

# Laryngeal Assimilation, Markedness, and Typology\*

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Accepted typologies of voice assimilation within obstruents include languages that exhibit either assimilation to voicelessness (i.e. a type of “emergence of the unmarked” effect) or onset-controlled patterns, where the value controlling the change is in the onset obstruent. In either case, this type of local assimilation is considered to result in (contextually) unmarked structures. This paper presents data that outlines a previously unrecognized typological pattern: assimilation resulting in voicing (i.e. an “emergence of the marked” effect). This pattern has implications for how markedness is expressed in grammar. It is argued here that voicing is a privative feature, and that faithfulness constraints regulating the feature [voice] yield a rich typology that includes emergence of both marked and unmarked patterns. In addition, this typology yields benefits that are lost if voicing is considered a binary feature. This is illustrated by extending the dynamics of this voicing typology to other laryngeal features, such as [spread glottis], where similar predictions are made and confirmed.

## 1. Introduction

Current typological approaches to voice assimilation in obstruents define two basic patterns: assimilation which is “controlled” by a specific prosodic position such as the syllable onset, and assimilation which results in, all other things being equal, unmarkedness; i.e., assimilation resulting in voicelessness. This “emergence of the unmarked” effect arises through the interaction of constraints requiring voicing agreement with constraints banning the marked feature [voice]. Given this, there is a pattern that is predicted never to arise: assimilation to the marked. In other words, when a grammar is given the choice between two competing repairs for a structure with

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underlyingly disagreeing voicing values, both of which result in voicing agreement, it will always select the option that best satisfies markedness demands. Patterns of voice assimilation in favor of marked structures have been considered true gaps; for instance, Baković (1999:2) notes that “there are apparently no languages in which there is assimilation to the marked value [+v] when onset-specific faithfulness is irrelevant.”

This paper aims to enrich the typology of voice assimilation patterns by presenting a genuine case of “emergence of the marked” – assimilation that results in obstruent voicing on the surface, even when onset faithfulness is irrelevant. Since this pattern fills a previously unrecognized position in the typology, it raises interesting questions as to how constraints governing voice assimilation are conceptualized. It is argued that, based on other cases where unmarked structures are irrelevant, faithfulness constraints regulating marked structures provide a solution. This proposal is extended to systems where voicing is irrelevant for obstruents, but where aspiration, rather than voicing, is the relevant laryngeal contrast. It is demonstrated that patterns found in these types of languages provide additional evidence for the claims made in this paper – that laryngeal features are privative, and that the most economical way of accounting for laryngeal assimilation is with faithfulness constraints governing insertion and deletion of such features.

The paper is structured as follows: Section 2 presents a typology of voice assimilation, with an emphasis on which patterns are possible and the theoretical reasons behind the patterns predicted to be impossible. Section 3 presents data that fills a gap in the typology, and which forces a revision of the assumptions about the role that markedness plays in voice assimilation. Section 4 presents two models: one based on a privative conception of [voice], with faithfulness constraints that govern this feature, and one based on a binary conception of [voice], with markedness constraints that penalize each value of [ $\pm$ voice]. A range of evidence is presented in support of the former. Section 5 presents evidence from systems exploiting a contrast in [spread glottis] to support the privative model, including typological predictions and attested languages. Section 6 concludes with a brief discussion of the role of markedness in grammar and the language-specific nature of rankings.

## **2. Voice Assimilation: Background and Assumptions**

This section lays out the basic assumptions concerning laryngeal features and the constraints necessary to derive a basic typology of voice assimilation. This work will adopt the viewpoint of Laryngeal Realism, an approach that considers laryngeal representations to be grounded in the phonetic properties and phonological patterns of a given language, rather than being a product of

typology or the number of contrasts a language makes. Adopting this approach has a direct impact on how the empirical base is interpreted, including defining which languages make use of a contrast based on [voice], and by extension, which languages exhibit patterns of assimilation based on [voice]. Thus, the typological landscape changes with the adoption of Laryngeal Realism. While previous analyses and their resulting typologies, including that of Lombardi (1999), have adopted a more traditional view of laryngeal features, the basic Optimality-Theoretic typology developed by Lombardi will be shown to adequately handle the existing patterns of voice assimilation under assumptions of Laryngeal Realism. It is this typology that will be extended in accounting for the emergence of voicing pattern in assimilation.

## 2.1. Laryngeal Realism

It is important to be clear about the assumptions being made about laryngeal features and contrasts, as these can have ramifications for how laryngeal assimilation is modeled, and can have cascading theoretical effects. The traditional view of laryngeal features will be presented, alongside the view that has come to be known as LARYNGEAL REALISM.

In their cross-linguistic overview of laryngeal states during the production of stops, Lisker & Abramson (1964) illustrated that languages carve up laryngeal contrasts along a voice onset time (VOT) continuum, though they tend to categorically choose either voicing fully throughout the stop (i.e. prevoicing), very little voicing lag, or a large voicing lag. Under a privative theory of features, these categorical choices are typically represented with the distinctive features [voice],  $\emptyset$ , and [spread glottis], respectively. Measurements illustrate that VOT for initial stops in the two-way contrast of English is qualitatively different than the two-way contrast for other languages, such as Russian. While both languages have a contrastive series of stops, their VOT values fall into different categories. The VOT values for the English lenis stops (“b” “d” “g”) are short lag, while those for Russian voiced stops (“b” “d” “g”) are prevoiced. Likewise, the values for English fortis stops (“p” “t” “k”) are long lag, while those for Russian voiceless stops (“p” “t” “k”) are short lag. The symbols used for stops in the following tables are based on the stops’ phonetic values, for ease of comparison across languages.

(1) VOT values for initial stops in English (in ms); only means for speakers with non-negative VOTs are reported here (following Beckman et al. 2013:263)

/p/	/t/	/k/	/p <sup>h</sup> /	/t <sup>h</sup> /	/k <sup>h</sup> /
1	5	21	58	70	80

(2) VOT values for initial stops in Russian (in ms) (Ringen & Kulikov 2012:278)

/b/	/d/	/g/	/p/	/t/	/k/
-70	-75	-78	18	20	38

In comparing the stops of English and Russian, the VOT values indicate that the lenis series in English is roughly equivalent to the voiceless unaspirated series in Russian. A system that has all three categories provides an ideal reference point. A language that exploits all three types of laryngeal states for stops is Eastern Armenian, which has voiced (i.e. prevoiced), voiceless (short lag), and voiceless aspirated (long lag) stops:

(3) VOT values for initial stops in Eastern Armenian (Lisker & Abramson 1964:395-396)

/b/	/d/	/g/	/p/	/t/	/k/	/p <sup>h</sup> /	/t <sup>h</sup> /	/k <sup>h</sup> /
-96	-102	-115	3	15	30	78	59	98

Again, the lenis stops of English have values approximating the voiceless unaspirated stops of Eastern Armenian, while the English fortis stops have values similar to the voiceless aspirated stops of Armenian.

The traditional<sup>1</sup> approach to laryngeal contrasts in obstruent systems has assumed an abstract [ $\pm$ voice] category. Under this view, if a language only contrasts two series of obstruents, then these will be [+voice] vs. [-voice], or, in privative terms, [voice] vs. no feature specification. The point is that this contrast will be posited no matter where on the VOT continuum these series lie (Keating 1984, Kingston & Diehl 1994). Thus, a language like English, which has short-lag and long-lag stops in initial position, has traditionally been classified as having a contrast in voicing, despite the fact that prevoicing is not necessary in the phonetic implementation of these stops, nor is prevoicing categorical. In other words, under this view, all lenis obstruents are considered phonologically [+voice], and all fortis obstruents are [-voice].

One assumption that the present work adopts is the stance towards laryngeal features termed LARYNGEAL REALISM (Iverson & Salmons 1995, 2003, 2007, Jessen 1998, Avery & Idsardi 2001, van Rooy & Wissing 2001, Jessen & Ringen 2002, Honeybone 2005, Vaux & Samuels 2005, Kager et al. 2007, Beckman et al. 2013; the term is attributed to Honeybone 2005). While many researchers in this tradition still adhere to fairly abstract distinctive features, the laryngeal oppositions themselves are taken to be more highly articulated than traditionally has been

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<sup>1</sup> The use of the term “traditional” warrants some caution. As an anonymous reviewer points out, there is a longstanding tradition extending back into the 19<sup>th</sup> century that treats Germanic languages roughly on par with the Laryngeal Realism view. Thus, “traditional” in the present context will be narrowly referring to work done in the mid- to late 20<sup>th</sup> century in phonological theory.

assumed.<sup>2</sup> Given a language with a two-way obstruent contrast, if the phonetic realization of the stops involves prevoicing vs. short lag voicing, then the resultant feature specification involves [voice]. If, however, the contrast involves short lag vs. long lag voicing, then the contrast involves [spread glottis] (where, depending on whether a privative or binary theory is adopted, the short lag series will be either unspecified, [-voice], or [-spread glottis]). Thus, Laryngeal Realism adopts a more transparent relationship between distinctive features as phonological entities and the phonetic substance of those features.

