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AN OT ANALYSIS OF THE BASIC VOICING TYPOLOGY
AND VOICE ASSIMILATION IN DUTCH

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INTRODUCTION

In Wetzels and Mascaró (2001) we have evaluated a number of theoretical proposals, derivational, as well as non-derivational (constraint-based), that deal with devoicing and voice assimilation. In the course of that evaluation we have pursued a double objective. One was to establish the cross-linguistic typology of devoicing and [+voice] assimilation, the results of which are summarized *infra*. In this paper, we will interpret this typology in terms of universal constraints, and it will be shown how the interaction of the constraints proposed accounts for the (de)voicing patterns that are encountered. A detailed analysis of devoicing and voice assimilation in Dutch is proposed, and it is shown that, to account for positional neutralization in this language, an appeal must be made to both positional markedness and positional faithfulness constraints.

Another objective of Wetzels and Mascaró (2001) was to check the validity of the recent arguments to eliminate [-voice] from phonological feature theory. Given that all of the arguments were presented in the framework of derivational phonology, our counterarguments have been presented within that theory also. The privativity hypothesis was nevertheless carried over by Lombardi (1996) into the Optimality Theory (OT) framework. As we pointed out in Wetzels & Mascaró (2001), the privativity hypothesis, also when integrated in OT, is problematical in view of the description of languages that spread [-voice] only, either lexically or post-lexically, or that use [-voice] as a lexically contrastive

feature. Here we will therefore keep to the assumption that [voice] is a binary feature, until it is shown that the specific 'voicelessness' effects that we have observed can be explained more plausibly as the result of a different constraint type, one that does not involve the feature [-voice]. As expected, the traditional assumption that [voice] is binary does not run into the problems of the privativity hypothesis.

SYLLABLE-FINAL DEVOICING AND WORD-FINAL DEVOICING

Voice assimilation affects [voice] in the normal case, but it may affect [-voice] only, or [+voice] only. Voice neutralisation, which may occur independently of assimilation, is usually obtained by a prosodically conditioned domain-end rule. Abstracting away from the fact that languages may choose a final devoicing rule conditioned by a prosodic category higher than the word, the table in (1) contains all possible combinations of the relevant (de)voicing parameters.

TABLE 1

<i>σ</i> -final devoicing	<i>ω</i> -final devoicing	assimilation	language	/az+laz+tas+dad/ [as+las+taz+dat]
yes	(yes)	yes	Dutch	[as+las+taz+dat]
yes	(yes)	no	German	[as+las+tas+dat]
yes	no	no	Impossible	
yes	no	yes	Impossible	
(no)	no	no	English	[az+laz+tas+dad]
no	yes	yes	Walloon	[az+las+taz+dat]
(no)	no	yes ([+voice])	Ukrainian	[az+laz+taz+dad]
(no)	no	yes ([-voice])	Yathé	[az+las+tas+dad]
(no)	no	yes ([α voice])	Yiddish	[az+las+taz+dad]
no	yes	no	(?)	[az+laz+tas+dad ¹]

Because of the implicational relation that holds between syllable-final and word-final devoicing, some languages are predicted, rightly as we think, not to exist. One language type that we predict to exist, illustrated in the last row of (1), was not encountered in the literature. This language would be like English, but with word-final devoicing. We

suppose that its rareness is due to the relative rareness of the 'no-assimilation' languages. Otherwise, all predicted combinations are attested. Notice, finally, that it is structurally impossible to show for syllable-final devoicing languages the three types of [voice] spreading we have distinguished for assimilation-only languages. This is because syllable-final devoicing reduces the possible clusters that are inputs to assimilation to [-voice] [+voice] or [-voice] [-voice]. If assimilation applies in a [-voice] [-voice] sequence, the effect of [-voice] spreading is invisible, or, in other terms, '[-voice]-spreading only' remains indistinguishable from 'no spreading'. Furthermore, when [+voice] spreads in a [-voice] [+voice] cluster, the process is indistinguishable from the spreading of [-voice]. To be able to show the relevance of single feature spreading combined with syllable-final devoicing, we need to find languages that also possess, for example, consonantal prefixes with different lexical voice specifications, hypothetically /F+[C...]/ and /z+[C...]/, of which only one, but not the other adapts to the voice value of the root-initial consonant. We have not found such languages.

