Restrictions on direction of voicing assimilation: an OT account*

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In Lombardi (1996) I propose a set of constraints within Optimality Theory (Prince and Smolensky 1993) that account for patterns of obstruent devoicing and assimilation phenomena in the world's languages. Rerankings of these constraints produce only patterns in which voicing assimilation is regressive. However, there are cases of progressive voicing assimilation. I will argue in this paper that the constraints of Lombardi (1996) make a correct prediction: that voicing assimilation will always be regressive unless additional constraints are active. While many languages have regressive voicing assimilation in all clusters, I will show that cases of progressive assimilation always involve additional restrictions to special circumstances and thus show the action of additional constraints.

1. Voicing assimilation and word-final obstruents

Mester and Ito (1989) first proposed a way to handle regressive voicing assimilation, which appears to refer to both values of a feature [-/+voice], with a privative [voice] feature. They suggested that voicing assimilation was a combination of neutralization and spreading. Apparent spread of [-voice], then, was actually a result of neutralization, as follows:

	/pigpen/	/pikben/
	|	|
	voice	voice
Nonprevocalic obstruents lose [voice]:	pikpen	NA
Voice spreads to the left:	NA	pigben
		\/
		voice

Thus, we get both uniformly voiced and uniformly voiceless clusters without need for a [-voice] feature to spread.

This suggestion was taken up by subsequent authors such as Cho (1990) and Lombardi

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(1991, 1995a). A problem that arises with this type of analysis is that it predicts that, all other things being equal, assimilation will always cooccur with word-final devoicing, as word-final consonants are in coda position. This is true is many familiar cases. However, as both Cho and Lombardi found, some languages with voicing assimilation do not devoice word-final consonants:

(1) Voicing assimilation in obstruent clusters:
a. With word-final neutralization
Polish, Dutch, Catalan, Sanskrit

b. With word-final faithfulness
Yiddish, Romanian, Serbo-Croatian

Both authors therefore needed to propose additional mechanisms to account for the full range of languages. For example, Lombardi (1991,1995a) proposes a special additional licensing possibility at word-edge. The result is that languages like Yiddish have a more complex grammar than languages like Polish. However, this additional complexity results from purely theory-internal considerations and does not seem to reflect any true generalization about the naturalness of the two patterns.

In Lombardi (1996) I propose a set of constraints within Optimality Theory which account for these patterns of obstruent voicing assimilation and devoicing, which I summarize here:

(2) IDentOnset(Laryngeal) (IDOnsLar):
Onsets should be faithful to underlying laryngeal specification

(3) IDent(Laryngeal) (IDLar)
Consonants should be faithful to underlying laryngeal specification

(4) *Lar: Don't have Laryngeal features

(5) Agree: Obstruent clusters should agree in voicing

The constraint Agree, which requires obstruent clusters to agree in voicing, will sometimes be in conflict with the Faithfulness constraints, which prefer underlying specifications to remain the same. But not all faithfulness constraints are equal: the subset relationship between IDOnsLar and IDLar has the result that it is usually more important to be faithful to onset laryngeal specification than to coda (or elsewhere) specification. Thus, the only assimilation pattern that can satisfy Agree will be one where onsets stay the same and codas assimilate to them, since it will always be worse to change the onset than to change the coda. This is demonstrated in (6). (Hypothetical inputs are used in all tableaus to facilitate comparisons across different grammars.)

(6) Direction of voicing assimilation

/pikben/	Agree	IDOnsLar	IDLar
a. pikben	*!		
b.☞pigben			*
c. pikpen		*!	*

In the tableau above, candidate (a) violates Agree because it has an obstruent cluster that does not agree in voicing. Candidate (c) also agrees in voicing and so satisfies Agree; but it has done this at the expense of being unfaithful to the onset's laryngeal specification, violating IDOnsLar and IDLar. Thus, both (a) and (c) will lose to (b), where the coda has assimilated to the onset, satisfying both Agree and IDOnsLar, and violating only IDLar.

Like the neutralization and spread analysis of Lombardi (1991, 1995a) Cho (1990), Mester and Ito (1989), this analysis achieves assimilation to voicelessness without use of a feature [-voice], also due to the interaction of Agree and the faithfulness constraints, as we see in (7).

