit'	'spill'	syllabified as raz.lit'
	b.	po+zlit'	'make angry'	syllabified as po.zlit'
	c.	ob+mɨt'	'wash around'	syllabified as ob.mɨt'
				(cf. ot+mɨt' 'wash off')

To account for these data, we assume that in Russian there is a high-ranking positional faithfulness constraint of the type proposed by Selkirk (1994) and

Beckman (1995, 1997, 1998), **IDpreson voi**, which states that a presonorant position is privileged: the segment in this position must be faithful to an input value for [voice]. This is necessary to assure that assimilation will be regressive in obstruent clusters, always triggered by the rightmost obstruent. This constraint is a modified version of Lombardi's (1999) constraint, **ID-Ons Lar**, which is discussed below. We assume that voice is privative.[5]

(3) **ID Presonorant Voice** (IDpreson voi)
An obstruent in presonorant position must be faithful to the input specification for voice.

We also assume a constraint **Agree**, which requires that obstruents in clusters have the same specification for laryngeal features.

(4) *Agree Laryngeal* (Agree)
Obstruents in clusters must agree in laryngeal specifications.

We assume the markedness constraint ***voice**, which prohibits voiced obstruents, and a faithfulness constraint, **ID voice,** which requires that if a segment is specified as [voice] in the input, it must be specified as [voice] in the output.

(5) a. ***voice** (*voi)
Voiced obstruents are prohibited.
b. **ID voice** (IDvoi)[6]
Correspondent input and output segments have the same specification for [voice].

The tableaux in (6) show that these constraints, ranked **Agree**, **IDpreson voi** $\gg$ ***voice** $\gg$ **IDvoi**, correctly account for the forms in (1). The obstruent clusters agree in [voice], and it is the rightmost obstruent, i.e,. the one in presonorant position, that is faithful to its input voice specification. In (6a) it can be seen that the optimal output has a voiceless stop even though the input has a voiced stop.

5. In recent papers, Rubach (1996, 1997) and Wetzels and Mascaró (2001) argue that [voice] is a binary feature. The analyses presented here would not be substantially different if we assumed that [voice] is binary. See Beckman and Ringen (2004a) for some discussion. See Iverson and Salmons (2003) for arguments against the claims of Wetzels and Mascaró (2001). Petrova (2003) and Petrova and Szentgyörgyi (2004) employ binary [voice] to accommodate the facts of Russian sonorant transparency and voice assimilation across full word boundaries in Russian and Hungarian. These facts are beyond the scope of this article.
6. Lombardi (2001) argues for a constraint **MAXLar**, which is violated if input laryngeal features are not present in the output. A MAX-feature constraint, **MAXvoi**, could be substituted for the *IDvoi* constraint in our analysis with no difference in empirical coverage.

(6) Russian

a. vra/g/	Agree	IDpreson voi	*voi	IDvoi
vra[g]			*!	
☞ vra[k]				*
b. le/dk/a				
☞ le[tk]a				*
le[dk]a	*!		*	
le[dg]a		*!	**	*
c. pro/s'b/a				
pro[s'b]a	*!		*	
☞ pro[z'b]a			**	*
pro[s'p]a		*!		*

The tableaux in (7) show that **IDpreson voi** gives the correct output for the forms with an obstruent before a sonorant, whether it is syllable-final or not. Under the system of constraints proposed here, candidates (7b), (7d), and (7f) lose because an obstruent which was voiced in the input is devoiced before a sonorant, in violation of **IDpreson voi**.[7]

(7) Russian

o/b/+mit'	Agree	IDpreson voi	*voi	IDvoi
☞ a. o[b].mit'			*	
b. o[p].mit'		*!		*
ra/z/+lit'				
☞ c. raz.lit'			*	
d. ras.lit'		*!		*
po+/z/lit'				
☞ e. po.zlit'			*	
f. po.slit'		*!		*

Lombardi (1999) presents an analysis of voice assimilation in obstruent clusters. She assumes that the feature [voice] is privative and adopts two faithfulness constraints for laryngeal features. One is a positional faithfulness constraint, **IDOnsLar**, which requires that segments in an *onset* in a presonorant position retain their underlying specifications for voice. The other is the general constraint **IDLar**,[8] which requires that correspondent input and out-

7. Note that there are exceptional segments in voice assimilation, such as Russian /v/ and Hungarian /v/, /h/, and /j/. For a detailed discussion see Petrova and Szentgyörgyi (2004), Siptár and Szentgyörgyi (2002, 2004), Szentgyörgyi and Siptár (2004) and references cited therein.

8. Lombardi (2001) suggests that **MaxLar** (every laryngeal autosegment in the input has a correspondent in the output) should replace **IDLar**. If we replace **IDLar** with **MaxLar** in her (1999) analysis, there is no effect on the predictions for Russian, (the analysis is problematic

put segments have the same laryngeal specification. In addition, she adopts a markedness constraint, ***Lar**, which prohibits obstruents with laryngeal specifications.[9] These constraints are given below:

(8) **IDentOnset-Laryngeal** (IDOnsLar)
A presonorant consonant in an onset should be faithful to underlying laryngeal specification.[10]

(9) **IDent-Laryngeal** (IDLar)
Consonants should be faithful to underlying laryngeal specification.

(10) ***Lar**
Do not have laryngeal specifications.

She also assumes the **Agree** constraint which was introduced above. Lombardi proposes the ranking **Agree**, **IDOns** $\gg$ ***Lar** $\gg$ **IDLar** for languages such as Russian. This ranking correctly accounts for the data in (1), as illustrated in (11). This ranking is problematic, however. To accommodate Russian, Lombardi is committed to assume that word-internally, whenever an obstruent is followed by a sonorant consonant, the obstruent is syllabified in an onset together with the following sonorant consonant, which is incorrect. The tableau in (12a) below shows that the ranking and constraints that Lombardi proposes for a language like Russian will not work with the correct syllabification. The only way these constraints can be successful is if the incorrect syllabification in (12b) is assumed (we indicate the left edge of the stem by ‘{’):

for other reasons – see below), but it does have negative consequences for her other analyses (Yiddish and Swedish), which are no longer empirically adequate. The analysis of Hungarian (which is typologically identical to Yiddish) with her (1999) constraints is empirically inadequate, and the analysis with **MaxLar** is also empirically inadequate, but for different reasons.

9. In fact, the constraint only serves to penalize voiced obstruents in Lombardi’s analysis, but in theory it would prohibit segments with any kind of laryngeal specification, for example, aspirated or glottalized segments.
10. Note that the difference between (8) and (3) is that (8) considers syllabic position whereas (3) does not.

(11) Russian-Lombardi (1999)

		Agree	IDOns	*Lar	IDLar
a.	vra/g/	Agree	IDOns	*Lar	IDLar
	vra[g]			*!	
	☞ vra[k]				*
b.	le/dk/a				
	☞ le[t.k]a				*
	le[d.k]a	*!		*	
	le[d.g]a		*!	**	*
c.	pro/s'b/a				
	pro[s'.b]a	*!		*	
	☞ pro[z'.b]a			**	*
	pro[s'.p]a		*!		*

(12) Russian-Lombardi (1999)

		Agree	IDOns	*Lar	IDLar
a.	/ob{mɨt'/	Agree	IDOns	*Lar	IDLar
	ob.{mɨt'			*!	
	☹ op.{mɨt'				*
b.	/ob{mɨt'/				
	☞ o.b{mɨt'			*	
	o.p{mɨt'		*!		*

As is clear in (12a), with Lombardi's system of constraints, the competition between the candidates in which a presonorant obstruent is syllabified in the coda of the preceding syllable is incorrectly resolved in favor of the candidate with the devoiced obstruent. This is because Lombardi's syllable-sensitive positional faithfulness constraint **IDOns** is incapable of eliminating the incorrect candidate. By contrast, the assumption that the presonorant obstruent is syllabified in an onset, as in (12b), allows the selection of the actual surface form as optimal because **IDOns** eliminates the candidate with the value of voice that is not faithful to the input specification. However, as noted above, the syllabification that must be assumed is incorrect. As Rubach (1997: 335) notes, although Lombardi's theory predicts that languages with final devoicing and a contrast in voicing in presonorant position will also maximize onsets, there is no such correlation: "Polish maximizes onsets, but Slovak, Czech and Macedonian do not." Russian maximizes onsets only if such maximization does not jeopardize the integrity of morphological composition of the input form.[11]

11. While sonorants do not play any kind of role in Hungarian and Russian voice assimilation as far as serving as triggers or targets for assimilation, there is one way they influence voice assimilation in Russian: word-initial sonorant consonants followed by an obstruent permit assimilation through them if preceded by a preposition ending in an obstruent, as in *i*[s#mt^{s}]*enska* 'out of Mtsensk', cf. *i*[z#o]*kna* 'out of the window', and *o*[d#mg]*li* 'from the darkness', cf. *o*[t#o]*kna* 'from the window'. This problem is resolved if we assume that the

2.2. Hungarian

In Hungarian, like Russian, there is regressive voice assimilation in obstruent clusters, but unlike Russian, there is no word-final devoicing. In word-final clusters in Hungarian, it is the voicing of the final obstruent that determines the voicing of the entire cluster. The data in (13a), from Zsigri (1998), show that if a word-final obstruent is voiced, the preceding obstruent will be voiced as well. The data in (13b) show that when the word-final obstruent in Hungarian is voiceless, the entire cluster is voiceless. The data in (13c) from Zsigri (1998) show that, word-internally, it is the obstruent in presonorant position that determines the voicing of the entire cluster.