If the typology provided in table (1) is correct, non-assimilatory devoicing is either both syllable-final and word-final, or only word-final. In (1) below, this is illustrated by data from English (no devoicing), German (syllable-final and word-final devoicing), and Walloon (word-final devoicing only).

(1) Contrasting English	Syllable-final	Word-final
English pri[z]es	pri[z]money	pri[z]
German el[z]ig 'icy'	Ei[s]lauf 'skating match'	Ei[s] 'ice'
Walloon (Francard and Morin, 1986) lɛ [d] ɛtʁ 'ugliness'	prɛs [d] u 'near him'	lɛ [t] 'ugly'

In OT, there are two obvious ways to obtain final devoicing effects: through a positional markedness constraint prohibiting voice in syllable final obstruents, *Vo/CODA, which dominates a constraint that requires faithfulness to lexical voice specifications, IDENT (Vo), or through a constraint requiring (positional) faithfulness to [+voice] in onsets, which dominates a markedness constraint disallowing voiced obstruents, IDENT (Vo/ONS) >> *Vo/OBS (see e.g. Beckman 1998, Padgett 1995, for discussion of positional faithfulness constraints). We illustrate both possibilities with German *Ei/z/* → *Ei[s]*, *ei/z/ig* → *ei[z]ig*.

devoicing—IDENT (Vo) must be ranked between *VOICE/CODA₁ and *VOICE/CODA₂. In Birnbaum's words '[oral obstruents are always voiceless], when followed by a break in speaking, even a short one, and of course, at the end of a sentence' (1979:211). Some examples are:

- (7) *zaan vaɑ/b/* → *zaan vaɑ[p]*, demtl 'his wife, at that time ...'
er is miɪ/d/ → *er is miɪ[t]*, bin rich 'He is tired, so I ...'
di maa/z/ → *di maa[s]*, er vet 'the mice, he will ...'

In this way, the universal devoicing hierarchy predicts that devoicing at the edge of some smaller domain must imply devoicing at the edge of the domain within which it is contained.

The remaining languages, the ones that do not have contrasting obstruents, are derived by the ordering *Vo/Obs >> IDENT (Vo).

REGRESSIVE ASSIMILATION

We now turn to the treatment of [+voice] assimilation, which is typologically independent of final devoicing, as we have shown above and more extensively in Wetzels and Mascaró (2001). We consider the assimilation of a feature F as the effect of maximizing the domain of feature bearers over which F spans. Where assimilatory processes obtain, 'maximal span' effects are limited to more specific configurations, other constraints should successfully compete with assimilation to circumscribe it to the cases that surface. Some of the relevant situations are illustrated in (8), for a feature F and an uninterrupted sequence of feature bearers C...C³. In (8a), the span is minimal for all F autosegments and in (8b) the span over the sequence of C's is maximized; (8c) shows an intermediate situation. We return to (8d) below.

- (8) a. $\begin{array}{c} +F-F+F \\ \downarrow \downarrow \downarrow \\ CVCCCV \end{array}$ b. $\begin{array}{c} +F \\ \downarrow \downarrow \downarrow \\ CVCCCV \end{array}$ c. $\begin{array}{c} +F-F \\ \downarrow \downarrow \\ CVCCCV \end{array}$ d. $\begin{array}{c} +F \\ \downarrow \\ CVCCCV \end{array}$

³ Where sonorants are assimilatory triggers (Catalan, Dutch and Polish dialects, Spanish), substitution of obstruent by consonant, and a constraint requiring that sonorants be voiced yields the desired effects. Similar adjustments will take care of sonorant transparency effects (Russian).

There are different formal ways to derive the desired homorganic [+voice] sequences. We will assume here that the maximal span effect derives from a condition on alignment of voicing with the outermost elements in the sequence. In the case of a heterosyllabic sequence, these are the left edge of the coda and the right edge of the onset. This results in a general form of non-directional assimilation over a MAXIMAL SEQUENCE OF CS (which we represent as C*).