As further support for this approach, in observations of word-initial stops, it can be shown that most varieties of English do not exhibit voicing throughout the duration of the closure for lenis stops – that only a portion of the stop is voiced. This is evidenced in Lisker & Abramson’s study mentioned above. This behavior is different from languages with a true voicing contrast, such as Russian, where the phonologically voiced obstruents are prevoiced. In non-initial position, there is also a phonetic difference between languages like Russian and languages like English. Russian intervocalic obstruents are voiced for their full duration (Ringen & Kulikov 2012), whereas English obstruents in this position are not always categorically voiced; instead, they are subject to passive, or contextual voicing which is the result of coarticulation with neighbouring voiced sounds (cf. Kohler 1984, Docherty 1992, Avery 1996, Beckman et al. 2013). As many of these authors argue, active voicing (i.e. consistent voicing throughout the duration of a segment) indicates that the segment in question is fully specified, while passive voicing implies a phonetic coarticulatory effect, not to be confused with phonological specification.

If we concede that languages can contrast [spread] vs.  $\emptyset$  (or even [spread] vs. [voice], as is claimed for Swedish), then this warrants a further investigation into the dynamics of [spread] in assimilation and neutralization contexts. It is important to make this clear, as many of the languages that have been used as examples in the past of voice assimilation (e.g. English) or final devoicing (e.g. German) do not actually employ a contrast based on [voice].

## **2.2. A Basic Typology of [voice] Assimilation**

The typology to be presented here is based on the basic typology and constraints provided by Lombardi (1999). Since Lombardi does not adopt a “laryngeally realistic” viewpoint, there are languages in her typology that do not have contrasts based on [voice]. Therefore, the discussion

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<sup>2</sup> What can be subsumed under Laryngeal Realism is sometimes termed the “narrow” interpretation of [voice], as opposed to the “broad” interpretation (cf. van Rooy & Wissing 2001), which is essentially what is labeled the “traditional” approach here. Thus, while some of the works cited in this respect do not employ the term “Laryngeal Realism”, they adopt do a narrow interpretation of the feature [voice].

around assimilation will be refined so as to include only languages that exhibit a true voicing contrast, where the contrast is between stops that are prevoiced vs. some other series (cf. Petrova et al. 2006). Despite this, Lombardi's original predictions will be shown to hold.

There have been several approaches to the typology of voice assimilation in obstruents, and although they differ in detail, they share the same basic qualities. Anderson (1979) proposes a preliminary typology that includes progressive assimilation, regressive assimilation, and bidirectional assimilation resulting in one value of [ $\pm$  voice]. Cho (1990, 1991) and Lombardi (1995, 1999) elaborate on this basic typology, and exploit an analysis based on a privative conception of [voice]. What results is a typology that allows for assimilation controlled by an onset obstruent (i.e. regressive assimilation, either [voice] or the absence of laryngeal features) and an emergence of the unmarked type of pattern, where agreement in the lack of laryngeal features (i.e. plain voicelessness) surfaces. In Lombardi (1999) it is claimed that it is the interplay of the following constraints that results in the predicted surface patterns of assimilation. The first is AGREE (Lombardi 1997, 1999, Butska 1998, Baković 2000):

(4) AGREE: Adjacent output obstruents must have the same value of the feature [voice]

AGREE could be re-defined such that if [voice] is present for one obstruent, then adjacent obstruents must also be specified for [voice].<sup>3</sup> Since a goal of the present work is to determine whether an analysis based on binary features or privative features is preferable, the definition of AGREE can be interpreted equally under either viewpoint as enforcing agreement in adjacent obstruents. In cases of underlyingly non-agreeing obstruents, the pressure exerted by AGREE comes in direct conflict with the demands of IDENT[voice] and its positional<sup>4</sup> counterpart, IDENTONS[voice]. Finally, the markedness constraint [ $\ast$ voice] plays the role of penalizing any occurrence of voiced obstruents. The typology generated by these constraints yields several distinct patterns, each commonly found in languages of the world (Lombardi 1999).

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<sup>3</sup> Lombardi (1999:275) discusses problems with the interpretation of [ $\ast$ voice] (her constraint is  $\ast$ Lar) whereby a single autosegment [voice] is multiply linked to segments in the output and thus incur only a single violation. Given these problems, I assume, along with Lombardi, that violations are incurred for each individual surface segment that bears the feature [voice].

<sup>4</sup> Kenstowicz et al. (2003) and Petrova et al. (2006) have argued that onset faithfulness is not the correct formulation, and that instead, pre-sonorant faithfulness correctly captures the phenomena at hand. It should be understood that while onset faithfulness is employed throughout the paper, this is a cover constraint that could also potentially be interpreted as a more fine-grained constraint, as Kenstowicz et al. and Petrova et al. suggest.

Table 1: Typology of voice assimilation

Ranking	Pattern	Example
*[voice] » IDENTONS[voice], IDENT[voice]	No voicing contrast	Hawaiian
IDENTONS[voice] » *[voice] » AGREE, IDENT[voice]	Coda devoicing	Afar
IDENT[voice] » *[voice], AGREE	Voice unrestricted	Berber
IDENTONS[voice], AGREE » *[voice] » IDENT[voice]	Assimilation, devoicing	Dutch
IDENTONS[voice], AGREE » IDENT[voice] » *[voice]	Assimilation, contrast	Hungarian
IDENT[voice], AGREE » *[voice] » IDENTONS[voice]	Assimilation: Bidirectional [-voice]	Jamaican

Some voice assimilation patterns resemble the emergence of the unmarked type of phenomena (Baković 1999; cf. McCarthy & Prince 1994). For instance, the stops of Jamaican Creole (at various points in the acrolectal continuum) have been described as voiced, even to the point of having implosive variants (Devonish & Harry 2008, Gooden & Donnelly 2008). Jamaican Creole also exhibits the plural allomorphy that most varieties of English do, which provides the contexts for voice assimilation: *ba*[gz] *dem* ‘bags’, but *boo*[ks] *dem* ‘books’. Jamaican enforces agreement in voicing between obstruents, and when faced with underlyingly disagreeing obstruents, selects the candidate with both obstruents being voiceless rather than the candidate with both obstruents voiced. Since voiced obstruents are otherwise legal in the lexicon, the sub-ranking IDENT[voice] » \*[voice] must be established, and since disagreeing forms never surface, AGREE » IDENT[voice]. As noted by Lombardi (1999) and Baković (1999), it is the lowly-ranking \*[voice] which springs into action in order to select between competing agreeing forms (i.e. KS or GZ), resulting in unmarked voiceless outputs. Importantly, the typology generated by this set of constraints does not predict a pattern of assimilation yielding voiced obstruent pairs. The analytic reason behind this is that given the options for satisfying AGREE, the grammar cannot resort to selecting a marked structure. In other words, there is no mechanism which can favor a marked structure over an unmarked structure, all other things being equal. The formal reason for this is that there is no markedness constraint \*[-voice] that could block an unmarked form from surfacing in these contexts. With respect to underlyingly disagreeing adjacent obstruents, Lombardi (1999:287) notes that

“Either kind of assimilation - to voicelessness or to voicing - will change one of the consonants in the cluster, resulting in one IDLAR violation. Thus, the decision must be passed on to \*LAR, which decides in favour of the voiceless cluster in both cases. Because IDONS<sub>Lar</sub> is lowest ranked, there is no constraint that favors one *direction* of assimilation over another; instead, \*LAR favors assimilation to the unmarked state, voicelessness, regardless of direction.” [emphasis in original]

This prediction will be challenged in section 3 below, where new data that bears on the issue is presented, and the undesirable effects of a constraint like \*[-voice] will be discussed in 4.1.2.

Another pattern is regressive in nature, with the voicing value of the final segment (typically in the onset of the subsequent syllable) in a cluster determining the value of the preceding segment. A prime example is Hungarian, where agreement is mandatory, and where a stem-final obstruent changes to match the voicing value of the suffix-initial consonant (Siptár & Törkenczy 2000:78):

- (5) kút-ban [db] 'in a well' vs. kút-tól [tt] 'from a well'  
 kád-ban [db] 'in a tub' kád-tól [tt] 'from a tub'

What this requires is a highly-ranking faithfulness to the onset voicing value, alongside a highly-ranked AGREE. In addition, IDENT[voice] must dominate \*[voice] in order to allow voiced obstruents lexically, thus: AGREE, IDENTONS[voice] » IDENT[voice] » \*[voice]. This ranking ensures that assimilation is regressive.

The significance of IDENTONS[voice] also lies in the side-effect which it yields in non-assimilative contexts: word-final (or coda) devoicing. Syllable-final neutralization is the result of ranking IDENTONS[voice] » \*[voice] » IDENT[voice] and is significant because it has been intimately linked with patterns of assimilation (Mascaró 1987, Cho 1991, Lombardi 1991, 1995, 1999, Wetzels & Mascaró 2001). Having IDENTONS[voice] dominate \*[voice], and having that in turn dominate AGREE results in a language with only coda devoicing, and no voice assimilation. An example of this pattern is Afar, which according to Bliese (1981) has voiceless, voiced, and aspirated stops (though not across all places of articulation) and exhibits obligatory coda devoicing of obstruents, but which also allows medial stop clusters such as [tg], [tb], [td], [kd], etc. Another example is Mosetén, where according to Sakel (2004), voiced stops are not found in codas, and where there seem to be no restrictions on voiceless-voiced stop clusters (cf. [ʃokdiʔ] 'chicha'). A well-known case of a language having *both* final-devoicing and voice assimilation is Dutch. In their seminal work on the topic, Berendsen (1983) and Zonneveld (1983) noted that while final obstruent devoicing (6a) and voice assimilation (6b) occur independently, they interact in contexts where one obstruent is in syllable-coda position, with the result that assimilation can override devoicing, yielding voiced obstruents in the otherwise unexpected syllable coda position (6c). This is the effect of a high ranking IDENTONS[voice] and AGREE (dominating \*[voice] and IDENT[voice]).