(13) Hungarian

a.	[rɔk]	*rak*	3 sg. decl. def. 'put'	[rɔgd]	*rak-d*	2 sg. imp. def.
	[teːp]	*tép*	3 sg. decl. def. 'tear'	[teːbd]	*tép-d*	2 sg. imp. def.
	[moʃ]	*mos*	3 sg. decl. def. 'wash'	[moʒd]	*mos-d*	2 sg. imp. def.
b.	[göːz]	*gőz*	'steam'	[göːst]	*gőz-t*	acc.
c.	[haːz]	*ház*	'house'	[haːstoːl]	*ház-tól*	'from the house'
	[kɛrt]	*kert*	'garden'	[kɛrdbɛ]	*kert-be*	'in the garden'

We suggest that languages such as Hungarian have a positional faithfulness constraint (Beckman 1997, 1998), which requires that word-final obstruents be faithful to their input laryngeal specifications (see (14) below). This means that an input with a voiced obstruent in word-final position will have a voiced obstruent in the output. This is consistent with the well-known fact that, like beginnings, ends are psycholinguistically salient. Words in sentences can be identified either from word-initial or word-final information, and both types of information interact with higher-level contextual information (Salasoo and Pisoni 1985: 217–221); truncated words can be recognized from initial and final fragments (Nooteboom 1981: 418); beginnings and ends of synthesized words are equally good as recognition prompts when the other part of the word is masked by noise (Nooteboom and van der Vlugt 1988: 2029–2031), and identification of spoken words is facilitated by prior presentation of rhyming items (Milberg, Blumstein and Dworetzky 1988: 308).[12]

constraint **IDpreson voi** only refers to obstruents before ***syllabified*** sonorants. For a detailed analysis, see Petrova and Szentgyörgyi (2004).

12. See also Walker (2005) on word-final faithfulness constraints.

(14) **ID-Word-Final Voice** (IDwf voi)
Correspondent input and output word-final obstruents must have the same specification for voice.

In (15) we illustrate how this constraint, ranked high, will correctly predict the Hungarian facts. We assume, following Steriade's (1997) discussion of cues for voicing of a consonant, that the positional faithfulness constraints have a fixed ranking: **IDpreson voi** ≫ **IDwf voi.** This ranking reflects the number of cues for voicing in a stop consonant in the various positions: the position before a sonorant has more cues for voicing than word-final position,[13] according to Steriade's hierarchy. Steriade claims that "… all else equal, the better the cue package, the greater the likelihood of contrast preservation." This translates into the claim that the input voice specification is more likely to be maintained in presonorant position (there are more cues to voicing here) than in word-final position.[14] The total ranking for Hungarian is as follows: **Agree**, **IDpreson voi** ≫ **IDwf voi** ≫ **IDvoi** ≫ ***voi**.

(15) Hungarian

		Agree	ID preson voi	ID-wf voi	IDvoi	*voi
a.	/rɔk+d/	Agree	ID preson voi	ID-wf voi	IDvoi	*voi
☞	rɔgd				*	**
	rɔkd	*!				*
	rɔkt			*!	*	
b.	/gö:z+t/					
	gö:zt[15]	*!				*
☞	gö:st				*	
	gö:zd			*!	*	**
c.	/kɛrt+bɛ/					
	kɛrtbɛ	*!				*
	kɛrtpɛ		*!		*	
☞	kɛrdbɛ				*	**

ID-wf voi ≫ *voi; Agree ≫ IDvoi; ID-wf voi ≫IDvoi; ID voi ≫ *voi

13. Steriade points out that in presonorant position following a vowel, there are more cues to the voice category of a stop than there are in word-final position following a vowel: in the environment V_1 ___ Son, the cues are: closure voicing, closure duration, V_1 duration, F_0 and F_1 values in V_1, burst duration and amplitude, VOT value, F_0 and F_1 at the onset of voicing in V_2, whereas in the environment V ____#, the cues are: closure voicing, closure duration, V duration, F_0 and F_1 values in V, burst duration and amplitude.
14. We are grateful to Paul Boersma for pointing this out to us.
15. We do not record the violations of ***voi** incurred by the initial [g] since the focus here is on the stop cluster.

We have now seen that the constraints proposed to account for Russian, supplemented with a word-final faithfulness constraint, can predict the actual surface forms in Hungarian.[16]

Lombardi (1999) also suggests that her constraints account for languages like Yiddish and Hungarian, which both have regressive voice assimilation and no final devoicing. Lombardi claims that the constraints are ranked **Agree**, **IDOns** ≫ **IDLar** ≫ ***Lar** for Yiddish, yielding the forms in (16).

(16) Yiddish

[vog]	‘weight’	[vokʃoi]	‘scale’
[bak]	‘cheek’	[bagbeyn]	‘cheekbone’

(17) Yiddish – Lombardi (1999)

		Agree	IDOns	IDLar	*Lar
a.	/bak+beyn/				
	bak.beyn	*!			*
☞	bag.beyn			*	**
	bak.peyn		*!	*	
b.	/vog+ʃoi/				
	vog.ʃoi	*!			*
☞	vok.ʃoi			*	
	vog.ʒoi		*!	*	**
c.	/vog/				
☞	vog				*
	vok			*!	

Lombardi notes, however, that in a final cluster with consonants that disagree in voicing, her constraints predict a final voiceless cluster. The example in (18a) is from Yiddish. (18b) is Lombardi’s hypothetical example because, according to Lombardi, Yiddish has no suffixes consisting solely of a voiced obstruent. She also suggests that a voiceless cluster is what one would expect for Yiddish if there were an appropriate voiced suffix, and this is what her constraints predict:

16. In a triconsonantal cluster, as in /pɛʃt+bɛn/ ‘in Pest’, [pɛʒdbɛn] cf. [pɛʃt], consonants agree with the rightmost stop, as illustrated below:

(i)

	/pɛʃt+bɛn/	Agree	ID preson voi	ID-wf voi	IDvoi	*voi
	[pɛʃt+bɛn]	*!				*
☞	[pɛʒd+bɛn]				**	***
	[pɛʃt+pɛn]		*!		*	
	[pɛʃd+bɛn]	*!			*	**

(18) Yiddish – Lombardi (1999)

		Agree	IDOns	IDLar	*Lar
a.	/zog+t/				
	zogt	*!			*
	zogd			*	*!*
☞	zokt			*	
b.	/pik+d/				
	pikd	*!			*
	pigd			*	*!*
☞	pikt			*	

Lombardi further notes that her constraint system makes implausible predictions about what would happen in longer clusters with different underlying specifications for voice. Here, as Lombardi notes, the prediction is that voicing in the cluster will be determined by whether there are more voiced or voiceless obstruents in the input:

(19) Yiddish – Lombardi (1999)[17]

		Agree	IDOns	IDLar	*Lar
a.	/pigds/				
	pigds	*!			**
☞	pigdz			*	***
	pikts			**!	
b.	/piktz/				
	piktz	*!			*
	pigdz			**!	***
☞	pikts			*	

This prediction, dubbed "majority rule" by Baković (1999a), is problematic because no natural language is known to exhibit this type of behavior. Lombardi suggests that this means that any number of feature faithfulness violations are counted as one violation. On the other hand, Baković suggests that the problem disappears if we assume that two constraints, ***Lar** and **IDLar,** are conjoined and high-ranked. All word-final clusters are then predicted to be voiceless.[18]

17. These examples are Lombardi's. They are not actual words in Yiddish or Hungarian; they are used to illustrate what the predictions are for word-final three-obstruent clusters.
18. Although substituting **MaxLar** for **IDLar** in Lombardi's (1999) account does not improve the empirical coverage of that analysis, it does eliminate the majority rule problem as noted by Baković (1999a). However, contrary to the claim in Lombardi (2001), using **MaxLar** in Swedish results in incorrect predictions in clusters.