- (9) ALIGN (Vo, C*) (=Spreading) Align the left and right edges of a [+voice] autosegment with the left and right edges, respectively, of a (maximal) C-sequence. (Equivalent to the conjunction of ALIGN (Voice, L, C*, L) and ALIGN (Voice, R, C*, R)).

In (8a) the middle F will violate ALIGN (Vo, C*) twice, the others only once, which results in a total of four violations. Similarly, (8c) yields two violations, and (8b) doesn't violate the constraint, since [+F] exhaustively dominates CCC in [+F][C][C][C]_{4F}. Notice that, the way ALIGN (Vo, C*) is formulated, (8d), although an ill formed structure, does not violate the constraint, since [+F] is well aligned with C*, both to the left and to the right, i.e. [+F][C][C][C]_{4F} with improper bracketing. Following McCarthy (1997), we will block structure (8d) by 'NO GAP', a superordinate constraint that prohibits discontinuity⁴.

Regressive assimilation has been analyzed as assimilation of codas to the leftmost obstruent in the onset, or as assimilation of obstruents to the rightmost obstruent in the sequence. The second mechanism seems to be necessary for languages of the Slavic type, which show voicing assimilation in onsets, as in Russian /vzt/revozit' → [fst]revozit' 'to alarm', or Serbo-Croatian /sb/ogom → [zb]ogom 'farewell'. For other languages, both analyses seem to work, since complex onsets consisting of obstruents only are rare and are always homogenous for voice in assimilation languages. Thus in the Dutch examples in (10) the same result is obtained by saying that the stem final voiced obstruent assimilates to the following /s/, or by saying that both the stem final obstruent and the /s/ assimilate to the rightmost consonant in the cluster.

- (10) hui/d#sp/ectalist hui[isp]ectalist 'skin specialist'
 bree/d+st/e bree[ist]e 'largest'
 braa/v+st/e braa[fst]e 'most obedient'

⁴ The precise formulation of the constraint requiring assimilated clusters is not crucial here. Other formulations, like AGREE (Lombardi 1996, Beckman 1998), will have the same effects.

However, assimilation to the leftmost onset consonant predicts that onsets could possibly consist of obstruents disagreeing in voicing ([zɫ], [zβ], etc.), even in assimilation languages. We do not know of such cases. In addition, when alternations obtain, we also get assimilation in obstruent clusters in onsets, as for the Italian prefix *s-*:

- (11) tra[zβ]ordare 'to transfer' [zβ]arcare 'to disembark'
 tra[zv]ersale 'transverse' [zv]altiare 'to devaluate'
 tra[sk]orrere 'to elapse' [zg]onfiare 'to deflate'
 tra[sf]ormare 'to transform' [sp]ellare 'to skin'
 [sf]igurare 'to disfigure'
 [sk]alzare 'to take off the shoes'

We conclude that regressive assimilation can be homogeneously treated in all cases as assimilation of obstruents to the last obstruent in a sequence⁵. Since an internal sequence of obstruents is followed by a sonorant, we can define the position of the voice spreader as a pre-sonorant position. In such a position, an obstruent is faithful to its underlying voicing value. When the obstruent sequence agrees in voicing and the last obstruent in the sequence maintains its underlying value, we get regressive assimilation:

- (12) IDENT (Vo/PRES). An obstruent that is tautosyllabic with a following sonorant preserves the voice value of its lexical correspondent⁶.

⁵ The only case that might constitute an argument for syllable controlled assimilation comes from a language like Catalan, where obstruents assimilate to both obstruents and sonorant consonants. In C₁C₂S sequences where S is a sonorant and C₁ and C₂ form different syllables, we do not get assimilation of C₁ and to C₂ to S, but of C₁ to C₂.

de[s]pentinar	'to uncomb'	su[p]itrol	'subtle'	de[s]plegar	'to unfold'
de[z]lligar	'to untie'	su[b]limit	'sublimit'	de[s]triar	*de[zβ]legar
de[z]rattizar	'to clear of rats'	su[b]rogar	'subrogate'	su[p]tropical	*de[z]triar
		su[p]classe	'subclass'		*su[b]d]topical
					*su[b]g]lasse

⁶ As can be seen below in (13), the tautosyllabicity requirement that applies to the obstruent + sonorant cluster is necessary, since otherwise it would be incorrectly predicted that /d/ as in brood/d/#mas 'bread knife' is not devoiced in Dutch. As formulated, the constraint mirrors the 'Voice Constraint' of Lombardi (1991). See Padgett (1995) for pre-sonorant or 'release' position as a prominent position.