(6) Devoicing and assimilation in Dutch

- a. rond [t] 'round' rond-e [d]  
 hard [t] 'hard' hard-e [d]  
 krab [p] 'crab' krabb-en [b] (Zonneveld 1983:298)

- b. [st]al 'stable', [sp]eer 'spear', [ts]aar 'czar', [ps]alm 'psalm', etc. (Zonneveld 1983:303-304)

c.	klapband	'flat tyre'	/pb/	[b:]	
	opdruk	'imprint'	/pd/	[bd]	
	eetbaar	'edible'	/tb/	[db]	
	afbellen	'to ring off'	/fb/	[vb]	(Booij 1995:59)

The Dutch patterns of voice assimilation are admittedly much more complex than this,<sup>5</sup> and there is a rich literature dedicated to this issue alone (cf. Berendsen 1983, Zonneveld 1983, 2007, Booij 1995, van de Weijer & van der Torre 2007, etc.). Some of the dynamics involving the past tense affix and its exceptional behavior will be discussed in 4.1.2.

The typology predicts languages with no voice assimilation at all, where mixed-voice clusters surface intact (by virtue of IDENT[voice] dominating markedness). Wetzels & Mascaró (2001:208) cite the example of Berber, which exhibits no coda devoicing (igmiz 'cap'), and also exhibits a range of voicing possibilities in clusters, including voiceless-voiced (ak<sup>w</sup>zar 'fig'), and voiced-voiceless (radsun 'they will drink'). The same pattern of allowed disagreement is found in Khasi (Henderson 1976, 1989-1990), where clusters exhibit an almost unrestricted distribution:

(7) Khasi obstruent clusters

bdi	'twenty'	kba	'paddy'
bta	'plainsman, non-Khasi'	kpa	'father'

In fact, Henderson (1976, 1989-90) claims that Khasi not only *allows* laryngeal disagreement in obstruent clusters, but that it actually *favors* this type of disagreement. Finally, the typology also predicts a pattern where voiced obstruents are banned from the phonemic inventory entirely. Many languages exhibit this pattern, including the well-cited case of Hawaiian (Elbert & Pukui 1979), which has /p k ʔ h/, and whereby the ranking is \*[voice] » IDENTONS[voice], IDENT[voice].

Importantly, a pattern not predicted by this typology is assimilation resulting in surface [voice] on agreeing obstruents, as this pattern is not derivable from the set of constraints employed. The reason for this lies in the nature of the markedness constraint \*[voice]: this constraint will penalize structures with [voice], while structures without this feature (i.e. voiceless obstruents) will satisfy the constraint. This mechanism allows the emergence of the unmarked pattern (i.e. emergence of voicelessness), and at the same time rules out the emergence of the marked (i.e.

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<sup>5</sup> Dutch fricatives provide just one of these complexities. For instance, in contexts where a fricative follows a stop, the fricative surfaces as devoiced: hand-zaam [ts] 'manageable', ont-vangen [tʃ] 'to receive', ad-vies [tʃ] 'advice', (Zonneveld 2007:6-7). This work will assume, along with Lombardi (1997) and Iverson & Salmons (2003), that this is the result of voice neutralization that targets any fricative following a stop, and is not the result of voice assimilation (cf. Zonneveld 2007 for a detailed discussion of the differences between the assimilation and neutralization approaches to post-stop fricatives).

emergence of voicing). As will be illustrated in the next section, this substantive gap is actually manifested in the pattern of voice assimilation in Bangla.

### 3. Expanding the Empirical Base: Emergence of the Marked

Having laid out a basic typology of voice assimilation patterns, this section aims to present a case of emergence of the marked – assimilation resulting in surface [voice] on obstruents. While the emergence of the marked is predicted not to occur under the constraints proposed by Lombardi, this section aims to fill this gap by highlighting patterns of assimilation in Bangla (Indo-Aryan; also known as Bengali).

Bangla contrasts plain voiceless, voiceless aspirated, voiced, and voiced aspirated stops.

#### (8) Bangla stop contrasts

Labial	Dental	Alveolar	Retroflex	Velar
p p <sup>h</sup> b b <sup>h</sup>	t̪ t̪ <sup>h</sup> d̪ d̪ <sup>h</sup>	t t <sup>h</sup> d d <sup>h</sup>	ʈ ʈ <sup>h</sup> ɖ ɖ <sup>h</sup>	k k <sup>h</sup> g g <sup>h</sup>

Given these contrasts, the marked distinctive features for the voiced and voiced aspirated stops must be [voice] and [voice, spread], respectively.

As Dan (2012) illustrates, the preferred syllable (for monosyllabic forms) is CV, though syllable codas are allowed. While complex onsets and codas are not found in indigenous monosyllabic forms, complex onsets are found in loans from Sanskrit and English, and complex codas are found in loans from Perso-Arabic. The fact that syllable codas are allowed in the language provides a possible context for voice assimilation in clusters. While there is no syllable-final devoicing in most dialects, there is neutralization of aspiration in syllable-final position (Chatterji 1926, Vijayakrishnan 2003, Dan 2012); cf. alternations such as underlying /lab<sup>h</sup>/ surfacing as [lab] ‘profit’ vs. [lab<sup>h</sup>er] ‘profit gen.’ (Vijayakrishnan 2003:242). Thus, any word-medial cases of voice assimilation in obstruent clusters would constitute genuine cases of voice assimilation, and would not be due to other independent constraints on syllable structure.

Bangla exhibits voice assimilation that prohibits mixed voicing clusters. A search of the Samsad Bengali-English dictionary (Biswas 2000) indicates that there are no sequences<sup>6</sup> in lexical

<sup>6</sup> The only apparent exception to this statement is the sequence [tb], a search of which results in 74 lexical entries. The reason for this exception is orthographic in nature: there are several forms utilizing suffixes such as *-va* from Sanskrit (phonetically [ba]), which historically resulted in a fused orthographic character in the Devanagari script, with the second consonant not realized phonetically (cf. Anderson 1917, Thompson 2012:xxiv). In other words, the consonant that is spelled in these suffixes is silent, and there is no phonetic [tb] sequence, only an orthographic one. Ferguson & Chowdhury (1960) note [tb], [cb], and [kb] as legal clusters, but do not provide lexical forms to support this. As noted above, these clusters are not found in the Samsad dictionary.

items with a voiced-voiceless or voiceless-voiced sequence of obstruents; Ferguson & Chowdhury (1960) arrive at virtually the same conclusion. Thompson (2012:19-20) provides a list of word-medial clusters (where clustering is least restrictive), where it can be observed that mixed-voicing obstruents do not occur:

(9) Bangla word-medial obstruent clusters

voiceless:	kk, kt, ks, tʃʃ, tʃʃʰ, tʃ, tt, pt, pp, ʃʃ, ʃk/sk, ʃt
voiced:	gdʰ, dʒdʒ, dʒ, dd, ddʰ, db, dbʰ, bd, bdʰ, bb

The lexical gaps cited above attest to the high ranking of AGREE: since there are no exceptions to this generalization, the constraint must be undominated. However, since these are lexical patterns, they do not provide much evidence for voicing alternations, nor for the repair strategy employed for underlyingly disagreeing obstruents. Alternations, however, do exist in affixed forms, compounds, and across phrasal boundaries.

Some reports of voice assimilation in the language claim that assimilation is onset-controlled; cf. Hayes & Lahiri (1991:82-83) and Kar (2012) (though Kar presents no data from contexts that would support this pattern; i.e. /D.T/ contexts). For instance, Hayes & Lahiri note that assimilation is optional, and is regressive:

(10) Reports of onset-control (Hayes & Lahiri 1991:82-83)

pat-bo ~ pad-bo	'lay down-1st p. fut.'	(cf. <i>pat-i</i> 1st p. pres.)
rag-tam ~ rak-tam	'be angry-1st p. habit. past'	(cf. <i>rag-i</i> 1st p. pres.)
map-ben ~ mab-ben	'measure-3 p. honorific fut.'	(cf. <i>map-i</i> 1st p. pres.)

There are, however, conflicting reports in the literature. Chatterji (1926:450-451) notes that there is regressive assimilation for stops that *also* agree in place of articulation; for those that disagree in place of articulation, there may be slight voicing/devoicing of a stop preceding a voiced/voiceless stop, but there is no categorical assimilation. The data that is presented in this paper provides evidence for a different pattern. It is important to stress the point that the data and patterns presented here are not to be taken to directly conflict with reports such as Hayes & Lahiri's or Chatterji's; instead, it is likely that the observed patterns are dialectal<sup>7</sup> in nature (in fact, some dialects spoken in Bangladesh exhibit a completely different emergence of the unmarked pattern, with assimilation resulting in voicelessness).

<sup>7</sup> The pattern is not associated with a particular official dialect, and the continuous nature of dialect differentiation in Indo-Aryan makes it difficult to identify exactly which demographic(s) of speakers exhibit these patterns. Given that there are over 193,000,000 speakers of the language (Lewis et al. 2014), it would be surprising if this type of phonological variation *didn't* exist. The discussion of varieties of English throughout this paper in part supports this.