(7) Assimilation to voicelessness

/pigpen/	Agree	IDOnsLar	IDLar
a. pigpen	*!		
b.☞pikpen			*
c. pigben		*!	*

Candidate (a) violates Agree, since the cluster does not agree in voicing. Candidate (c), with progressive assimilation, obeys Agree, but has done so at the expense of violating both IDOnsLar and IDLar, as it has voiced an underlyingly voiceless onset. Therefore, the winner will be (b). By devoicing the coda, this candidate has achieved satisfaction of Agree - the cluster agrees in voicing - and it has achieved this by violating only IDLar (the coda has changed from voiced to voiceless) but not IDOnsLar (the onset has not changed). This shows that we can maintain privative [voice] in OT under this analysis; the value [-voice] is not needed to account for voicing assimilation, as also argued in various pre-OT works (Cho 1990, Mester and Ito 1989, Lombardi 1991, 1995a). (See also Lombardi 1995b for another argument for privative [voice] in OT.)

A good result of this analysis is the fact that the (1b) pattern of a language like Yiddish does not require any additional mechanisms. The possible differences in treatment of word-final consonants - either devoiced, or faithful - come out of basic constraint reranking.

(8) Ranking for assimilation and word-final devoicing:
IDOnsLar, Agree >> *Lar >> IDLar

(9)

a./pig/	Agree	IDOnsLar	*Lar	IDLar
pig			*!	
☞pik				*

b. /pigpen/	Agree	IDOnsLar	*Lar	IDLar
pigpen	*!		*	
☞pikpen				*
pigben		*!	**	*

c. /pikben/	Agree	IDOnsLar	*Lar	IDLar
pikben	*!		*	
☞pigben			**	*
pikpen		*!		*

As we see in this tableau, where there is no obstruent cluster, Agree is irrelevant, so in word-final (a) position there is devoicing as a consequence of *Lar >> IDLar. Agree >> IDLar means that there will be assimilation to voicelessness in (b): IDOnsLar is high ranked, so Agree cannot be satisfied by spreading [voice] to the onset; however, Agree can be satisfied, at the cost only of a low ranked IDLar violation, by devoicing the coda. However, we do get syllable-final voiced consonants where they are a consequence of assimilation, in (c,d): Satisfying *Lar (by leaving the coda voiceless) is not possible because it is more important to satisfy Agree and IDOnsLar: thus we get a cluster that shares the [voice] of the onset.

(10) Ranking for assimilation and word-final faithfulness:
IDOnsLar, Agree, IDLar >> *Lar

In this ranking, again Agree >> *Lar gives obstruent voicing assimilation, but IDLar >> *Lar results in word-final faithfulness to voicing:

(11) Voicing assimilation and word-final faithfulness

a. /pig/	Agree	IDOnsLar	IDLar	*Lar
☞pig				*
pik			*!	

b. /pigpen/	Agree	IDOnsLar	IDLar	*Lar
pigpen	*!			*
☞pikpen			*	
pigben		*!	*	**

c. /pigpen/	Agree	IDOnsLar	IDLar	*Lar
pikben	*!			*
☞pigben			*	**
pikpen		*!	**	

The majority of the interactions are the same here as in the last tableau: in both, obeying Agree is more important than avoiding additional *Lar violations, due to Agree >> *Lar, and assimilation is regressive due to the relationship between IDOnsLar and IDLar, which favors preserving onset voicing over preserving coda voicing. Thus we get regressive voicing assimilation in clusters (b,c). But for obstruents that are not in clusters, where Agree is not at issue, the languages differ. In (9), *Lar >> IDLar, so we have word-final devoicing. But in (11), as we see in (a), since IDLar >> *Lar, voiced word-final consonants remain: it is more important to be faithful to an underlying [voice] than to obey *Lar by eliminating it.

2. Direction of assimilation and factorial typology

We see, then, that with the proposed constraints, either faithfulness or devoicing of word-final consonants is equally natural in a language with voicing assimilation. Thus the factorial typology of the constraints produces the correct patterns. Also, in all cases the direction of voicing assimilation is regressive; rerankings of the core constraints will not produce progressive assimilation.