(20) Yiddish – Baković (1999a)

		*Lar&IDLar	Agree	IDOns	IDLar	*Lar
a.	/pigds/					
	pigds		*!			**
	pigdz	*!			*	***
	☞ pikts				**	
b.	/piktz/					
	piktz		*!			*
	pigdz	*!*			**	***
	☞ pikts				*	
c.	/pig/					
	pik				*!	
	☞ pig					*

The effect of such a high-ranking conjoined constraint is that in word-final position, all clusters with underlying obstruents that differ in voice specification will be voiceless.

This entire discussion of the majority rule problem presupposes that if there were a voiced obstruent in a suffix in Yiddish, it would be voiceless if it followed a stem with a final voiceless obstruent. While there is apparently no test case for Yiddish, there is for Hungarian, a language which is typologically identical to Yiddish, and this prediction is not borne out (Zsigri 1998) (cf. (13a) and (15a) above). Hence, Lombardi's account is problematic, with or without Baković's suggested reformulation, because it does not correctly predict that word-final voiced obstruent clusters are allowed in a language like Hungarian.[19]

(21) Lombardi (1999) predictions for Hungarian

/rɔk+d/	Agree	IDOns	IDLar	*Lar
a. ☹ rɔkt			*	
b. rɔgd			*	**!
c. rɔkd	*!			*

The analysis we have proposed does not suffer from the majority rule problem. In a language such as Hungarian or Yiddish, all stops in a word-final cluster will agree in voicing with the rightmost stop.

19. Zsigri (1998) and Kenstowicz, Abu-Mansour and Törkenczy (2003) also note that Lombardi's analysis fails to account for Hungarian.

(22) Our analysis, no majority rule/Hungarian or Yiddish

		Agree	ID preson voi	ID-wf voi	IDvoi	*voi
a.	/pigds/					
	pigds	!*				**
	pigdz			*!	*	***
☞	pikts				**	
b.	/pigts/					
	pigts	*!				*
☞	pikts				*	
	pigdz			*!	**	***
c.	/piktz/					
☞	pigdz				**	***
	piktz	*!				
	pikts			*!	*	

In this section, we have given an OT account of two true voice languages, Russian and Hungarian.[20] The same set of constraints (with different rankings) is assumed for both languages. The word-final faithfulness constraint, which is relatively high-ranking for Hungarian, must be assumed to be ranked below *voi in Russian. Our account of Russian does not depend on an incorrect syllabification as does Lombardi's. Our analysis of Hungarian does not suffer from the majority rule problem and accounts for the word-final obstruent clusters, which Lombardi's account does not.

3. German

The fact that there are no aspirated stops in Hungarian, Russian, and Yiddish suggests that a constraint ***[spread]** (no [spread] stops) is high-ranked in these languages, whereas ***voice** is low-ranking.

(23) ***[spread]** (*sg)
Stops specified as [spread] are prohibited.

But if ***sg** is a constraint, it should occur in other positions in the hierarchy in other languages. We suggest that in German, in contrast to Russian, Hungarian, and Yiddish, the constraint *sg is low-ranking, since German has aspirated stops, as illustrated in (24).

20. Dutch is another true voice language with prevoiced stops. In Dutch, unlike Russian, stops are always voiceless before sonorant consonants when the syllable boundary is between the stop and the sonorant consonant. Hence Dutch apparently requires onset faithfulness, not presonorant faithfulness, for stops. Dutch fricatives exhibit different behavior. We do not consider fricatives in this article; for some recent discussion see Iverson and Salmons (2003), van Ostendorp (2003), and Zonneveld (2004).

(24) German

Tag	[t^h]a[k]	'day'	*Tage*	[t^h]a[g]e	'day pl.'
Tier	[t^h]ier	'animal'	*Ratgeber*	Ra[tk]eber	'advisor'
Hecke	he[k^h]e	'hedge'	*Reitgerte*	Rei[tk]erte	'riding crop'
jagen	ja[g]en	'to hunt'	*(sie) jagten*	ja[kt^h]en	'(they) hunted'
Jagd	Ja[kt]	'hunt sg.'	*(die) Jagden*	Ja[kt]en[21]	'(the) hunt pl.'
(es) deckte	(es) [t]eckte	'(it) covered'			

Here we follow the analysis of German stops presented in Jessen and Ringen (2002), which is based on the analysis presented in Petrova et al. (2000), to account for the distribution of voice and aspiration in German. We assume that in a language such as German, the underlying contrast is not between voiced and voiceless stops, but between stops that are [spread] and those which are not.[22] Voiced stops are excluded by the constraint ***voi.** The voicing of stops that occurs between sonorants, we assume, is the result of (phonetic) passive voicing.[23] Passive voicing occurs when stops without glottal spreading are voiced during most or all of closure if they occur in the context of sonorant sounds, even without any active voicing gestures (such as vocal-fold slacking, tongue root advancement, etc.) on the part of the speaker (Westbury 1983; Westbury and Keating 1986).

We assume a high-ranked constraint against voiced, spread glottis stops.

(25) ***voi/sg**
Voiced spread glottis stops are prohibited (Davis and Cho 2003).

We also assume a faithfulness constraint for the feature [sg]:

(26) **ID [spread]** (IDsg)
Correspondent input and output segments have the same specification for [spread].

There is no syllable-final devoicing of stops because all underlying stops in German are voiceless, either with the feature [sg] or without. In this analysis,

21. Note: *Jagden* is the plural of *Jagd* 'hunt' whereas *jagten* is a verb, '(they) hunted'.
22. Anderson and Ewen (1987), Iverson and Salmons (1995, 1999, 2003), Jessen (1989, 1996, 1998), Jessen and Ringen (2002), are but a few recent examples of linguists who also argue for this position.
23. In earlier versions of this article, we assumed that Passive Voice was a phonological constraint. Here we assume that it is phonetic, following Jessen and Ringen (2002).

forms such as *Tag* and *Jagden* are analyzed as in (27) and (28).[24] We assume that aspiration is the phonetic realization of a [sg] stop in German. However, [sg] is realized phonetically as aspirated if and only if it occurs before a sonorant.

(27) *Tag* 'day'

	/t^sg^ɑk/	*voi/sg	IDsg	*voi	*sg
a. ☞	[t^sg^ɑk]				*
b.	[tɑk]		*!		
c.	[d^sg^ɑk]	*!		*	*

In (28) the input has two voiceless non-[sg] stops. As shown in Jessen and Ringen (2002), the second stop in such clusters is voiceless and unaspirated. In our analysis, the second stop in the optimal output, (28a), is accurately represented as voiceless and unaspirated.

(28) *Jagden* (the) 'hunt' pl.

	Ja/k+t/+en	*voi/sg	IDsg	*voi	*sg
a. ☞	Ja[kt]en				
b.	Ja[kd]en			*!	
c.	Ja[gd]en			*!*	
d.	Ja[kt^sg^]en		*!		*

Further, in (29) the input has one intervocalic non-[sg] stop. The optimal candidate has a voiceless stop which is (variably) voiced by the phonetic constraint of passive voice.

(29) *jagen* 'to hunt'

	ja/k/+en	*voi/sg	IDsg	*voi	*sg
a.	ja[g]en			*!	
b. ☞	ja[k]en				
c.	ja[k^sg^]en		*!		*
d.	ja[g^sg^]en	*!	*	*	*

↳ *In the phonetics,* PASSIVE VOICE *yields [jagen]*

An initial non-[sg] stop is predicted to be voiceless (unaspirated), as illustrated in (30), and this is the correct surface form (see Jessen and Ringen 2002 for discussion).

24. We assume that **Agree** is low-ranked in German as there is no agreement of [spread] in stop clusters. If there were, we would expect the second stop in the word medial cluster in *Reitgerte* to be aspirated, but it is not.

(30) *deckte* '(it) covered'

	/t/eckte	*voi/sg	IDsg	*voi	*sg
a. ☞	[t]eckte				
b.	[d]eckte			*!	
c.	[t^{sg}]eckte		*!		*
d.	[d^{sg}]eckte	*!	*	*	*

*voi ≫ *sg

In (31), where the input has an intervocalic [sg] stop, the optimal output will have a voiceless aspirated stop, which is correct.

(31) *Hecke* 'hedge'

	he/k^{sg}/+e	*voi/sg	IDsg	*voi	*sg
a. ☞	he[k^{sg}]e				*
b.	he[k]e		*!		
c.	he[g]e		*!	*	
d.	he[g^{sg}]e	*!		*	*

When the first stop in a cluster is underlyingly [sg], as in (32), this feature is preserved in the output, but since the stop is not in presonorant position, it is not aspirated. As noted above, we assume that a stop specified as [sg] is aspirated if and only if it is followed by a sonorant segment. Hence, this analysis predicts that the entire cluster should be voiceless with no aspiration on the second stop, since this is the only stop in presonorant position.