Data from compounds and phrases illustrates the fact that assimilation in the language is the inverse of Jamaican; namely, assimilation is to the marked [voice] value. Observe first cases of disagreeing obstruents with the underlying voiced obstruent following the voiceless (with the result appearing superficially similar to onset-control). Bangla data are from Mandal (2012) and also supplied by Sam Mandal (personal communication).

(11) Bangla regressive voice assimilation

ɟaṭ	'night'	ḍin	'day'	[ɟaḍḍin]	'day and night (24 hours a day)'
ʃaṭ	'seven'	ḍin	'day'	[ʃaḍḍin]	'seven days'
haṭ	'market'	gelo	'go'	[hadgelo]	'went to the market'
kaḱ	'crow'	ḍaḱce	'calling'	[kaḱḍaḱce]	'crows are crowing'
ʃaḅ	'snake'	gelo	'go'	[ʃaḅgelo]	'the/a snake went (this way and that)'
kaṭḱ	'glass'	ḍeḱ <sup>h</sup> e	'see'	[kaḱḍeḱ <sup>h</sup> e]	'having seen the glass'
haṭ	'hand'	gune	'calculate'	[hadḡune]	'having consulted astrology'

Next, observe cases where the voiced obstruent precedes the voiceless, where the result of assimilation is the same: both obstruents surface as voiced.<sup>8</sup>

(12) Bangla progressive assimilation

baḍ	'except'	ṭin	'three'	[baddin]	'except three'
ʃaḍ <sup>h</sup>	'whim'	ṭ <sup>h</sup> eke	'from'	[ʃaḍḍ <sup>h</sup> eke]	'whimsically'
ɟaḡ	'anger'	c <sup>h</sup> a.ɽo	'leave'	[ɟaḡɽa.ɽo]	'calm down'
baḡ	'tiger'	paḱalo	'fled'	[baḡbaḱalo]	'the tiger fled'
ʃaṭ	'makeup'	poḱaḱ	'dress'	[ʃaṭpoḱaḱ]	'costumes'
mḱḍ	'alcohol'	kena	'to buy'	[mḱḍgena]	'to buy alcohol'

Alternations are also present in affixed forms. (13) illustrates this with examples taking the definite article /-ta/:

(13)	b <sup>h</sup> aluk-[t]a	'the bear'
	tḱb-[d]a	'the pot'
	cf. horin-[t]a	'the deer'

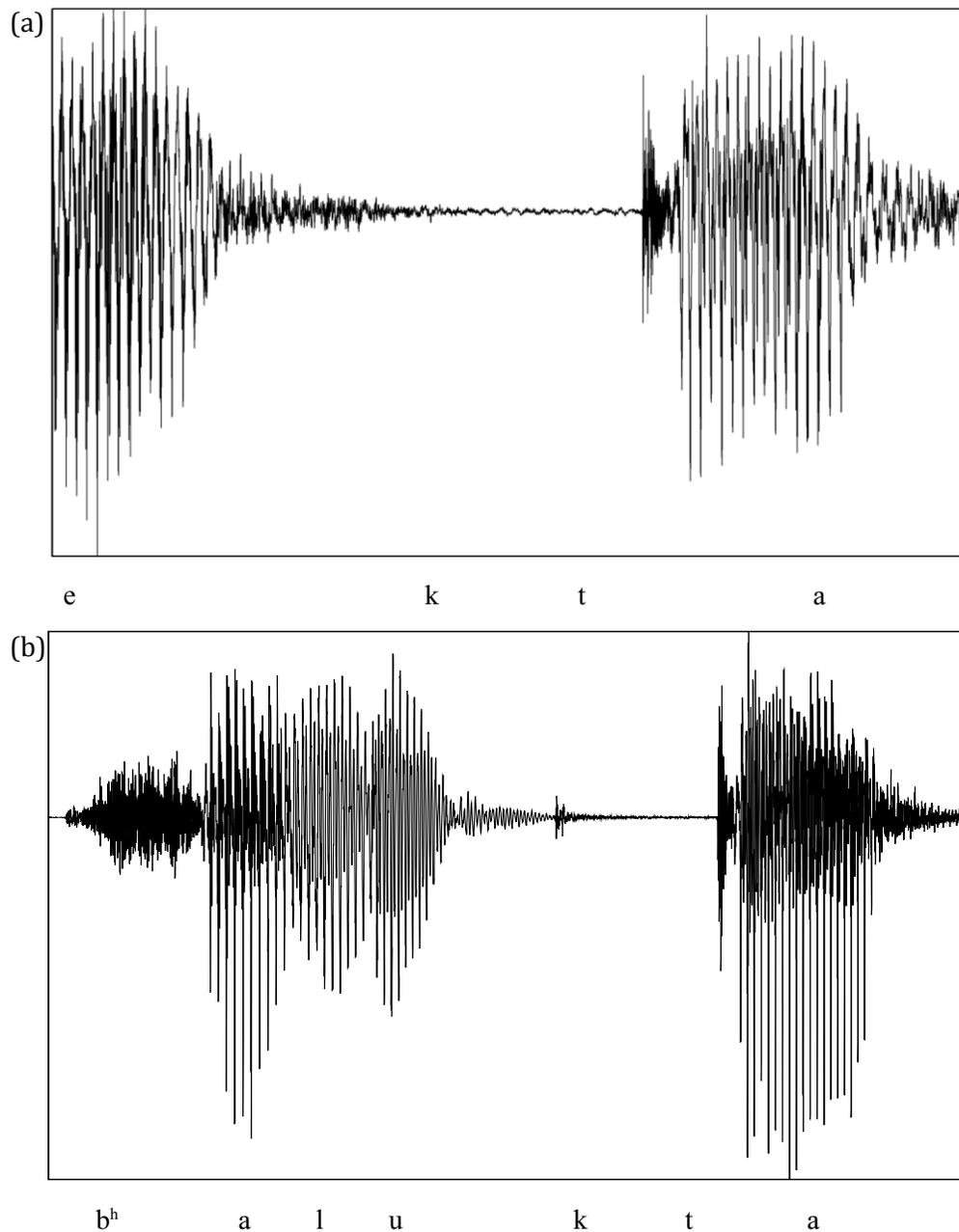
In order to probe the potential interactions between adjacent obstruents with respect to laryngeal features, Mandal (in prep) recorded 2 speakers (one male, one female) from the Burdwan

<sup>8</sup> Lombardi (1999) employs the markedness constraint \*Lar, which prohibits the presence of a laryngeal node (rather than just the feature [voice]). There is, however, evidence in Bangla that the relevant constraint is \*[voice]. In addition to the voiceless and voiced obstruents, Bangla also makes use of an aspirated series of obstruents, which are not affected by the assimilation process: [baḍ] 'leave' [ṭ<sup>h</sup>aḱ] 'keep' [baḍḍ<sup>h</sup>aḱ] 'leave it out'. There is also a contrast between voiceless and voiced obstruents in word-final position, but aspirated stops are de-aspirated in this same position (cf. Ferguson & Chowdhury 1960:45, Dan 2012). In order for the grammar to target only voicing and not aspiration (and vice versa), then the entire laryngeal node cannot serve as the marked structure; if it were, it would make the incorrect prediction that assimilation would neutralize ALL laryngeal features. Thus, the relevant constraint \*[voice] will be employed here.

district of West Bengal, India, eliciting a series of words that were designed to create the context for voice assimilation. The first set of words consisted of transitive clauses with an affected object in order to induce usage of the case suffix /-ke/ and the definite article /-ta/ (e.g. *b<sup>h</sup>aluk-ta tɔb-ta b<sup>h</sup>anglo* ‘The bear broke the pot’). The nouns used varied in their final consonant (voiceless unaspirated vs. voiced). The suffixes are relatively frequent, and in combination with the nouns provide the context for testing /T-T/ sequences (as a control) and the crucial /D-T/ sequences. The second set of words consisted of first names that likewise varied in their final consonant, and the case suffix was again used (*Bhuvan Arnab-ke k<sup>h</sup>awalo* ‘Bhuvan fed Arnab’ vs. *Bhuvan Pratap-ke dekhlo* ‘Bhuvan saw Pratap’). Finally, the forms in (13) were directly elicited as words in isolation.

Mandal’s recordings were independently analyzed in this study for voicing through visual inspection of the waveform/spectrogram. Judgments on voicing were confirmed by a phonetician who was unaware of the details of the study, but was made aware that there is a four-way laryngeal contrast in the language. Because of complications with geminates, including a longer closure duration with no clear acoustic or auditory boundaries, only the forms disagreeing in place of articulation were observed. For both speakers, all underlying /T-T/ pairs surfaced faithfully. For mixed pairs where the sequence is /T-D/, all forms surfaced as voiced (2/2 for male, 2/2 for female). For the crucial contexts, where the sequence is /D-T/, 9/10 (90.0%) of the pairs surfaced as [D-D] for the male speaker (there was one instance of /b-k/ which surfaced faithfully, while the other token underwent progressive assimilation), and 10/11 (90.9%) surfaced [D-D] for the female speaker (where the faithful form was /g-t/). Importantly, there were NO cases of the underlying /D-T/ pairs surfacing as entirely voiceless for either speaker, a result which rules out the onset-control analysis for this particular set of data.