If IDENT (Vo/PRES) and AL (Vo, C*) dominate *Vo/Obs and the latter in turn dominates IDENT (Vo), we get regressive assimilation and final devoicing, as for Dutch *misdad* 'crime' (as usual, constraints that are not crucially ordered are separated by a dotted line):

- (13) Dutch assimilation and coda devoicing

	Ident (Vo/PRES)	AL (Vo, C*)	*Voice/Coda _σ	Ident (Vo)
-VO+VO +VO m/ #d/ aad				
-VO+VO+VO mis daad		*!*	*	
+VO +VO miz daad			*!*	*
-VO +VO mis taad	*!		*	*
+VO -VO miz daad			*	**

If IDENT (Vo/PRES) and AL (Vo, C*) dominate IDENT (Vo) and the latter in turn dominates *VOICE/CODA_σ, we get only regressive assimilation, as for Yiddish *bakhey* and *shrayb*:

(14) Yiddish: assimilation only (*bakbeyn* 'cheekbone', *shrayb* 'write')

	Ident (Vo/Pres)	Al (Vo, C*)	Ident (Vo)	*Voice/Coda ₀
-VO+VO a. /bak b eyn/ -VO+VO bak beyn		*!*		
+VO bag beyn		*	*	*
-VO bak peyn	*!		*	
+VO b. /shrayb / +VO shrayb				*
-VO shrayp			*!	

For obstruents that occur before a heterosyllabic sonorant, like /d/ in *nidnek* 'the (male) bore', the evaluation is the same as for /b/ in *shrayb*. Consider next Walloon. We have already accounted for the fact that it has devoicing of obstruents in word final position, but no devoicing in internal codas in (4). However, Walloon also has regressive assimilation (Francard and Morin 1986:454-456):

- (15) ni[v]er 'to snow' ni[f]er 'to snow a little'
djo[ɫ] [f]ejans 'we do it' dju [vʒ]ans 'we do'

As for Dutch, the ranking IDENT (Vo/Pres), AL (Vo, C*) >> IDENT (Vo) will determine regressive assimilation, while the ranking *VO/COD_{A₀} >> IDENT (Vo) will cause word final devoicing only.

Note that the last type of language in table (1), namely a language with only word final devoicing, is predicted by *VO/COD_{A₀} >> IDENT (Vo) and IDENT (Vo) >> AL (Vo, C*).

So far we have accounted for six of the eight possible language types in table (1). We will now consider the two remaining cases, Ukrai-

nian and Ya:thé. To be sure, these languages do not present any special problem, since we assume that both [+voice] and [-voice] are primitives of feature theory. We can consequently treat these languages as Serbo-Croatian or Yiddish, except that Ukrainian only assimilates the [+voice] value and Ya:thé only the [-voice] value. The constraint which selects assimilated obstruent sequences should be AL (+Vo, C*) for Ukrainian and AL (-Vo, C*) for Ya:thé. Yet, we wish to devote some more discussion to Ukrainian voice assimilation, which is a bit more complicated than is usually suggested in the theoretical literature.

Below we give examples of heterosyllabic clusters that are homogeneously voiced (16a) and of non-homorganic [+voice] [-voice] sequences (16b). The examples are taken from Danyenko & Yakutenko (1995).