(32) *Reitgerte* 'riding crop'

	Rei/t^{sg}+k/erte	*voi/sg	IDsg	*voi	*sg
a.	Rei[tk]erte		*!		
b. ☞	Rei[t^{sg}k]erte				*
c.	Rei[$t^{sg}k^{sg}$]erte		*!		**

When the second stop in a cluster is specified as [sg], it is correctly predicted to be aspirated, as illustrated in (33), if we assume that a [sg] segment before a sonorant is aspirated. [25]

(33) *jagten* '(they) hunted'

	ja/k+t^{sg}/+en	*voi/sg	IDsg	*voi	*sg
a.	ja[kt]en		*!		
b. ☞	ja[kt^{sg}]en[26]				*

25. Note that our analysis also predicts that in word-final position underlying [sg] stops have the [sg] feature in the output whereas non-[sg] stops do not. See Jessen and Ringen (2002) for discussion and an additional constraint that requires that all stops at the right edge of a prosodic word be [sg].

By Richness of the Base, we must also consider what happens to an input with a voiced stop. The optimal output for an input with a voiced stop, as in (34), will have a voiceless (unaspirated) stop. As Tableau (34) illustrates, **IDvoi** must be ranked below ***voi.**

(34)

/d/eckte[27]	*voi/sg	IDsg	*voi	IDvoi	*sg
a. [d]eckte			*!		
b. ☞ [t]eckte				*	
c. [t^{sg}]eckte		*!		*	*

*voi ≫ IDvoi

We have presented an account of German stops in which the feature of contrast is [sg], not [voice].[28] This analysis correctly predicts the distribution of both voice and aspiration.

In contrast to the [sg] analysis of German, a [voice] analysis accounts neither for the distribution of voicing nor aspiration. The problem with such an analysis is that it does not give an accurate account of the distribution of voiced and voiceless stops in German. Lombardi (1999) is but one recent example of an account in which [voice] is assumed to be the feature of contrast in German. She suggests that her constraints are ranked **IDOns** ≫ ***Lar** ≫ **Agree**, **IDLar** in German. On Lombardi's account, syllable-final devoicing occurs because an obstruent which is not in an onset before a sonorant is not required by **IDOns** to be faithful to its input laryngeal specification. Hence, if it is specified as [voice], it will violate ***Lar**. This is illustrated in (35):

(35) German – Lombardi (1999)

Ta/g/ 'day'	IDOns	*Lar	Agree	IDLar
☞ Ta[k]				*
Ta[g]		*!		
ja/g+t/en '(they) hunted'				
☞ jakten				*
jagten		*!	*	*

In an onset before a vowel, a stop is faithful to its input specification for voice, as illustrated in (36):

26. As noted by Jessen and Ringen (2002), in some cases the [t] had a nasal release.
27. By Lexicon Optimization, the lexical representation for *decken* would be /t/ecken, with /t/. We consider /d/eckte only to show that even an input with /d/ will result in a possible German output, as required by Richness of the Base.
28. For an account of German fricatives that is consistent with the Jessen and Ringen (2002) account of stops, see Beckman and Ringen (2004b).

(36) *jagen* ‘to hunt’ Lombardi (1999)

ja/g/+en	IDOns	*Lar	Agree	IDLar
a. ☞ ja.[g]en		*		
b. ja.[k]en	*!			*

On this analysis, the optimal output candidate for an input with a voiceless stop followed by a voiced stop has a cluster with the same specifications for voice as in the input, as illustrated in (37).

(37) *Ratgeber* ‘adviser’ Lombardi (1999)

Ra/t+g/eber	IDOns	*Lar	Agree	IDLar
a. ☹ Ra[t.g]eber		*	*	
b. Ra[d.g]eber		**!		*
c. Ra[t.k]eber	*!			*

However, as shown in Jessen and Ringen (2002), in words such as *Ratgeber*, the word-medial cluster is voiceless throughout, not voiceless-voiced, as predicted by Lombardi’s analysis. Moreover, in word-initial position, German orthographic *b*, *d*, *g* are pronounced as voiceless unaspirated stops unless preceded by a voiced sound, in which case passive voicing (may) occur. Hence, a form such as *(es) deckte* would be predicted to begin with a voiced stop on Lombardi’s analysis, and this is incorrect.

(38) *(es) deckte* ‘(it) covered’ Lombardi (1999)

/d/eckte	IDOns	*Lar	Agree	IDLar
a. ☹ [d]eckte		*		
b. [t]eckte	*!			*

On Lombardi’s analysis, it is not possible to assume that the initial stop in *deckte* is underlyingly voiceless, since German *does* have a two-way contrast between initial stops, as in *Tak* [t^h] ‘day’ and *Dach* [t] ‘roof’. If the initial stop in *deckte* (and *Dach*) is assumed to be voiceless, then it would not be distinct from the initial stop in a form such as *Tag*. However, if the distinction is instead between the presence of [spread] and lack of [spread], as assumed here, the absence of initial voiced stops is expected.

4. Swedish and Turkish

Swedish and Turkish are interesting because, unlike the languages considered so far, they have both aspirated stops and prevoiced stops.

4.1. Swedish

In Swedish[29] voiceless (post-)aspirated[30] stops occur in word-initial position whereas in intervocalic and final position, voiceless stops are preaspirated or unaspirated (Ringen and Helgason 2004). In clusters of voiceless stops (...VC_1 C_2V...), the presonorant stop (C_2) is unaspirated whereas the postsonorant stop (C_1) is preaspirated or unaspirated. Prevoiced stops are found in word-initial position; intervocalically, and word-finally fully voiced stops occur.[31] Examples of prevoiced and aspirated word-initial stops are given in (39):[32]

(39)	[p^h]acka	'pack'	[b]ad	'bath'
	[t^h]ak	'roof'	[d]äck	'deck'
	[k^h]ub	'cube'	[g]ap	'mouth'

Examples of fully voiced stops in intervocalic and word-final position are given in (40a). Examples of voiceless (preaspirated) stops in intervocalic position and in word-final position are illustrated in (40b).

(40)	a.	vä[g]a	'weigh'
		la[g]	'lie'
	b.	kö[^{h}p]a ~ kö[p]a	'buy'
		ta[^{h}k] ~ ta[k]	'roof'

Swedish has been characterized as having bidirectional devoicing. Wetzels and Mascaró (2001) use Swedish as an example to argue against privative voice, suggesting that it is a language in which [-voice] spreads. The basic facts of voice alternations in stop clusters are given in (41). As shown in (41a), the initial stop of the past tense suffix, /de/, is devoiced following the /p/ of *köp-* (progressive assimilation). In contrast, when the supine suffix /t/ follows a root ending with an underlying voiced stop, as in *väg-* (see 41b), the root-final stop is devoiced (regressive assimilation). (41c) shows that the underlying form of

29. Here we consider Central Standard Swedish.
30. Up to this point, all the aspirated stops that we have discussed have been postaspirated. Since Swedish has both preaspirated and postaspirated stops, we will use these terms when discussing aspiration in Swedish to distinguish the two types of aspiration.
31. Jessen (1998) suggests that Swedish is like German in having a [sg] rather than [voice] contrast. However, although Swedish has aspirated stops, it also has prevoiced stops in initial position.
32. Ringen and Helgason (2004) measured prevoicing for 6 speakers of Central Standard Swedish. They found that 212 of 228 tokens (93 %) of word-initial so-called 'lenis' stops exhibited some degree of prevoicing. Word-initial so-called 'fortis' stops were aspirated. For more on Swedish preaspiration, see also Helgason (2002). Most discussions of Swedish in the phonological literature cite Helberg's (1972, 1974) works, which are based on impressionistic transcriptions.

the past suffix begins with a voiced stop and the underlying form of the supine suffix is a voiceless stop.

(41) a. kö[^{h}p-t]e ∼ kö[p-t]e < kö/p+d/e (past)
kö[^{h}p-t] ∼ kö[p-t] 'bought (supine)' < kö/p+t/
b. vä[g-d]e < vä/g+d/e (past)
vä[^{h}k-t] ∼ vä[k-t] 'weighed (supine)' < vä/g+t/
c. skyl-[d]e 'cover (past)' skyl-[t] 'cover (supine)' cf. *skyla* 'cover'

If we assume that Swedish has both underlying [spread] and [voice] stops, the bidirectional devoicing in Swedish can be accounted for with the constraints assumed for German with two additional assumptions. First, we adopt the constraint **Specify**, requiring that a stop be specified for a laryngeal feature (Kaun 1995; Beckman and Ringen 2004a).