For reference, waveforms from the data in Mandal’s study are presented in Figures 1 and 2 below. Figure 1 exemplifies a voiceless-voiceless sequence:



*Figure 1: Waveforms of (a) female production of /ek-ta/ 'one-DEF', and (b) male production of /b<sup>h</sup>aluk-ta/ 'bear-DEF'*

The waveforms in Figure 1 can be compared with those in Figure 2, which phonetically illustrate the progressive voice assimilation described above. The presence of voicing was identified through a visible voicing bar in the spectrogram, the presence of fundamental frequency and periodicity in the signal, and a lack of high frequency components during closure.

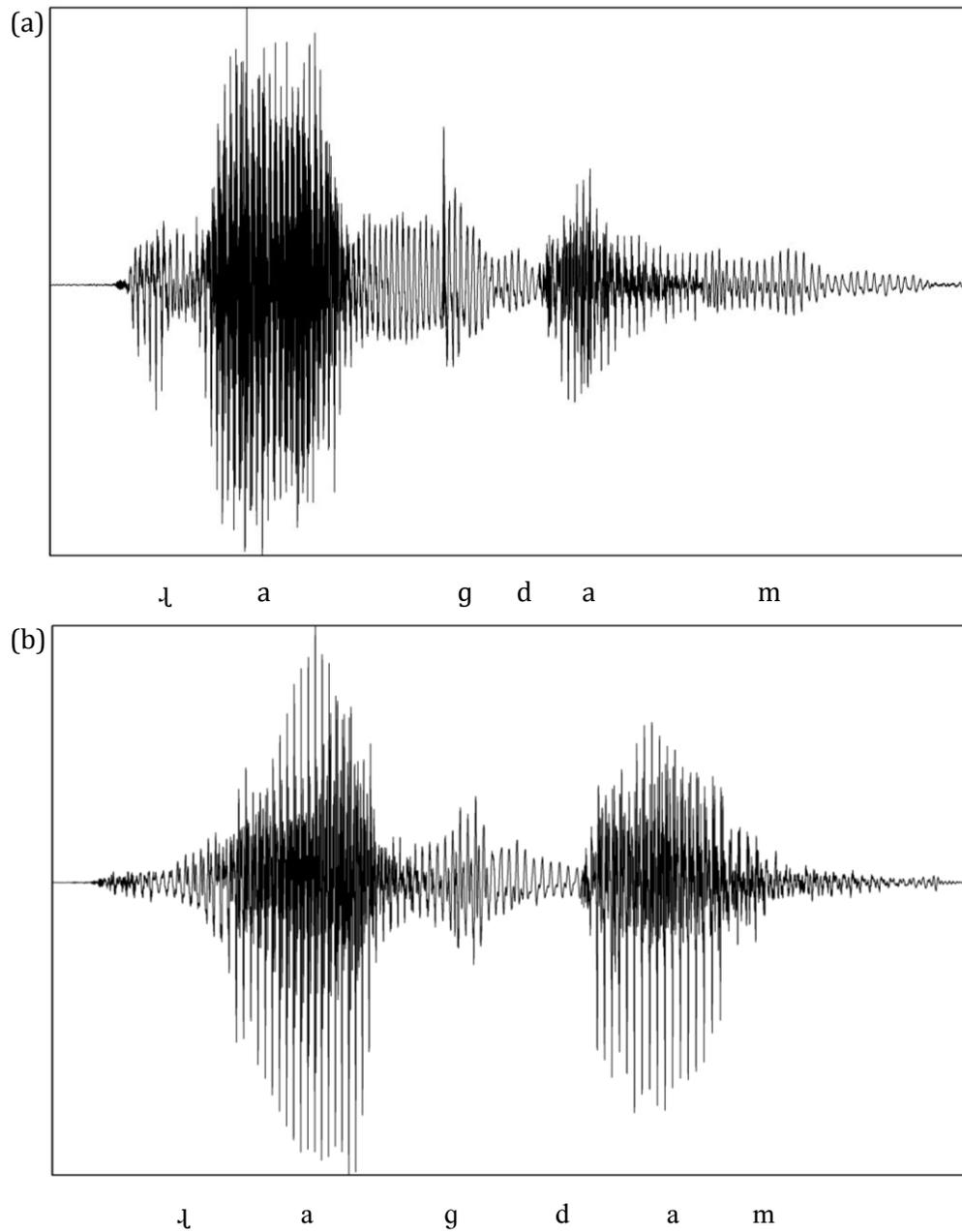


Figure 2: Waveforms of (a) female and (b) male productions of /ɟag-tam/ 'be angry-1p.hab.past'

Some speakers apparently maintain clusters that are exceptions<sup>9</sup> to the generalization above. For instance, a different speaker never exhibited voice assimilation in intervocalic clusters

<sup>9</sup> Some Bangla linguists have informally reported that some affixes are immune from assimilation (such as some classifiers), but inflectional affixes consistently undergo voicing, resisting any kind of devoicing. Other affixes are reported to exhibit more flexible behavior, with forms like /rag-to/ 'anger (3<sup>rd</sup> person non-honorific habitual past)' varying between faithful [ragto] and assimilated [ragdo], and with [rakto] being the

with /tʃ/. The existence of such exceptions, however, is supportive of the pattern itself, as they attest to the robustness of the phenomenon (i.e. if it were purely a phonetic effect, exceptional clusters that defy the pattern would be unexpected).

There are two important points to be made regarding this pattern. The first is that faithfulness to voicing specifications exclusive to values in the onset is not relevant to the process of assimilation for these speakers. If this were the case, then the examples in Figure 2 would yield voiceless outputs as the result of assimilation. The second point centers on the mechanism required to yield assimilation to the voiced. Under the approach advocated by Lombardi, this pattern cannot be derived. In order to derive this emergence of the marked effect, whereby voiced obstruents are favored over voiceless ones in assimilative contexts, there are two possible analyses: either adopt a binary feature for voicing and allow markedness constraints based on both of these feature values (i.e. \*[+voice] and \*[-voice]) to be freely ranked, or maintain a privative conception of voicing and enhance faithfulness constraints such that they regulate insertion and deletion of [voice], resulting in distinct processes. Each of these analyses will be outlined and discussed below.

#### **4. Binary Voice vs. Voice Faithfulness**

The Bangla patterns require an analysis that goes beyond the constraint set and typology presented in Section 2. This section aims to tease apart the implications of the two possible analyses introduced above.

Presenting evidence from voice assimilation patterns, Wetzels & Mascaró (2001) have claimed that voicing is a binary feature: [ $\pm$ voice] (cf. also Gussman 1992, Rubach 1996 for other arguments from Polish voice assimilation for a binary conception of voice). This claim is to an extent consistent with the two assimilation patterns noted above: emergence of the unmarked, and emergence of the marked. If this were translated into constraints, then languages which exhibit emergence of the unmarked patterns would exploit the ranking \*[+voice] » \*[-voice] (consistent with the overall unmarked nature of voiceless obstruents), while languages exhibiting emergence of the marked would be characterized as having the reverse ranking \*[-voice] » \*[+voice]. Thus, the Bangla pattern would be modeled as such:

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least acceptable form for most speakers of this variety. These affixes were not observed in Mandal's (2012, in prep) data.

(14) Bangla voice assimilation assuming [ $\pm$ voice]

/fapgelo/	AGREE	IDENT[voice]	*[-voice]	*[+voice]
fapgelo	*!		*	*
$\rightarrow$ fabgelo		*		**
fapkelo		*	*!*	

It has been suggested that markedness effects be encoded in harmonic rankings of markedness constraints (Prince & Smolensky 1993). The consequence of the approach above is that a putative fixed ranking  $*[+voice] \gg *[-voice]$  would be reversed in Bangla. The implications of this “free” ranking of  $*[+voice]$  and  $*[-voice]$  cross-linguistically will be explored in section 4.1.2. where typological aspects of the analysis are discussed.

The alternative approach is to maintain a privative conception of [voice] (following Mester & Itô 1989, Cho 1990, 1991, Lombardi 1991, 1995, 1999, Abu-Mansour 1996), and to allow faithfulness constraints to do the work required in accounting for the different assimilation patterns. For instance, if IDENT[voice] were replaced with a finer-grained set of constraints regulating the insertion and deletion of [voice], then the same results could in principle be achieved. Baković (1999) proposes IDENT[+voice] and IDENT[-voice] (designed to tackle the “majority rule” problem, whereby the relative percentages of input values for a feature determine outputs when onset-faith is irrelevant). Such a proposal regulates input-output mappings that change voiceless to voiced and voiced to voiceless (cf. also Pater 1999 for this approach with respect to nasality and de Lacy 2006:254-262 for a similar approach to voice assimilation). This builds an asymmetry into faithfulness constraints; however, the way the asymmetry is implemented in terms of laryngeal features is problematic. Lombardi (2001) points out that the biggest problem with IDENT with respect to [voice] is that it would not be possible to rule out strategies like epenthesis or deletion to repair coda voicing. More specifically, since featural correspondence relations do not hold between an input segment and an output segment which has been deleted, this would in principle allow the deletion of an output segment as a viable strategy for circumventing the force of IDENT. As Lombardi notes, however, coda devoicing is never repaired by epenthesis or deletion (as opposed to codas with place features, etc., which *are* repaired by these strategies), and she argues that in this context IDENT should be replaced by MAX and DEP.