The lack of progressive voicing assimilation in the rankings above is not due to the formulation of the Agree constraint, which is not inherently directional. (See Padgett 1995 for a similar nondirectional constraint for Place assimilation.) Rather it is due to the positional faithfulness constraints, which will give priority to the voicing of the last consonant in a cluster, if any consonants must change their voicing in order for Agree to be satisfied. The prediction of the proposed set of constraints is that in the normal case - when no other constraints are active in the relevant environment - voicing assimilation will always be regressive.

However, progressive assimilation will be possible, since the Agree constraint is

non-directional. But it will only be possible when other constraints come into play, outranking the effects of the positional faithfulness constraint IDOnsLar. As I will show in this section, this is the correctly restrictive prediction. Straightforward cluster voicing assimilation, with no additional conditions, is always regressive, as in the languages discussed in the previous section. Progressive voicing assimilation always has additional morphological or phonological restrictions, showing the activity of additional constraints; there are no languages where we can simply say that whenever two obstruents come together, they show progressive voicing assimilation. Thus the proposed constraints allow us to capture the generalization that all voicing agreement in clusters is motivated by the same constraint, Agree, regardless of direction; but the correct prediction is made that regressive assimilation is the normal case, and progressive assimilation only occurs in special circumstances.

2.1 English plural

The English plural provides a simple example to begin with. I will account for this alternation by formalizing within OT the analysis proposed by Mester and Ito (1989; see also Lombardi 1991). They assume that the underlying form is voiced /z/ and so need to account for progressive voicing assimilation after voiceless consonants, as in cats , and the retention of voicing in pigs . They propose that this is due to a universal syllable-wellformedness condition noted by Harms (1973) and by Greenberg (1978): Voiced obstruents are more sonorous than voiceless, and thus must be closer to the syllable nucleus. Thus the following form is universally ruled out:

[kætz] * by Harms' generalization

Adding this as a top-ranked constraint to the ranking already required for English will account for these facts. [1] English after Level I has no restrictions on the distribution of voiced and voiceless obstruents, and so has the ranking IDOnsLar, IDLar >> *Lar >> Agree. (Only the relevant constraints for this example are shown in the following tableau).

(12)

/kæt+z/	Harms' genl.	IDLar	*Lar
a. kætz	*!		*
b. kædz		*	*!*
c.☞kæts		*	

Candidate (a) violates the universal Harms' generalization, so the only possibilities are the voice-agreeing candidates (b,c). Both of these violate voice faithfulness for a single segment, so the decision falls to *Lar, which chooses the voiceless cluster.

(13)

/pIg+z/	Harms' genl.	IDLar	*Lar
☞a. pIgz			**
b. pIks		*!*	
c. pIgs		*!	*

In this tableau we see that correctly, when the voiced ending is added to a voiced consonant there is no change. There is no motivation to change from the faithful candidate (a), since it does not violate top-ranked Harms' generalization. Because faithfulness to voicing is higher than *Lar, the faithfulness violations in (b,c) are fatal.

The English example, then, shows the action of an additional universally high-ranked constraint, along with the basic constraints for laryngeal phonology proposed in Lombardi (1996). The existence of progressive assimilation in English is a result of the fact that there are single- segment voiced obstruent suffixes, which bring out the effects of top-ranked Harms' generalization when suffixed to voiceless-final roots. Correctly, this ranking does not predict any more general progressive voicing assimilation in English, such as in word-internal heterosyllabic clusters.

2.2 Yiddish

Progressive assimilation may also be restricted by appearing only in specific morphological situations. Such a case is found in Yiddish. Although Yiddish normally has regressive voicing assimilation as in (11) above, progressive assimilation may occur with what Katz (1987) calls the "verbal additive", reflexive /zikh/. When following a voiceless obstruent, the /z/ may devoice (the vowel also reduces to [a] or schwa):

(14) [vos hertsakh] "What's new?" /her+t zikh/

The resultant cluster agrees in voicing, as do all Yiddish obstruent clusters. But rather than onset voicing taking priority, as in all other cases, preserving the voicing of this particular morpheme seems to take a back seat to faithfulness to the voicing of the verb it is attached to.