(42) **Specify**
Stops must be specified for a laryngeal feature.

Second, we assume, following Pater (1999), that the (bidirectional) constraint, IDsg, is actually two unidirectional constraints, ID-I→Osg and ID-O→Isg.

(43) **ID-I→Osg**[33]
If an input segment is specified as [spread], its correspondent output segment must be specified as [spread].

(44) **ID-O→Isg**
If an output segment is specified as [spread], its correspondent input segment must be specified as [spread].

We assume that aspiration, whether pre- or post-, is the *phonetic* realization of the phonological feature [spread]. Thus, in some languages, the phonetic realization of [spread] is postaspiration, whereas in Swedish it is sometimes post- and sometimes pre-aspiration. We do not attempt to predict whether a particular language will realize [spread] as pre- or post-aspiration, as this, we

33. This constraint is unidirectional, that is, it is violated if the output correspondent of an input segment which is specified with [spread] is not also specified with [spread], but not if the input correspondent of an output segment specified with the feature [spread] is not also specified with [spread]. Lombardi (2001) argues for a similar constraint, **MaxLar**, which is violated if input laryngeal features are not present in the output. The two are not equivalent. A unidirectional faithfulness constraint is not violated if the input segment is deleted, a Max-feature constraint is. A unidirectional faithfulness constraint is violated if the input feature in question is associated with a different segment in the output than it is in the input, A Max feature constraint is not. A Max-feature constraint, **Maxsg**, could be substituted for the unidirectional **ID-I→Osg** constraint in our analysis with no difference in empirical coverage.

assume, is part of the phonetics, not the phonology. Moreover, we assume that the fact that a stop specified as [spread] may not always be realized as aspirated, or may be less aspirated in an unstressed syllable, has to do with the *phonetic* implementation of the phonological feature [spread].

Our account follows the analysis sketched in Ringen and Helgason (2004). The tableau in (45) illustrates progressive assimilation of the feature [spread], which results in the devoicing of the underlying /d/. Here we see that for Swedish, the constraint ID-I→Osg must be ranked above the constraint ID-O→Isg because with the other ranking, (45c) would be optimal.

(45) Progressive

kö/p^{sg}+d/e	*voi/sg	Specify	Agree	ID-I→Osg	ID-O→Isg	IDvoi	*sg	*voi
a. kö[pt]e		*!*		*		*		
b. kö[p^{sg}d]e			*!*				*	*
c. kö[bd]e				*!		*		**
d. ☞ kö[p^{sg}t^{sg}]e					*	*	**	
e. kö[b^{sg}d^{sg}]e	*!*				*	*	**	**

Agree ≫ ID-O→Isg; ID-I→Osg ≫ ID-O→Isg;
Specify ≫ ID-O→Isg

In (45) the optimal output has two stops specified as [spread], yet only one is (pre)aspirated. We assume that the *phonetic* implementation of [spread] is different in Swedish and in German. In Swedish, [spread] of a post-sonorant stop in a cluster is realized as preaspiration whereas in German such a [spread] stop is *not* preaspirated (see (32)). In German, [spread] stops are only realized as (post)aspirated before sonorants.

The tableau in (46) illustrates regressive assimilation of the [spread] feature, which results in the devoicing of the underlying /g/. Note here that the fact that the [k] is preaspirated means that it must be specified as [spread]. If devoicing were the result of the spreading of a [−voice] feature, as suggested by Wetzels and Mascaró (2001), this preaspiration would not be expected.

(46) Regressive

vä/g+t^{sg}/	*voi/sg	Specify	Agree	ID-I→Osg	ID-O→Isg	IDvoi	*sg	*voi
vä[kt^{sg}]		*!	*			*	*	
vä[gt^{sg}]			*!*				*	*
vä[gd]				*!		*		**
☞ vä[k^{sg}t^{sg}]					*	*	**	
vä[g^{sg}d^{sg}]	*!*				*	*	**	**

The next tableau illustrates that, although it is assumed that both [voice] and [spread] are found in inputs, no three-way contrast is possible: an input voiceless unaspirated stop surfaces as voiced.[34, 35] We omit *voi/sg from subsequent tableaux.

(47)

	/k/ub	Specify	Agree	ID-I→Osg	ID-O→Isg	IDvoi	*sg	*voi
	[k]ub	*!						
☞	[g]ub					*		*
	[k^{sg}]ub				*!		*	

Inputs with voiceless [spread] or [voice] stops surface with underlying laryngeal specifications intact, as illustrated in the tableaux in (48):

(48)

	/k^{sg}/ub	ID-I→Osg	ID-O→Isg	IDvoi	*sg	*voi
	[k]ub	*!				
	[g]ub	*!		*		*
☞	[k^{sg}]ub				*	
	/g/ap					
	[k]ap			*!		
	[k^{sg}]ap		*!	*	*	
☞	[g]ap					*

IDsg ≫*sg; *voi ≫ *sg; IDvoi ≫ *voi

Lombardi (1999) assumes that her positional faithfulness constraint is ranked below a general faithfulness constraint, **IDLar** ≫ **IDOns** in Swedish.[36] Her analysis of the bidirectional devoicing in the clusters in (49) is shown in (50). (Lombardi states that **Agree** and **IDLar** are not crucially ranked, but this is apparently an error since her own tableaux show that they must be ranked as in (50).)

34. By Richness of the Base, an input with no laryngeal specification must yield a *possible* output. By Lexicon Optimization (Prince and Smolensky 1993/2002) an input such as /k/ub would never actually be chosen as the optimal *lexical representation* for a word such as [g]ub.
35. The constraint **Specify** suggests that there should be languages with only voiced stops and others with only voiceless aspirated stops. Whether such languages exist is an empirical question that cannot be answered without investigation of the phonetic facts of languages with only one stop series. An alternative to **Specify** would be to assume only input [spread] stops and a phonetic enhancement constraint that maximizes laryngeal contrast (Avery and Idsardi 2001) by supplying [voice] to unspecified stops. Another alternative would be to assume that [voice] is binary and that aspiration results from a probabilistic constraint to enhance the voicing contrast (Boersma 2003). On this account, the speaker produces the [−voice] stop with aspiration to avoid the hearer *misperceiving* it as voiced. Full discussion of the differences in these approaches is not possible here.
36. Beckman (1998) suggests that positional faithfulness constraints are always ranked above general faithfulness constraints. Lombardi's ranking is the opposite.

(49) sko[g] 'forest' sko[ks] gen.
ste[kt]e 'fried' < ste/k+d/e (cf. *skyl-de* 'covered')

(50)

a. sko/gs/	Agree	IDLar	*Lar	IDOns
sko[gs]	*!		*	
☞ sko[ks]		*		
sko[gz]		*	*!*	
b. ste/kd/e				
ste[kd]e	*!		*	
ste[gd]e		*	*!*	
☞ ste[kt]e		*		*

As Baković (1999b) notes, Lombardi's analysis of Swedish also (potentially) suffers from the majority rule problem. The optimal output for an input with two voiced obstruents and one voiceless obstruent will have a voiced cluster, as illustrated in (51a), whereas the optimal output for an input with two voiceless obstruents and one voiced obstruent will have a voiceless cluster, as illustrated in (51b).

(51) Lombardi (1999)

a. /kdz/	Agree	IDLar	*Lar	IDOns
[kts]		**!		
☞ [gdz]		*	***	
b. /ktz/				
☞ [kts]		*		
[gdz]		**!	***	

As noted in Section 2.2 above, analyses that involve majority rule are problematic because no language is known in which the voice quality of final clusters is determined by whether there are more input voiced or voiceless obstruents. As can be seen by the examples in (52), the account proposed here does not suffer from the majority rule problem. Here we assume that voiceless fricatives are [spread].[37] Clusters with a segment specified as [spread] in the input are [spread] (and hence voiceless) in the output. Otherwise, they are voiced. The number of voiced or voiceless segments in the input cluster is irrelevant.

37. See Vaux (1998) and Jessen (1998) for discussion of the laryngeal specification of voiceless fricatives.

(52) Our analysis

a. /kdz/	Specify	Agree	ID-I→Osg	ID-O→Isg	IDvoi	*sg	*voi
[kts]	*!**				**		
☞ [gdz]					*		***
[$k^{sg}t^{sg}s^{sg}$]				*!**	**	***	
b. /ktz/							
[kts]	*!**				*		
☞ [gdz]					**		***
[$k^{sg}t^{sg}s^{sg}$]				*!**	*	***	
c. /$p^{sg}t^{sg}z$/							
[$p^{sg}t^{sg}z$]		*!*				**	*
[bdz]			*!*		**		***
☞ [$p^{sg}t^{sg}s^{sg}$]				*	*	***	
[pts]	*!**		**		*		

In this section, we have seen that the long-standing problem of Swedish bidirectional devoicing has a straightforward solution.[38] The account of assimilation in stop clusters does not require the specification of [−voice], as claimed by Wetzels and Mascaró (2001).[39] Finally, this analysis does not suffer from the majority rule problem.