As alluded to above, an alternative to IDENT would be to adopt MAX/DEP[Feature] constraints: MAX[voice] and DEP[voice]. The adoption of feature-based correspondence constraints such as these has been proposed generally, and for the feature [voice] by various authors (Lamontagne & Rice 1995, Causley 1997, Lombardi 1998, 2001, Zoll 1998, Zhang 2000, McCarthy

2008<sup>10</sup>). This is the analysis provided by Butska (1998) for the case of Ukrainian voice assimilation and T. A. Hall (2007) for Meccan Arabic, both to be discussed below (cf. also D. C. Hall 2007 for problems related to the exploded version of MAX[voice] for Czech voice assimilation). Under this approach, the pressure to preserve underlying [voice] and the pressure for obstruent voice agreement work in tandem, even if this means voice disagreement is repaired by inserting [voice]. This is illustrated below for the Bangla pattern under discussion:

(15) Bangla voice assimilation assuming MAX/DEP[voice]

/[ʃapɡelo/	AGREE	MAX[voice]	DEP[voice]	*[voice]
[ʃapɡelo	*!			*
☞ [ʃabɡelo			*	**
[ʃapkelo		*!		

As the tableau above illustrates, the ‘assimilation to [voice]’ pattern in Bangla is easily modeled with MAX[voice] and DEP[voice]. If AGREE and MAX[voice] are ranked above DEP[voice], then the emergence of the marked pattern results. Notice also that since a voicing contrast is present in the language, both MAX[voice] and DEP[voice] must dominate \*[voice]. This renders \*[voice] ineffective in making any decisions with respect to voice assimilation – all of the work is done by the faithfulness constraints.

This proposal is based in ideas around “preservation of the marked” (de Lacy 2006) or “submergence of the unmarked” (Rice 2007:84-85). De Lacy (2006) has claimed that there is a pressure for marked structures to be preserved at the expense of unmarked ones. This pressure will only be relevant when preservation is possible - i.e. when there are marked structures in the input to be faithful to. As both de Lacy and Rice illustrate, there are several cases where marked features are preferred over unmarked alternatives, such as in assimilation, inventory structures, and neutralization. The proposal advanced here builds on these important ideas, and like de Lacy’s approach, provides a highly articulated theory of preservation of the marked.

#### 4.1. Arguments for MAX[voice] and DEP[voice]

As noted above, there are two approaches that can be entertained in light of the new assimilation pattern: either the feature [voice] is binary and the constraint \*[-voice] must be active (and ranked

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<sup>10</sup> While McCarthy (2008:290-292) ultimately casts doubt on the possibility of MAX[voice] as a constraint, he raises an interesting discussion about the surface effect that MAX[Feature] constraints play in assimilation phenomena, which were previously conceived as combinations of deletion plus spreading rules; this is especially relevant in the context of rule-based approaches to voice assimilation which rely on similar mechanisms of feature delinking and spreading (Mascaró 1987, Cho 1990, Lombardi 1991, 1995, Abu-Mansour 1996).

above \*[+voice] in Bangla), or else [voice] is a privative feature and the faithfulness constraints regulating the feature are more powerful than an undifferentiated IDENT[voice]. This paper argues for the latter view, that there is a single markedness constraint \*[voice], which is accompanied by the faithfulness constraints MAX[voice] and DEP[voice]. The evidence for this comes in cases of restricted onset control, where only a single voicing value in the onset triggers assimilation. Corroborating evidence can be found in the typologies that each approach generates: assuming binary [ $\pm$ voice] yields a typology with undesirable qualities (e.g. under- and over-generation), while the privative [voice] and MAX/DEP approach yields a typology that fits very close to patterns that are found cross-linguistically.

#### 4.1.1. Restricted Onset-Control

Arguments for privative [voice] and the faithfulness constraints that regulate the feature can be found in patterns of assimilation that are restricted to one of either voiced or voiceless in contexts of onset-control. A somewhat restricted version of the onset-controlled pattern exhibited by Hungarian above is found in Ukrainian (Cho 1990, Butska 1998, Kenstowicz et al. 2003). In Ukrainian, voice assimilation is triggered only when the onset obstruent is voiced (never when voiceless), and the result of assimilation is voicing.<sup>11</sup> Observe the following (data from Butska 1998:66):

(16) Regressive voice assimilation in /voiceless+voiced/ clusters

boro-[t]ɪ	'struggle-inf.'	boro[d]'-ba	'struggle-nom fem.'
pro[s]ɪ-tɪ	'request-inf.'	pro[z]'-ba	'request-nom fem.'
li[tʃ]ɪ-tɪ	'count-inf.'	li[dʒ]-ba	'count-nom fem.'
molo[t]ɪ-tɪ	'thresh-inf.'	molo[d]'-ba	'threshing-nom fem.'

(17) No voice assimilation in /voiced+voiceless/ clusters

koro[b]-ok	'box-gen. pl'	koro[b]-k-a	'box-dim-nom. fem.'
li[ʒ]-ok	'bed-gen.pl'	li[ʒ]-ko	'bed-nom. neutre'
ri[d]ɪ-tɪ	'raref-inf.'	ri[d]-ko	'rarely-neutre'

Note that even though voiced stops are licit in codas (as opposed to other Slavic languages such as Polish or Russian, which exhibit coda devoicing), they are not repaired when followed by a voiceless onset, thus violating AGREE.<sup>12</sup> This essentially creates an asymmetry in the onset-control pattern, yielding a sub-pattern that favors voicing over voicelessness. The Ukrainian pattern can be

<sup>11</sup> This same pattern is exhibited by Frisian (Tiersma 1985:27-28).

<sup>12</sup> Within the context of the discussion of voice assimilation, Harris (1994:137-138) cites dialects of English (from the northeast of England) which have a true voicing contrast, and which (presumably) exhibit a similar pattern of assimilation.

characterized as satisfaction of AGREE only if this is attained through inserting [voice] in the coda (or through accidental underlying agreement), never through deletion of a [voice] feature. Butska (1998) takes this pattern as evidence that faithfulness constraints other than IDENT[voice] are responsible for the patterns that are found in voice assimilation, namely, MAX[voice] and DEP[voice] (and specifically, MAXONS[voice]).

It is conceivable that the opposite pattern – voicelessness spreading in onset-controlled assimilation – would be possible. Meccan Arabic exhibits such a pattern of voice assimilation (Abu-Mansour 1996, Kenstowicz et al. 2003, McCarthy 2003, T. A. Hall 2007), where a voiceless obstruent triggers regressive assimilation (18a), but a voiced obstruent fails to induce assimilation (18b).

(18) Meccan Arabic (Abu-Mansour 1996:217)

- a. /ʔagsam/ [ʔaksam] ‘he made an oath’  
 /mazku:r/ [masku:r] ‘mentioned’
- b. /akbar/ [akbar] ‘older’  
 /matdʒar/ [matdʒar] ‘shop’

T. A. Hall (2007) arrives at much the same conclusion for Meccan Arabic as Butska does for Ukrainian, such that MAX[voice] and DEP[voice] are employed in order to model the general condition of faithfulness to [voice] in onsets, but also because of the fact that [voice] is deleted in codas when forced by AGREE. The Meccan pattern is modeled below:

(19) Meccan Arabic regressive assimilation

a. /voiced+voiceless/

/d-t/	DEP[voice]	DEPONS[voice]	MAXONS[voice]	AGREE	MAX[voice]	*[voice]
☞ tt					*	
dt				*!		*
dd	*!	*!				**

b. /voiceless+voiced/

/t-d/	DEP[voice]	DEPONS[voice]	MAXONS[voice]	AGREE	MAX[voice]	*[voice]
☞ td				*		
tt			*!		*	*
dd	*!					**

In contrast, these types of patterns are problematic for the binary theory of [voice]. Employing both markedness constraints \*[-voice] and \*[+voice] is inadequate to account for the pattern:

(20) Failure of \*[+/-voice]

a. voiced-voiceless

/d-t/	IDENTONS[voice]	AGREE	IDENT[voice]	*[+voice]	*[-voice]
☞ tt			*		**
dt		*!		*	*
dd	*!		*	*	

b. /voiceless-voiced/

/t-d/	IDENTONS[voice]	AGREE	IDENT[voice]	*[+voice]	*[-voice]
td		*!		*	*
tt	*!		*		**
☞* dd			*	**	

Finally, the adoption of MAX/DEP[voice] remains unproblematic for unrestricted onset-control, as in Hungarian: this pattern simply relies on the high-ranking of MAXONS[voice], DEPONS[voice] and AGREE, which must all dominate \*[voice], MAX[voice] and DEP[voice]. This ensures that the grammar is being maximally faithful to onsets (whether they are voiced or voiceless), while at the same time enforcing agreement amongst adjacent obstruents.

#### 4.1.2. Typological Implications

In addition to the evidence presented above for privative [voice], there are also typological reasons for adopting this approach. Privative [voice] and the constraints MAX/DEP[voice] make correct typological predictions about voice assimilation, whereas \*[-voice]/\*[+voice] constraints make undesirable predictions. In the following, only languages that exploit the feature [voice] or exhibit no contrast at all will be considered; systems based on [spread glottis] will be discussed in section 5.

Given the constraints AGREE, MAX[voice], MAXONS[voice], DEP[voice], DEPONS[voice], and \*[voice], a typology of 11 distinct patterns results from all 720 possible rankings.<sup>13</sup> This typology is presented below:

<sup>13</sup> Typologies were generated using OTSoft (Hayes et al. 2013).