- (16) a. pro[ʃ]iɹy 'to request' pro[z^h+b]a 'a request'
mo[ɫ]tʃ 'to tresh' mo[ɫd^h+b]a 'treshing'
na[ʃ] 'our' na[ʒ#d]id 'our grandfather'
žyra[f] 'giraffe' žyra[v#b]ižyt 'the giraffe is running'
ča[ʃ] 'time' ča[ʒ#d]ijay 'time to act'
da[x] 'roof' da[ɹ#b]udynku 'the roof of the house'

- (16) b. o[bs]jah 'volume'
ji[ʒ+t]e 'ea+IMP SG'
berel[ʒ+k]a 'little birch'
ri[d+k]o 'rare'
xo[ɫ]y 'trunk+GEN SG'
ve[ʒ+t]y 'to drive'
be[ʒ+č]esta 'dishonor'

The Ukrainian facts actually point to an explanation for a residual problem of the OT account of the (de)voicing typology proposed here, which concerns the definition of the IboNSVo constraint, of which two interpretations are possible. One is suggested in Lombardi (1995:10) where 'onset' is defined as 'the released prenuclear position'. Under this interpretation, it is predicted that a language like German devoic- es all but the prenuclear obstruent in a sequence. This would mean that not only codas are voiceless, but also part of a complex obstruent onset. This prediction is incorrect, witness words like *Budget* [bʏ.dʒe] 'budget', *Gin* [dʒin] 'gin', *Dschungel* [dʒʊŋl] 'jungle' *Dschihad* [dʒihət] 'dihad', etc. where the cluster /dʒ/ is tautosyllabic in German. If, on the other hand, 'onset' is understood in its usual meaning as the

consonant(s) that is/are tautosyllabic with a following nuclear segment, it would make the wrong predictions in the case of, for example, Serbo-Croatian, where a complex onset can be composed of a segment sequence that is lexically not homogeneous for [voice], as in [zbogom] from underlying /s+bogom/ 'with god'. Clearly, some proviso must be made to allow for an adequate description of these languages. Notice that the partial grammar in (2a), which uses the constraint *Vo/CODA, does not make that prediction. Still, even if devoicing in German is derived by the positional markedness constraint *Vo/CODA, and, consequently, the underlying voice value of onset obstruents is preserved, one would not really explain the generalization that German, which is a non-assimilating language, requires laryngeal homogeneity in tautosyllabic obstruent sequences (see Lessen Klooke 1982). In this respect German is different from some other languages that allow for non-homogeneous voice clusters lexically⁷. Considering this fact from an OT perspective, we must conclude that there are languages that obey a constraint requiring syllable-internal obstruent sequences to be homorganic for [±voice], even if homorganicity is not required across syllable boundaries. Interestingly enough, Ukrainian appears to be another language of this type. As was repeatedly mentioned before, standard Ukrainian has general regressive assimilation only to [+voice]. However, inside syllables no [+voice] [-voice] sequences are allowed. Also, the language shows [-voice] assimilation with the preposition/prefix *z* 'with'. According to Zilyns'kij,

... *z* usually preserves its voice only in the preposition-prefixes *bez*, *roz*, where its voice is supported by the preceding vowel, e.g. *bezxodʲyʲ*, *bez tebʲe*, ..., *bezpʲečʲno*, *bezkatʲno*, ..., *rozkazatyʲ*, ..., *rozpʲyka*, ..., *rozxid*. On the other hand, the preposition-prefix *z* before initial voiceless consonants usually loses its voice, being pronounced as *s* (such pronunciation can now be seen in the orthography, when the prefix *z* precedes *h*, *t*, *h*, *x*). Examples are *spečʲi* (written з печі), ..., *s tobʲoju* (з тобою), ..., *s knyʲžkyʲ* (з книжки), ..., *s pomʲiž* (з-поміж), ..., *s francuzʲyʲ* (з францу́жени́й), *s cʲydyʲbyʲ* (за́йдити) ... (1979:147).

Zilyns'kij relates the difference in assimilatory behavior between the two prefix types to the presence of a vowel in the syllable-sized prefixes, which supports the voice of the following /z/. A slightly different explanation seems more plausible. We may guess that /z/ syllabifies

as a coda if there is the possibility for backwards syllabification, as in *bez*, *roz*, etc. On the other hand, in the case of the consonantal prefix/preposition /z-/, forward syllabification is obligatory. The difference between the spreading of 'voice' or 'voiceless' can then be related to a difference of domain: whereas the syllable is the domain for the spreading of [±voice], the assimilation of [-voice] happens across the board. This view is consistent with the generalisation that [-voice] obstruent sequences are always heterosyllabic in Ukrainian. The following examples, taken from Butska (1997)⁸, illustrate the alternation in the preposition/prefix /z-/ (17a), and the homogeneous voice clusters inside syllables (17b).