4.2. Turkish

Turkish is a language which, like Swedish, has surface aspirated stops and (pre)voiced stops.[40] Following Kallestinova (2004), we suggest that Turkish has both [voice] and [spread] in input forms.[41] Turkish has (pre)voiced stops and aspirated stops in word-initial position, both aspirated and voiced stops in intervocalic position, and voiced and voiceless stops word-finally.

38. As shown by Ringen and Helgason (2004), Swedish is a counter example to van Rooy and Wissing's (2001) claim that languages with prevoicing always have regressive assimilation of voicing.
39. See Beckman and Ringen (2004a) for an argument that specification of both [voice] and [spread] in Swedish is required by the tenets of Lexicon Optimization and Richness of the Base.
40. Kallestinova (2004) measured voicing during closure and VOT.
41. Our analysis differs in certain respects from that of Kallestinova (2004). For example, she assumes that Passive Voice is phonological, whereas we assume it is phonetic. However, the basic analysis of the three-way Turkish contrast in behavior of intervocalic stops follows her analysis.

(53) Turkish (Kallestinova 2004)

a.	[pʰul]	'stamp'	[bul]	'find'
b.	[kʰap]	'container'	[kʰabɨ]	'container-3sg. poss.'
	[kʰanat]	'wing'	[kʰanadɨ]	'wing-acc.'
c.	[sap]	'stem'	[sapʰɨ]	'stem-acc.'
	[at]	'horse'	[atʰɨ]	'horse-3sg. poss.'
d.	[ad]	'name'	[adɨ]	'name-3sg. poss.'
	[öd]	'gall'	[ödü]	'gall-acc.'

Both aspirated and voiced stops occur in word-initial position, as illustrated in (53a). Like German, Turkish non-sg stops are passively voiced intervocalically, as illustrated in (53b), and stops that are underlyingly [sg] are (post)aspirated intervocalically, as illustrated in (53c). However, Turkish differs from German in that there are underlying voiced stops, as illustrated by the forms in (53d), as well as those that arise because of passive voice (53b). Hence, there are some intervocalic voiced stops that are underlying (not a result of passive voicing). These stops are voiced in word-final position as well.

The constraints that we have assumed to be active in Swedish also play an important role in accounting for the distribution of voice and aspiration in Turkish, although it is not crucial that IDsg be split into two unidirectional constraints. The tableaux in (54) show that a stop that is specified as [spread] retains this feature in the output. It will only be realized as aspirated in presonorant position.

(54) Underlying [spread]

a/t^{sg}/+i	IDsg	IDvoi	*sg	*voi
☞ at^{sg}ɨ			*	
adɨ	*!	*		*
atɨ	*!			
a/t^{sg}/				
☞ at^{sg}			*	
ad	*!	*		*
at	*!			

IDsg ≫ *sg

The forms in (55) show that these constraints preserve [voice] of an underlying stop in root-final position.

(55) Underlying [voice]

	a/d/+i	IDsg	IDvoi	*sg	*voi
	at^{sg}ɨ	*!	*	*	
☞	adɨ				*
	atɨ		*!		
	a/d/				
	at^{sg}	*!	*	*	
☞	ad				*
	at		*!		

IDvoi ≫ *voi

The forms in (56) have underlying plain stops in root-final position, specified for neither [voice] nor [spread]. These stops are voiced in intervocalic position by phonetic passive voice, but are voiceless in word-final position.[42]

(56) Turkish

	ka/p/+i	IDsg	IDvoi	*sg	*voi
	kap^{sg}ɨ	*!		*	
☞	kapɨ				
	kabɨ		*!		*
	ka/p/				
	kap^{sg}	*!		*	
	kab		*!		*
☞	kap				

↳ *In the phonetics,* PASSIVE VOICE *yields [kabɨ]*

In clusters, obstruents agree in voicing. The data in (57) show that the ablative suffix alternates between a voiced and voiceless stop (Kallestinova 2004).

42. As Kallestinova notes, Passive Voice in Turkish only voices stops between vowels, not between sonorants, cf. ka[p]lar 'container pl' but ka[b]ɨ.

(57) The ablative suffix *tan/dan/ten/den*

a.	[k^{h}ap-tan]	‘container-abl.’	(cf. k^{h}ab-ɨ)
	[k^{h}anat-tan]	‘wing-abl.’	(cf. k^{h}anad-ɨ)
	[yat^{h}ak-tan]	‘bed-abl.’	(cf. yatağ-i)
b.	[sap-tan]	‘stem-abl.’	(cf. sap^h-ɨ)
	[at-tan]	‘horse-abl.’	(cf. at^h-ɨ)
c.	[ad-dan]	‘name-abl.’	(cf. ad-ɨ)
	[ud-dan]	‘oud-abl.’	(cf. ud-u)
	[ev-den]	‘house-abl.’	
d.	[masa-dan]	‘table-abl.’	
e.	[göl-den]	‘lake-abl.’	
	[k^{h}alem-den]	‘pen-abl.’	

It is apparently the root-final stop that determines the quality of the cluster, since the suffix has a voiceless stop when the root-final stop is voiceless, as in (57a-b), but a voiced stop when the root-final stop is voiced, as in (57c). The ablative suffix begins with a stop that is voiced when it follows a vowel, as seen in (57d). Thus, the underlying suffix-initial stop must be voiced or plain voiceless (not [spread]). We assume that the ablative suffix begins with a voiced stop because it is voiced following sonorant consonants, as in (57e), and passive voice only occurs between vowels in Turkish (cf. Fn. 42). Thus the underlying initial stop in the ablative suffix must be voiced.

In order to account for the voice alternations in the clusters in (57), we assume that an **Agree** constraint is active. However, since the suffix-initial stop in the forms in (57b) is not aspirated (Kallestinova 2004), the Agree constraint cannot be the **Agree**(Laryngeal) constraint we have assumed above, but rather must be more specific, namely **Agree$_{\mathbf{voi}}$**.

(58) **Agree voice** (Agree$_{voi}$)
Adjacent obstruents agree in specification for [voice]

In order to guarantee that it is always the root-final stop that determines the voicing in the cluster, we must also adopt a root faithfulness constraint:

(59) **ID-Root**
Correspondent input and output segments in the root must have identical specifications for laryngeal features.[43]

The tableaux in (60) illustrate how the forms in (57) are accounted for with these constraints.

43. We assume that ID-Root is low-ranked in German, Swedish, Russian, and Hungarian.

(60) Turkish

/k^{sg}ap+dan/	Agree$_{voi}$	IDsg	ID-Root	IDvoi	*sg	*voi
k^{sg}apdan	*!				*	*
k^{sg}abdan			*!	*	*	**
☞ k^{sg}aptan				*	*	
sa/p^{sg}+d/an						
sap^{sg}dan	*!				*	*
saptan		*!	*	*		
sap^{sg}t^{sg}an		*!		*	**	
☞ sap^{sg}tan				*	*	
a/d+d/an						
adtan	*!			*		*
attan			*!	**		
☞ addan						**

ID-Root, Agree$_{voi}$, IDsg ≫ IDvoi

The relative suffix -k^{h}i begins with an aspirated stop:

(61) masa-da-[k^{h}ɨ] 'the one on the table'
köşe-de-[k^{h}i] 'the one in the corner'

Although this and other suffixes beginning with an aspirated stop are never attached to roots, Kallestinova tested some nonce forms with these suffixes attached directly to roots. Some of these are given in (62):

(62) /ad+ k^{sg}i/ [atk^{h}ɨ]
/ud+k^{sg}i/ [utk^{h}u]
/sepet^{sg}+k^{sg}i/ [sepetk^{h}i]

These forms can be accounted for with the constraints we have assumed if **IDsg** and **Agree$_{voi}$** are ranked above **ID-Root**.

(63)

/ad+ k^{sg}i/	Agree$_{voi}$	IDsg	ID-Root	IDvoi	*sg	*voi
adk^{sg}i	*!				*	*
adgi		*!		*		**
☞ atk^{sg}ɨ			*	*	*	

IDsg, Agree$_{voi}$ ≫ ID-Root

In word-initial position, stops are either voiced or aspirated.[44] There is no three-way contrast of voice and aspiration here; there are both initial aspirated

44. Kallestinova (2004) reports on two speakers, both of whom exhibited consistent prevoicing only in initial bilabial stops. Stops with other places of articulation were usually voiceless unaspirated (or voiceless aspirated). Ringen (2005) tested six other Turkish speakers

and voiced stops, which are correctly predicted to occur, as illustrated in (64), but there are no plain voiceless stops in word-initial position. However, the analysis sketched so far predicts that there should be, as illustrated in (65).