Table 2: Typology generated by MAX/DEP[voice]

Ranking	Pattern	Example
AGREE, MAX, MAXONS » *[v], DEP, DEPONS	Assimilation: voice	Bangla
MAX, MAXONS » *[v] » AGREE » DEP, DEPONS	Assimilation: progressive [voice]	Norwegian
MAX, MAXONS, DEPONS » AGREE » *[v], DEP	Onset control: regressive [voice]	Ukrainian
MAX, MAXONS, DEP, DEPONS » AGREE, *[v]	Voice unrestricted	Berber
AGREE, MAXONS, DEPONS » MAX, DEP » *[v]	Onset-control	Hungarian
DEP, DEPONS, MAXONS » AGREE » MAX » *[v]	Onset-control: voiceless	Meccan Arabic
AGREE, DEP, DEPONS » MAX, MAXONS » *[v]	Assimilation: voiceless	Jamaican
AGREE, MAXONS, DEPONS » *[v], DEP » MAX	Onset-control + coda devoicing	Dutch
DEP, DEPONS, MAXONS » AGREE, *[v] » MAX	Coda devoicing only	Afar
AGREE, DEP, DEPONS » MAXONS » *[v], MAX	Coda devoicing + prog. voiceless	Breton
AGREE, *[v], DEP, DEPONS » MAX, MAXONS	No voicing contrast	Hawaiian

Note that in addition to the emergence of the unmarked/marked effects and onset-controlled assimilation, the typology includes languages with progressive assimilation of [voice] and languages with final devoicing plus progressive voiceless assimilation. The former pattern (progressive voicing) is found in Norwegian<sup>14</sup>, as reported by Odden (2005:237). In Norwegian, the regular past tense suffix *-te* exhibits alternations, surfacing as voiced [-de] following voiced consonants (Odden notes that the suffix surfaces as [-te] in sonorant-final forms, an argument for /-te/ being the underlying form):

(21) Norwegian progressive voice assimilation

a.	spis-e	spis-te	'eat'
	les-e	les-te	'read'
	tenk-e	tenk-te	'think'
b.	lev-e	lev-de	'lived'
	gnag-e	gnag-de	'gnaw'

The same pattern is also found with the Dutch past tense morpheme /-de/ (cognate with /-te/ in Norwegian).<sup>15</sup>

(22) Dutch progressive voice assimilation (data from Avery 1996:138)

a.	ski+de	'skied'
	talm+de	'hesitated'
b.	krab+de	'scratched'

<sup>14</sup> Norwegian is perhaps the most contentious case of a language employing [voice] in this typology; however, Ringen & van Dommelen (2013) analyze Norwegian as having a contrast between [voice] and [spread], similar to Swedish, which will be discussed in section 5.

<sup>15</sup> The progressive nature of this assimilation is at odds with the Dutch pattern presented in section 2.2.3, which is regressive. This is a long-standing problem in the analysis of Dutch voice assimilation (cf. Zonneveld 1983), and while a unified account is not attempted here, the reader is referred to works that have, including Zonneveld (1983, 2007), Booij (1995), and Avery (1996), among many others.

	bloed+de	'bled'
c.	schrap+te	'scraped'
	haat+te	'hated'

The latter pattern (devoicing with progressive assimilation to voiceless) occurs as a subset of the patterns found in Breton. For instance, D. C. Hall (2009:3, citing data from Ternes 1970) notes examples such as the following to illustrate this pattern: *peamzek* 'fifteen', *daj* 'day', *peamzek tay* 'fifteen days'.

The typology in Table 2 can be contrasted with one that emerges from a set of constraints employing the pair of markedness constraints \*[+voice] and \*[-voice], in addition to IDENT[voice], IDENTONS[voice], and AGREE. As can be seen in Table 3, the 120 unique rankings yield 10 distinct patterns. While much of this typology overlaps with the typology in Table 2 above, there are some notable differences.

Table 3: Typology generated by \*[+voice]/\*[-voice]

Ranking	Pattern	Example
AGREE » IDENT » *[-v] » *[+v], IDENTONS	Assimilation: [voice]	Bangla
*[-v], AGREE » *[+v], IDENT, IDENTONS	Voiced obstruents only	?
IDENTONS » *[-v] » *[+v], IDENT, AGREE	Coda Voicing	Lezgian?
IDENTONS, AGREE » IDENT » *[-v], *[+v]	Onset-control	Hungarian
IDENTONS, AGREE » *[-v] » *[+v], IDENT	Onset-control+coda voicing	?
IDENTONS, AGREE » *[+v] » *[-v], IDENT	Onset-control+coda devoicing	Dutch
IDENT, IDENTONS » *[-v], *[+v], AGREE	Voice unrestricted	Berber
IDENTONS » [+v] » *[-v], IDENT, AGREE	Coda devoicing	Afar
AGREE » IDENT » *[+v] » *[-v], IDENTONS	Assimilation: voiceless	Jamaican
*[+v], AGREE » *[-v], IDENT, IDENTONS	No contrast	Hawaiian

There are three major problems with the typology generated from binary [ $\pm$ voice] constraints: the prediction of languages with coda voicing, the prediction of languages with a voiced-only obstruent inventory (*in addition* to languages with a voiceless-only inventory), and the existence of patterns that are not generated by the typology, namely, the Ukrainian, Meccan Arabic, Norwegian and Breton patterns discussed above.

The first problem is that the typology predicts languages with coda voicing. There is some debate as to whether any languages actually exhibit this type of voicing. In their overview of laryngeal neutralization, Iverson & Salmons (2011:1628) note that "neutralization to a phonologically voiced member of an opposition may occur, but appears to be very rare, and

controversial [...].”<sup>16</sup> Much the same can be said for languages that exhibit a voiced-only obstruent inventory. While many languages make use of only a single series of obstruents which can vary phonetically between voiced and voiceless, there do not seem to be any cases of a language where phonologically the series is marked with [voice] *exclusively*. This rings especially true when considering the fact that the typology also predicts a language with *only* a voiceless series of obstruents. The typology predicts that there are languages with a single series of obstruents that are phonologically voiceless, and languages that exhibit a distinct pattern whereby their single obstruent series is voiced. This state of affairs does not seem to exist.

Finally, the Ukrainian, Meccan Arabic, Breton and Norwegian patterns that were accounted for under the MAX/DEP[voice] approach are not generated in the typology based on \*[+voice]/\*[-voice]. This stems primarily from the symmetrical nature of IDENT: since IDENT[voice] treats the insertion and deletion of [voice] as the same, this constraint cannot tease apart systems such as those listed above, where it is critical to be able to model assimilation by means of insertion *or* deletion. Employing MAX/DEP[voice], on the other hand, allows the grammar to make these distinctions. In short, the typology in Table 2 not only over-generates undesirable patterns, it also fails to generate existing patterns.

For these reasons, the typological predictions of the binary voice account result in undesirable patterns, while the typology predicted by the privative voice account yields a typology with a relatively good fit, cross-linguistically.

## 5. Extensions to Other Systems

Up to this point, the focus has been on languages that exploit the feature [voice] for a laryngeal contrast in their obstruent series. This section addresses laryngeal agreement in systems that do not rely on [voice] at all and instead make use of contrasts based on [spread glottis], such as most varieties of English. Perhaps the most natural outcomes of observing [spread glottis] systems is that the emergence of the marked pattern exists, and that if a system makes use of both [voice] and [spread glottis], the two can interact in contexts of laryngeal assimilation. Thus, the voicing typology laid out in section 2 has implications that extend naturally into other laryngeal features. While a full typology centered around [spread glottis] on par with the one centered on [voice] in

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<sup>16</sup> The case in question is Lezgian, claimed by many to be a genuine case of coda voicing (Haspelmath 1993, Yu 2004 Blevins 2006), or to involve a different laryngeal series of obstruents altogether (Kiparsky 2006). It is also worth noting in this context that there are robust cases of marked feature insertion in *word-final* position (Iverson & Salmons 2007).

section 2 is beyond the scope of this paper, it generates a subset of predictions that can be tested. The potential extension of the analysis to place assimilation will also be explored.

The first key prediction that the theory makes is an emergence of the marked pattern in languages exploiting the feature [spread]. As discussed in section 2.1, Iverson & Salmons (1995) have presented several arguments for the case that English (along with most other Germanic languages) employs a laryngeal contrast based on privative [spread] in its obstruent system (see also Harris 1994, and Houlihan 1977:236 for an early suggestion along these lines), and that it is the fortis [spread] obstruents that are the marked series.<sup>17</sup> For instance, they argue that if a privative [spread] is adopted, this naturally accounts for the processes of laryngeal neutralization of stops following [s] in clusters, and also for the devoicing of post-stop sonorants. This extends to assimilation: Assuming lenis -z as the underlying form of the plural (as this is the form that surfaces after sonorants), it can be observed that it assimilates to fortis when following a fortis obstruent; cf. /kæt-z/ [kæts] (in the traditional notion) (see also Mester & Itô 1989, Lombardi 1997, 1999, Borowsky 2000 for further discussion and analyses of this pattern). If [spread] is the marked feature in this system, and if constraints on featural faithfulness are employed, then this naturally captures the patterns in most varieties of English. The relevant constraint here is MAX[spread], which prevents deletion of any underlying specifications of [spread glottis].

(23) Many varieties of English (such as General American)

/kæt-z/	AGREE	MAX[spread]	*[spread]
kæt-z	*!		
☞ kæt-s			*!
kæd-z		*!	