This is reminiscent of the suggestion of McCarthy and Prince (1995), that faithfulness in affixes may be lower ranked than faithfulness in roots. However, that solution will not work here; aside from the fact that not all affixes have this behavior, the final segment of the verb that triggers the progressive devoicing of /zikh/ is frequently a suffix, not part of the root, as in the example in (14).

We can analyze these facts instead by using another means to differentiate phonological behavior under different morphological conditions: the output-output correspondence constraints of Benua (1995). Benua shows, for example, how a non-derivational account of the differences between English level I and level II phonology is possible by setting up differences in correspondence relations that must be satisfied by the different affix classes. Level I affixes are attached directly to roots, which are not independent words. But Level II affixes are different, the difference being essentially what has often been captured by the use of a word boundary rather than morpheme boundary:

pass+ive vs. pass#ing
[pass] $_{root}$ ive [[pass] $_{root}$] $_{word}$ ing

The fact that ing is attached to a base that exists as an independent output on its own - a word - means that faithfulness relationships for this form are going to be more complex. Not only is there an IO faithfulness relation between the underlying form and the surface output, Benua proposes that there is also a faithfulness relation between the ouput affixed form pass#ing and the separate output pass . However, this relationship does not hold for the level 1 affixed form pass+ive . The level 1 suffix is affixed directly to a verb root, which is not an independent word. So for this case, only IO faithfulness is relevant; there are no additional faithfulness requirements. Benua (1995) shows as an example how this can account for the overapplication of New York English æ-tensing with Level II forms like passing .

A similar difference is clearly relevant in the Yiddish case. Unlike other suffixes in Yiddish, /zikh/ affixes only to inflected verbs. Since the base of affixation for /zikh/ is a possible independent word, it will be in an output- output relationship with that word standing on its own. If the relevant output- output faithfulness is high ranked, we will see progressive assimilation, as I will show. I will use the following constraint:

OOIdentLar: Correspondent output segments should agree in voicing.

In tableau (15), OOIdentLar evaluates faithfulness to the base word [hert], the inflected verb form. Thus, voicing the final /t/ in candidate (b) is an OOfaith violation. However, since /zikh/ is not an independent word, it is never an output on its own. Therefore the reflexive morpheme does not stand in an OO relation to any base, and changing it in candidate (a) is not a violation of OOIdentLar.

(15)

/hert#zikh/	Agree	OOIDLar	IDOnsLar	IDLar	*Lar
a.☞hertsakh			*	*	
b. herdzakh		*!		*	**
c. hertzakh	*!				*

The result, then, is that progressive assimilation will be optimal as long as the ranking is OOFaith above IOFaith. [2]

Importantly, adding OOFaith to this ranking does not affect the results for any other situations, either with other affixes or in compounds: assimilation will still be regressive everywhere else. First, for other affixes, the base of affixation is not an independent word, but the infinitive of the verb. Thus there is no output-output relationship that applies to /raš/ in the following tableau, and OOIdent is vacuously satisfied no matter what happens to that infinitive. The result is the same regressive assimilation as in (11):

(16)

/raš+dik/	Agree	OOIDLar	IDOnsLar	IDLar	*Lar
a.☞raždik				*	**
b. raštik			*!	*	
c. rašdik	*!				*

In compounds, there is an output-output relationship, since compounds combine two independent words. However, since this is true of both members of the compound, assimilation in either direction will be a violation of OOFaith, as we see in the following tableau. Thus the decision will pass to the IOFaith constraints; then since changing the onset is a worse violation, assimilation will be regressive:

(17)

/vog#šoi/	Agree	OOIDLar	IDOnsLar	IDLar	*Lar
a.☞vokšoi		*		*	
b. vogžoi		*	*!	*	**
c. vogšoi	*!				*

/bak#beyn/	Agree	OOIDLar	IDOnsLar	IDLar	*Lar
a.☞bagbeyn		*		*	**
b. bakpeyn		*	*!	*	
c. bakbeyn	*!				*

This tableau also shows that Agree must dominate OOIdent. Thus the final ranking for Yiddish is:

(18) Agree >> OOIdentLar >> IDOnsLar, IDLar >> *Lar

2.3 Dutch

Another example of progressive assimilation that is apparently phonologically conditioned can be seen in Dutch. Dutch has final devoicing and the usual regressive voicing assimilation in stop-stop and fricative-stop clusters. However obstruent clusters with fricatives in second position behave differently. We see in (19a-d) below the usual regressive voicing assimilation. But in examples like (19e-f), where a voiced fricative follows another obstruent, rather than the

expected voiced cluster, the cluster is voiceless. ((19g) shows that fricatives following sonorants are unaffected.) (data from Mey 1968, Booij p.c.; see also van der Hulst 1980):

(19)
a. /kɑs + buk/ -> [kɑzbuk] 'cash book' ([kɑs, kɑsə] 'cash sg,pl')
b. /kaz + bot/ -> [kazbot] 'cheese boat' ([kas,kazə] 'cheese sg,pl')
c. /kaz + pɛrs/ -> [kaspɛrs] 'cheese press'
d. /kɑs + pɔst/ -> [kɑspɔst] 'cashbook entry'
e. /ɔp + zɛxe/ -> [ɔpsɛxə] 'recite' [zɛxə] 'say'
/ɔp + vure/ -> [ɔpfurə] 'perform' [vurə] 'carry'
f. /kɑz + vɔrm/ ->[kasfɔrm] 'cheese mold' [vɔrm] 'form'
/ɑz + voxel/ -> [asfoxəl] 'scavenger bird' [as, azə] 'carrion sg,pl' [voxəl] 'bird'
/rad + zam/ -> [ratsam] 'advisable' [radə] 'advice, pl'
g. [zwɛmvoxəl] 'swimming bird'

These facts can be analyzed as the result of a high-ranking constraint forbidding voicing on a fricative that follows an obstruent:

(20)
Postobstruent Fricative voicing constraint (FricVoice):[3] * [-son] [-son]
[+cont]
[voice]

Combined with the ranking needed to give normal regressive voicing assimilation, this will give the correct results.

(21)

/rad+zam/	FricVoice	Agree	IDOnsLar	*Lar	IDLar
☞a.ratsam			*		**
b. radzam	*!				*
c. ratzam	*!	*		*	*
d. radsam		*!	*	*	*

Here, because of highranked FricVoice, (b,c) are ruled out. The choice must then be made between the two candidates (a,d) which have devoiced fricatives. (d) has a fatal Agree violation, and so the winner is (a), where the cluster is voiceless throughout.

To ensure that this does not incorrectly affect the results for clusters without fricatives in second position, we now examine (22):

(22)

/kas+buk/	FricVoice	Agree	IDOnsLar	*Lar	IDLar
☞a.kazbuk				**	*
b. kaspuk			*!		*
c. kasbuk		*!		*	

In this tableau we see the usual type of regressive voicing assimilation. Because the second consonant in the cluster is not a fricative, highranked FricVoice is irrelevant, and so the decision is made in the familiar way by the remaining constraints. The faithful output (c) is ruled out by Agree, so the choice must be made between the two voice-agreeing candidates (a,b). (b) achieved voice agreement by devoicing the onset, and so incurs a fatal IDOnsLar violation. Thus (a) is the winner; the additional *Lar violation caused by voicing the coda consonant is too low to matter.

2.4 Additional cases

In this section I will describe other cases of progressive voicing assimilation that I know of. These cases all present additional complications of analysis that are not strictly relevant to the main point here, so I will not give formal treatments of them. However, descriptions of the facts suffice to show that they all conform to the prediction that progressive assimilation must involve additional constraints, since in all cases the environments for assimilation are restricted.

As we have seen above, the constraints that cause the environment for assimilation to be more specific may either be phonological in nature, as in Dutch, or relating to the phonology-morphology interface, as in Yiddish. Additional examples of each type can be found. For example, in Polish (Bethin 1992; see also Lombardi 1991) we find progressive voicing assimilation in a restricted phonological environment. After an obstruent [r] alternates with [š,ž] due to a palatalization requirement, as seen in the following examples:

(23)

[gr]a 'game' [gž]e loc.sg.
[kr]a 'ice float' [kš]e loc.sg.