(64)

/p^{sg}/ul	IDsg	ID-Root	IDvoi	*sg	*voi
☞ p^{sg}ul				*	
bul	*!	*	*		*
pul	*!	*			
/b/ul					
☞ bul					*
pul		*!	*		
p^{sg}ul	*!		*	*	

(65)

/p/ul	IDsg	ID-Root	IDvoi	*sg	*voi
☹ pul					
bul		*!	*		*
p^{sg}ul	*!	*		*	

We assume that a member of the Specify family requires that a stop in the initial syllable be specified for laryngeal features:

(66) **Specify** σ^1
A stop in the initial syllable must be specified for laryngeal features.[45]

With **Specify** $\boldsymbol{\sigma^1}$ ranked high, an input with a word-initial stop with no laryngeal specification will be voiced on the surface

(67)

/p/ul	Specifyσ^1	IDsg	ID-Root	IDvoi	*sg	*voi
pul	*!					
☞ bul			*	*		*
p^{sg}ul		*!	*		*	

Inkelas (1995) argues that Turkish “requires the contrastive use of underspecification.” She suggests that the alternating stops are unspecified for [voice], those that are always voiceless should be specified as [−voice], and those that are always voiced as [+voice]. For example, she gives the following underlying forms:

---

and found consistent prevoicing of initial stops in all places of articulation (94.6 % of the words beginning with lax stops exhibited prevoicing). Kallestinova assumes that the failure of [voice] to be realized as vocal fold vibration during closure on all the stops in Turkish for her speakers has a phonetic explanation: It is most difficult to maintain voicing for velars, less difficult for alveolars, and easiest for bilabials (Ohala 1983).

45. Kallestinova assumes a different constraint, one requiring that a stop in an initial syllable be voiced.

(68) /kanaD/ Ø 'wing'
/sanat/ [−voice] 'art'
/etüd/ [+voice] 'etude'

Inkelas also proposes a reformulation of Lexicon Optimization (Prince and Smolensky 1993/2002) which, she claims, designates an underspecified underlying form as the optimal input for alternating forms with predictable alternations. We have just seen that there is an alternative account of these otherwise problematic Turkish facts, which does not require a reformulation of Lexicon Optimization and which is more closely grounded in the phonetic facts of Turkish:[46] those stops that are aspirated are underlyingly [spread], those that are always voiced are specified as [voice] in the underlying form, and those that are sometimes voiced and sometimes voiceless are underlyingly plain voiceless unaspirated stops (of the type found in German) which undergo passive voicing in intervocalic environments.[47]

The example of Turkish illustrates an important point: constraints on laryngeal features and **Agree** can interact with other well-documented constraints, such as **ID-root**, to yield patterns of laryngeal agreement not even mentioned in the literature on voice assimilation. This shows that the typology of laryngeal assimilation is considerably richer than is generally recognized in the phonological literature.

5. Conclusion

In this article, we have considered a variety of languages that have usually been characterized in the literature of generative phonology as having a contrast of the feature [voice]. We have shown that if we hug the phonetic ground by using [voice] only for those systems which have prevoiced stops in word-initial position and [spread] in languages with an aspiration contrast, a better understanding of the laryngeal contrasts and assimilation of laryngeal features is possible. We have shown that this strategy allows for solutions to some long-standing puzzles. For example, we have seen that the bi-directional devoicing in Swedish can be described without reference to [−voice]. The question of

46. Inkelas and Orgun (1994) note that the analysis of Inkelas (1995) requires reference to [−voice], which is not possible if one adopts the widely held assumption that the feature [voice] is privative. They note that a possible alternative would be to use the feature [+asp] instead of [−voice], but do not trace through the implications of this assumption. It is important to note, however, that the substitution of the feature [+asp] (or [spread]) for [−voice] cannot be done without a major revision of the Inkelas (1995) account.
47. See Beckman and Ringen (2004a) for arguments that such an analysis of the Turkish stops follows from the tenets of OT, Richness of the Base and Lexicon Optimization.

how to account for Turkish laryngeal contrast is solved as soon as it is admitted that Turkish employs both [voice] and [spread]. We have shown that many of the same constraints are active in these different languages. However, we have not provided a complete typology of the array of languages with voiced or aspirated stops (or both). Such a typology is simply not possible without detailed phonetic descriptions, which are not always available. For example, in order to provide an analysis that correctly predicts where stops are aspirated or voiced, it is necessary to know where aspiration and voicing actually occur. Since most languages with aspiration contrasts have been treated as if the contrast is one of [voice] rather than one of [spread], such information is often not readily available. Further research is clearly needed to determine what the phonetic facts are.

Kirkwood Community College
University of Iowa
University of Veszprém

References

Anderson, John M. and Colin J. Ewen (1987). *Principles of Dependency Phonology*. Cambridge: Cambridge University Press.

Avery, Peter and William Idsardi (2001). Laryngeal dimensions, completion and enhancement. In *Distinctive Feature Theory*, T. Alan Hall, (ed.), 4–70. Berlin: de Gruyter.

Baković, Eric (1999a). Assimilation to the unmarked. *University of Pennsylvania Working Papers in Linguistics*, Vol. 6 (1): 1–16.

— (1999b). Assimilation to the unmarked. Handout from Penn Linguistics Colloquium, University of Pennsylvania, Philadelphia.

Beckman, Jill N. (1995). Shona height harmony: Markedness and positional identity. In *UMOP 18: Papers in Optimality Theory,* Jill N. Beckman, Laura W. Dickey and Suzanne Urbanczyk, (eds.), 53–76. Amherst, MA: GLSA.

— (1997). Positional faithfulness, positional neutralisation and Shona vowel harmony. *Phonology* 14: 1–46.

— (1999). *Positional Faithfulness*. New York: Garland.

Beckman, Jill and Catherine Ringen (2004a). Contrast and redundancy in OT. *Proceedings of WCCFL 23*. V. Chand, A. Kelleher, A. Rodriguez and B. Schmeiser (eds.), 85–98. Somerville, MA: Cascadilla Press.

— (2004b). The role of [voice] and [spread] in German obstruents. Paper presented at the Tenth Mid-Continent Workshop on Phonology, Northwestern University, October.

Boersma, Paul (2003). The control of comprehension. In *Proceedings of the Stockholm Workshop on Variation within Optimality Theory*, Jennifer Spenader, Anders Eriksson and Östen Dahl (eds.), 47–56. Stockholm University: Department of Linguistics.

Cho, Young-mee (1990). A typology of voicing assimilation. In *Proceedings of the Ninth West Coast Conference on Formal Linguistics*, A. Halpern (ed.), 141–155. Stanford: CSLI.

— (1994). Morphological and universal devoicing in English and Swedish. *The Linguistic Review* 11: 221–239.

Cohn, Abigail C. (1993). Nasalisation in English: Phonology or phonetics. *Phonology* 10: 43–81.

Darden, Bill J. (1991). Linear assimilation in clusters. *Papers from the 27th Meeting of the Chicago Linguistics Society*: 100–106.

Davis, Stuart and Mi-Hui Cho (2003). The distribution of aspirated stops and /h/ in American English and Korean: An alignment approach with typological implications. *Linguistics* 41: 607–652.

Helgason, Pétur (2002). Preaspiration in the Nordic Languages: Synchronic and Diachronic Aspects. Unpublished Ph.D. dissertation, Stockholm University.

Hellberg, Staffan (1972). Ordering relations in the phonology of Swedish adjectives. In *Gothenburg Papers in Theoretical Linguistics*, 1–16. University of Göteborg: Dept. of Linguistics.

— (1974). *Graphonomic Rules in Phonology*. Göteborg: Acta Universitatis Gothoburgensis.

Inkelas, Sharon (1995). The consequences of optimization for underspecification. *NELS* 25 (1): 287–302.

Inkelas, Sharon and Orhan Orgun (1994). Level economy, derived environment effects and the treatment of exceptions. In *Recent Developments in Lexical Phonology*, Richard Wiese (ed.), 63–90. Vol. 56 von Arbeiten des Sonderforschungsbereichs 282, Theorie des Lexikons, Seminar f. Allgemeine Sprachwissenschaft, Universität, Düsseldorf.

Iverson, Gregory K. and Joseph C. Salmons (1995). Aspiration and laryngeal representation in Germanic. *Phonology* 12: 369–396.