The coupled force of AGREE and MAX[spread] ensures that when there are laryngeally mixed pairs in the input, the optimal output candidate will be one that exhibits laryngeal agreement, and also preserves the underlying [spread] specifications.

Another important prediction is the existence of onset control in systems employing [spread]. One example is Ancient Greek, which exhibited a contrast between plain voiceless, voiced, and voiceless aspirated stops. In contexts of suffixation, the laryngeal feature of the left-hand obstruent must agree with that of the right-hand member, and where each of the laryngeal features triggers agreement (Kenstowicz 1994:157). As such, AGREE must make demands over all of the

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<sup>17</sup> The same holds true for approaches to English in Articulatory Phonology, where the gesture for the lenis stops requires closure at place of articulation, but where the fortis stops involve an additional, glottal opening (and possibly closing) gesture (Browman & Goldstein 1986:224-225). Thanks to Michael Proctor for pointing out this parallelism in markedness.

available laryngeal features, and the relevant faithfulness constraints here must protect values that include both [voice] and [spread]. Restricted onset control is found in Yorkshire English<sup>18</sup>: ‘bed-time’ *be[tt]ime* vs. ‘white book’ *whi[tb]ook* (Wetzels & Mascaró 2001, citing Wells 1982:367; the traditional notation is retained). Just as with Ukrainian, a high ranking constraint on inserting or deleting [spread] into onsets, alongside a general constraint on deleting [spread] will have the effect of protecting onsets and preventing deletion of [spread], and where assimilation will be triggered by AGREE. So long as DEP[spread] is ranked below AGREE, this yields a pattern of regressive [spread] assimilation. Incidentally, the same typological prediction that held for Ukrainian holds true for Yorkshire English: a typology based on [±spread] will not predict this type of pattern, whereas a typology based on privative [spread] with MAX and DEP constraints will.

It should also be pointed out that there is a pattern missing from the typology. To my knowledge, there does not exist a pattern that forces agreement with an onset plain voiceless stop, but not a voiceless aspirated stop, i.e. /T T<sup>h</sup>/ → [T T<sup>h</sup>], but /T<sup>h</sup> T/ → [T T], but independent of coda neutralization. This would be parallel to Meccan Arabic in the voice assimilation typology. At present, there is little explanation for why this pattern is lacking, aside from the possibility that the empirical base (i.e. the existing literature) that is being drawn from is not at the moment rich enough to yield a pattern that is predicted to be relatively uncommon to begin with.

The theory also predicts that multiple marked features can be in competition. While Swedish is used as an example of emergence of the unmarked by Cho (1990, 1991) and Lombardi (1999), recent work has shown that the laryngeal contrasts in the language are different to those previously reported. While it has been assumed in previous work that Swedish employs a voiced-voiceless contrast, Ringen & Helgason (2004), Petrova et al. (2006), Helgason & Ringen (2008) and Beckman et al. (2011) have analyzed Swedish as having a contrast between [voice] and [spread glottis]. Helgason & Ringen (2008) have shown that in initial, prevocalic position, the phonetic contrast in stops is between prevoicing and post-aspiration, and Beckman et al. (2011) have argued that both [spread glottis] and [voice] must be fully specified. Thus, Swedish is unique to the languages discussed so far in that its obstruent inventory is characterized by two marked laryngeal features, [voice] and [spread], rather than a marked feature and an unspecified value. In contexts of obstruent clusters, laryngeal assimilation always yields [spread] stops:

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<sup>18</sup> Incidentally, this pattern is used by Wetzels & Mascaró (2001) to argue for binary [±voice].

(24) Swedish voice assimilation (Ringen & Helgason 2004:60)

kö[p]a ~ kö <sup>[h]</sup> p]a	'to buy'
kö <sup>[h]</sup> p-t]e ~ kö[p-t]e < kö/p+d/e	(past)
kö <sup>[h]</sup> p-t] ~ kö[p-t] < kö/p+t/	'bought supine'
väga	'weigh'
vä[g-d]e < vä/g+d/e	(past)
vä <sup>[h]</sup> k-t] ~ vä[k-t] < vä/g+t/	'weighed supine'

Thus, while Swedish has traditionally been presented as a case involving a [voice] contrast with emergence of voicing in assimilation, it is here shown that current analyses of the language, which posit a [voice] vs. [spread] contrast, can be easily converted into a theory where MAX and DEP regulate feature insertion and deletion. It is in this way that Swedish provides an interesting case where the individual [voice] and [spread] typologies overlap.

This program of research promises to remain interesting as other laryngeal contrasts are considered. For instance, in Cushitic there are systems that exist which contrast plain stops with implosives, and often ejectives. As an example, in Oromo (Lloret 1995) voiced stops and affricates induce progressive voicing. While ejectives follow the same pattern of progressive assimilation of [constricted], implosives fail to induce the same kind of assimilation. Instead, implosives follow a different pattern, becoming voiceless preceding a plain voiceless stop. Ts'amakko (Savà 2005) exhibits a pattern where there is generally progressive voice assimilation, but like Oromo, implosives do not trigger assimilation and instead, they devoice before voiceless stops. The difference is that in Ts'amakko these devoiced implosives become ejectives. While there is still an open debate regarding the representational nature of implosive consonants, it is clear that in these cases there is some evidence for not treating them as specified for [voice] (cf. Lloret 1995), leaving open the question of what their laryngeal specification actually is. There is obviously a need for further research into systems that make use of less common (or less commonly described) laryngeal contrasts, systems that make use of multiple laryngeal contrasts, and systems that form unexpected classes from the set of laryngeal features. It is expected that once a fuller typology of laryngeal features and laryngeal assimilation is developed, a more nuanced analysis of laryngeal agreement and laryngeal faithfulness will emerge.

Finally, the point should be reiterated that emergence of the marked effects are not in themselves unexpected; instead, they are unexpected under a particular approach to assimilation employing a specific set of ranked constraints. The emergence of the marked is a state of affairs that is actually the norm in the context of place assimilation. A classic example is Catalan nasal

place assimilation, where coronals are the targets of assimilation, but never triggers (Mascaró 1976:61-62, Kiparsky 1985:95).

- (25) Catalan nasal place assimilation
- |          |             |                    |
|----------|-------------|--------------------|
| alveolar | so[n] amics | 'they are friends' |
| labial   | so[m] pocs  | 'they are few'     |
| velar    | so[ŋ] grans | 'they are big'     |

This pattern has received a natural explanation by means of underspecification: Coronals are underspecified for place, and thus not only fail to trigger assimilation, but also undergo it (Kiparsky 1985, Avery & Rice 1989, Rice 1994). While a full re-analysis of place assimilation will not be attempted here, the predictions of the underspecification analysis can be contrasted with the present proposal. The theory here relies on an assimilation 'driver' (AGREE), with the repair being determined by the relative ranking of featural faithfulness constraints. The underspecification approach predicts that all other things being equal, coronal can never trigger assimilation, because coronals are not specified underlyingly for place features. The featural faithfulness approach need not assume underspecified structure, and predicts that in most circumstances (e.g. when there is a ranking such as AGREE, MAXDOR » MAXCOR), marked structure could emerge, such as when dorsals trigger assimilation. Such an approach also predicts that place assimilation in other languages, such as Sri Lankan Portuguese Creole, labial behaves as the unmarked place rather than coronal (Hume & Tserdanelis 2002). Hume & Tserdanelis (2002) and de Lacy (2006) demonstrate that a faithfulness-based account of Sri Lankan Portuguese is possible, and de Lacy has shown that several other cases of 'preservation of the marked' can be provided an extensive analysis that captures not only assimilation, but a range of other phenomena, as well. Thus, the extension of featural faithfulness to place assimilation is a rich area for future research.

## 6. Conclusion

This paper has presented a previously unrecognized pattern in the voice assimilation literature: emergence of the marked, i.e. voice assimilation that results in [voice] agreement. Possible analyses of this pattern include freely ranking the markedness constraints \*[-voice] and \*[+voice] with respect to each other cross-linguistically, or adopting MAX/DEP[Feature] constraints that regulate the insertion/deletion of the feature [voice]. Evidence from onset-control systems demonstrates the need for MAX/DEP[voice] instead of binary feature constraints such as \*[-voice] and \*[+voice]. This position is supported by the typological predictions made by each set of constraints.

An immediate implication of this approach is that marked assimilation patterns can be reconceptualized as faithfulness effects. Instead of resorting to language-specific markedness constraints or rankings, the patterns presented above can be recast as the effects of interacting faithfulness constraints (Hume & Tserdanelis 2002, Howe & Pulleyblank 2004, Pulleyblank 2004, de Lacy 2006). The primary difference between this approach and those of Howe, Pulleyblank, and de Lacy lies in the scalar nature of constraint rankings: while their scalar approach demands that faithfulness constraints be arranged in a fixed (or stringent) ranking, the data above indicates that this cannot be so (cf. Hume & Tserdanelis 2002 for a similar conclusion). In order to capture the range of patterns presented above, the rankings MAX[voice] » DEP[voice] and DEP[voice] » MAX[voice] must both be permitted by the grammar. This is the only way to allow for assimilation patterns which yield voicing (MAX » DEP) and patterns which yield voicelessness (DEP » MAX).

The sum result of the analysis is that the feature responsible for voicing contrasts must be privative [voice], and the constraints responsible for voice assimilation patterns (in conjunction with \*[voice]) are MAX[voice] and DEP[voice], which are freely rankable cross-linguistically.

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