As these examples show, the voicing of [š,ž] is determined by the previous consonant in the cluster. The exact formulation of the palatalization constraint, which affects only clusters of precisely this sort, is obviously a difficult matter, but this is beside the point here. It is sufficient that as predicted, there are clearly other phonological constraints that come into play in this restricted situation where we find progressive assimilation in Polish, a language with regressive assimilation in all other situations.

Three other cases that I know of appear to involve morphological conditions or phonology-morphology interface constraints of some kind. One is the case of the Dutch past

tense morpheme, which undergoes progressive assimilation despite the fact that it is not a fricative. (See Lombardi 1991, 1991, 1995a for discussion and references). Some constraints specific to this morpheme or to the root/affix distinction are presumably involved here. Another is the case of Turkish progressive voicing assimilation that applies to some stop-initial suffixes. This may be a case where root faithfulness dominates affix faithfulness. However, since there are many additional complications involving voicing alternations in Turkish (see Inkelas and Orgun 1994 for details), a full analysis will not be attempted here. Finally, a number of Athabaskan languages show a kind of progressive voicing agreement at only the prefix-stem boundary (see Rice (1993) and references therein, for example).

3. Conclusion

In many languages, all obstruent clusters are subject to regressive voicing assimilation. Progressive voicing assimilation alternations exist, but all cases are restricted in some way: either their phonological or their morphological conditions are limited.

I have argued that the constraints proposed in Lombardi (1996) correctly predict this empirical generalization. Those core phonological constraints will only produce regressive voicing assimilation. When those constraints are the only ones that are high enough ranked to be active, only regressive assimilation is possible, as this avoids IDOnsLar violations. This assimilation will take place in all obstruent clusters, as all obstruent clusters are subject to the proposed constraints.

However, the Agree constraint that demands voicing agreement is inherently nondirectional. Thus the prediction is that progressive voicing assimilation will be possible, but only when some more specific constraint is high enough ranked to overcome the effects of IDOnsLar. As we have seen in this paper, all cases of progressive assimilation are more restricted in their environments, showing the effects of additional constraints that limit the application of voicing assimilation in particular situations. We do not see languages that simply show progressive voicing assimilation in all obstruent clusters; when assimilation is this general, it is always regressive.

Importantly, though, both directions of assimilation are prompted by the same Agree constraint, and this is especially significant in languages like Dutch and Polish. These languages have general regressive assimilation as in (9), but also certain limited cases of progressive assimilation as discussed at the end of section 2. Thus, while various factors may influence the direction of assimilation, the single surface generalization that clusters must agree in voicing is captured by a single constraint.

Notes

1. We would also get the same results from a constraint demanding that tautosyllabic obstruents agree in voicing; see Lombardi (1996) for discussion. Results would differ only if we needed to assume the plural to be underlyingly voiceless; then only the tautosyllabic voicing constraint would give the correct results, since e.g. [siyds] does not violate the Harms generalization.

2. Katz states that the progressive assimilation is optional, and that it and regressive assimilation with this particle are "equally widespread." See Ito and Mester (to appear) and references therein on how to handle optionality in OT. Following Ito and Mester, in this case optionality would be due to the ranking of IOIdent over OOIdent also being possible for speakers of this language.

3. Clearly more needs to be done to confirm the validity of (20) as a part of UG. But an alternative analysis which is specific to a morphological domain seems to be ruled out in this case: although these examples are all compounds, Booij (1995) argues from the pronunciation of acronyms that this constraint holds word-internally as well. (20) may actually be some kind of constraint interaction effect, and if so the markedness of voiced fricatives is likely to be involved. Although all voiced obstruents are marked, it appears that voiced fricatives are more marked than voiced stops. For example, a quick survey of the languages in Maddieson (1984) shows at least 96 languages that have a voicing distinction in stops but have only voiceless fricatives. Languages with the opposite situation, voiced fricatives but no voiced stops, are much less common - perhaps 12 or 13 possibilities - and given that Maddieson does not necessarily list only distinctive sounds, the number of authentic cases may be even smaller.

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