— (1999). Glottal spreading bias in Germanic. *Linguistische Berichte* 178: 135–151.

— (2003). Legacy specification in the laryngeal phonology of Dutch. *Journal of Germanic Linguistics* 15 (1): 1–26.

Jessen, Michael (1989). Laryngeale Mechanismen in der Phonetik und Phonologie des Deutschen. Auslautverhärtung, Stimmassimilation und Vokaleinsätze aus universal-grammatischer Sicht. Ms., University of Bielefeld [revised version of 1989 M.A. Thesis, University of Bielefeld].

— (1996). The relevance of phonetic reality for underlying phonological representation: The case of tense versus lax obstruents in German. In *Interfaces in Phonology,* Ursula Kleinhenz (ed.), 294–328. Berlin: Akademie-Verlag.

— (1998). *Phonetics and Phonology of Tense and Lax Obstruents in German.* Amsterdam: John Benjamins.

— (2001). Phonetic implementation of the distinctive auditory features [voice] and [tense] in stop consonants. In *Distinctive Feature Theory*, T. Alan Hall (ed.), 237–294. Berlin: Mouton de Gruyter.

Jessen, Michael and Catherine Ringen (2002). Laryngeal features in German. *Phonology* 19: 189–218.

Kallestinova, Elena (2004). Voice and aspiration in Turkish stops. In *Folia Linguistica 38: Special Issue on Voice,* Grzegorz Dogil (ed.), 117–143. Berlin: Mouton de Gruyter.

Kaun, Abigail (1995). The typology of rounding harmony: An Optimality Theoretic approach. Unpublished Ph.D. dissertation, UCLA, Los Angeles.

Keating, Patricia A. (1984). Phonetic and phonological representation of stop consonant voicing. *Language* 60: 286–319.

— (1996). The phonology-phonetics interface. In *Interfaces in Phonology*, Ursula Kleinhenz (ed.), 262–278. Berlin: Akademie-Verlag.

Kenstowicz, Michael, Mahasen Abu-Mansour, and Miklós Törkenczy (2003). Two notes on laryngeal licensing. In *Living on the Edge: 28 Papers in Honour of Jonathan Kaye*, Stefan Ploch, (ed.), 259–282. Berlin: Mouton de Gruyter.

Kingston, John and Randy L. Diehl (1994). Phonetic knowledge. *Language* 70: 419–454.

Lisker, Leigh and Arthur S. Abramson (1964). A cross-language study of voicing in initial stops: Acoustical measurements. *Word* 20: 384–422.

Lombardi, Linda (1994). *Laryngeal Features and Laryngeal Neutralization*. New York: Garland.

— (1999). Positional faithfulness and voicing assimilation in Optimality Theory. *NLLT* 17: 276–302.

— (2001). Why place and voice are different: Constraint-specific alternations in Optimality Theory. In *Segmental Phonology in Optimality Theory,* Linda Lombardi (ed.), 13–45. Cambridge: Cambridge University Press.

McCarthy, John and Alan Prince (1993). Prosodic morphology I: Constraint interaction and satisfaction. Ms., University of Massachusetts, Amherst and Rutgers University.

— (1995). Faithfulness and reduplicative identity. In *UMOP 18: Papers in Optimality Theory,* Jill N. Beckman, Laura W. Dickey and Suzanne Urbanczyk (eds.), 249–384. Amherst, MA: GLSA.

Milberg, W., S. Blumstein, and B. Dworetzky (1988). Phonological factors in lexical access: Evidence from an auditory lexical decision task. *Bulletin of the Psychonamic Society* 26: 305–308.

Nooteboom, S. G. (1981). Lexical retrieval from fragments of spoken words: Beginnings versus endings. *Journal of Phonetics* 9: 407–424.

Nooteboom, S. G. and N. J. van der Vlugt, (1988). A search for a word-beginning superiority effect. *Journal of the Acoustical Society of America* 84: 2018–2032.

Ohala, John J. (1983). The origin of sound patterns in vocal tract constraints. In *The Production of Speech*, Peter F. MacNeilage (ed.), 189–216. New York: Springer.

Ostendorp, Marc van (2003). Towards a quantitative analysis of fricative voicing. Handout, Manchester Phonology Meeting, Manchester, England.

Pater, Joe (1999). Austronesian nasal substitution and other NC̥ effects. In *The Prosody–Morphology Interface*, René Kager, Harry van der Hulst and Wim Zonneveld, (eds.), 310–343. Cambridge: Cambridge University Press.

Petrova Olga (2003). Sonorants and the labiodental continuant /v/ in Russian: An OT analysis. In *Annual Workshop on Formal Approaches to Slavic Linguistics, The Amherst Meeting 2002*, Wayles Browne, Ji-Yung Kim, Barbara H. Partee, and Robert Rothstein (eds.), 413–432. Ann Arbor: Michigan Slavic Publications.

Petrova, Olga, Rosemary Plapp, Catherine Ringen, and Szilárd Szentgyörgyi (2000). Constraints on voice: An OT typology. Paper presented at the Annual Meeting of the Linguistic Society of America.

Petrova, Olga and Szilárd Szentgyörgyi (2004). /v/ and voice assimilation in Hungarian and Russian. In *Folia Linguistica 38: Special Issue on Voice,* Grzegorz Dogil (ed.), 87–116. Berlin: Mouton de Gruyter.

Prince, Alan and Paul Smolensky (1993/2002). Optimality Theory: Constraint interaction in generative grammar. *Technical Report #2 of the Rutgers Center for Cognitive Science*. Rutgers University, New Brunswick, NJ.

Ringen, Catherine (2004). Cross-linguistic differences and similarities in stop voicing. Ms., University of Iowa, Iowa City.

Ringen, Catherine and Pétur Helgason (2004). Distinctive voice does not imply regressive assimilation: Evidence from Swedish. In *International Journal of English Studies* 4 (2): *Advances in Optimality Theory,* Paul Boersma and Juan Antonio Cutillas-Espinosa, (eds.), 53–71. Murcia, Spain: University of Murcia.

Rooy, Bertus van and Daan Wissing (2001). Distinctive [voice] implies regressive voicing assimilation. In *Distinctive Feature Theory,* T. Alan Hall (ed.), 295–334. Berlin: Mouton de Gruyter.

Rubach, Jerzy (1996). Nonsyllabic analysis of voice assimilation in Polish. *Linguistic Inquiry* 27: 69–110.

— (1997). Polish voice assimilation in Optimality Theory. *Rivista di Linguistica* 9 (2): 291–342.

Salasoo, A., and D. B. Pisoni (1985). Interaction of knowledge sources in spoken word identification. *Journal of Memory and Language* 24: 210–231.

Selkirk, Elisabeth (1994). The constraint question for feature structure: A review of some answers. Ms., University of Massachusetts, Amherst.

Siptár, Péter and Szilárd Szentgyörgyi (2002). H as in Hungarian. *Acta Linguistica Hungarica* 49: 427–451.

— (2004). A H-féle hangok optimális elemzéséről [About an optimal analysis of Hungarian H-type segments]. In *Nyelvtudományi Közlemények* 101. Budapest: Akadémiai Kiadó.

Steriade, Donca (1997). Phonetics in phonology: The case of laryngeal neutralization. Ms., UCLA, Los Angeles.

Szentgyörgyi, Szilárd and Péter Siptár (2004). Hungarian H-type segments in Optimality Theory. In *Approaches to Hungarian 9: Papers from the Düsseldorf conference,* Christopher Piñón and Péter Siptár, (eds.). Budapest: Akadémiai Kiadó.

Vaux, Bert (1998). The laryngeal specification of fricatives. *Linguistic Inquiry* 29: 497–511.

Walker, Rachel (2005). Weak triggers in vowel harmony. *NLLT* 23: 917–989.

Westbury, John R. (1983). Enlargement of the supraglottal cavity and its relation to stop consonant voicing. *Journal of the Acoustical Society of America* 73: 1322–1336.

Westbury, John R. and Patricia Keating (1986). On the naturalness of stop consonant voicing. *Journal of Linguistics* 22: 145–166.

Wetzels, W. Leo and Joan Mascaró (2001). The typology of voicing and devoicing. *Language* 77: 207–244.

Zsigri, Gyula (1998). Parametrical domains and clusters: An OT approach to voice agreement and final devoicing. Ms., József Attila University, Szeged, Hungary.

Zonneveld, Wim (2004). Issues regarding devoicing in Dutch. Ms., Research Institute of Language and Speech, Utrecht University, Netherlands.

Zubritskaya, Ekaterina L. (1995). The categorical and variable phonology of Russian. Unpublished Ph.D. dissertation, University of Pennsylvania.