(17) a. *z* prefix:

[s+k]osi-ti	'now down-INF'	[z+b]i-ti	'knock down-INF'
[s+p]ali-ti	'singe/burn down-INF'	[z+d]ari	'give up-INF'
[s+t]rima-ti	'hold in-INF'	[z+f]inu-ti	'die-INF'

z preposition:

[s#]ob-oju	'with you-INSTR'	[z#f]ori	'from above-GEN'
[s#k]aš-oju	'with porridge-INSTR'		
[s#p]ošan-oju	'with respect-INSTR'		

(17) b. syllable internal obstruent clusters

[tk]ač	'weaver-NOM.MASC'	[db]a-ti	'care-INF'
[sc]en-a	'stage-NOM FEM'	[ʒv]in	'bell-NOM MASC'
[pt]ax	'bird-NOM MASC'	[bʒ]ola	'bumblebee-NOM FEM'
[kx]ir	'skunk-NOM MASC'		

As we hinted at above, we can understand these facts if we assume that the constraint that takes care of laryngeal assimilation is in reality a constraint hierarchy that is stratified in conformity with the prosodic domain hierarchy, as in (18), where the usual (subscripted) symbols represent the prosodic domains that we suspect to be relevant for voice assimilation:

(18) $\Delta I (V_0, C^*)_{\sigma} \gg \Delta I (V_0, C^*)_{\phi} \gg \Delta I (V_0, C^*)_{\rho} \gg \Delta I (V_0, C^*)_{\tau} \gg \Delta I (V_0, C^*)_{\mu}$

In (18), assimilation inside syllables dominates assimilation inside words, and so forth. It is predicted that, when some laryngeal feature spreads over a sequence of Cs within a given prosodic domain, it also creates homogeneous voice clusters within some smaller domain. In the case of Ukrainian, we must account both for syllable internal assim-

⁷ As, for example, in English [sv]^lell.

⁸ Butska confirms that /z-/ appears as [s], except 'before vowels, sonorants, voice obstruents' (1997:15).

ilation of [+voice], and [+voice] assimilation that applies across word-boundaries within a domain that we will assume to be the intonational phrase. We obtain these facts through the constraint ranking in (19a):

- (19a) $Al(Vo, *C)_\sigma$, Ident (Vo/Pres) \gg Al ([+voice], $*C$) $_1 \gg$ Ident (Vo)
 (19b) $Al(Vo, *C)_\sigma$, Ident (Vo/Pres), $*Vo/Coda_\sigma \gg$ Ident (Vo)

We can now posit the constraint ranking in (19b) for German, and explain why newly created words or loans will always show syllable-internal homogeneous voice clusters.

PROGRESSIVE ASSIMILATORY EFFECTS IN DUTCH: FRICATIVE DEVOICING

As already mentioned, there are two possible ways of deriving positional neutralization in OT, namely positional faithfulness, e.g. IDENT (Vo/CON), where CON is some context, and positional markedness, e.g. $*Vo/\sim$ CON, where \sim CON is the complement of CON. Analyses favour in some cases the first, in other cases the second alternative (Lombardi 1996, Beckmann 1998, Zoll 1998). In this section we show that, for the same empirical case, both positional markedness and positional faithfulness are necessary.

As exemplified above in (13) with an obstruent-stop cluster, the Dutch grammar of voicing must contain the ordering shown in (20):

- (20) Ident (Vo/Pres), Align (Vo, C*) \gg $*Vo/Coda \gg$ Ident (Vo)

Consequently, the predicted effect on all obstruent clusters, including obstruent-fricative clusters, is regressive assimilation. But what we actually observe in obstruent-fricative clusters is general devoicing, as the examples in (21) show:

(21)	[v]allen	'fall'	o/pv/allen	o[pf]allen	'strike'
	eer[z]aam	'honest'	waɑ/kz/aam	waɑ[ks]aam	'aler'
	[z]ucht	'ambition'	han/dz/aam	han[ts]aam	'handy'
	[z]aag	'saw'	he/bz/ucht	hel[ps]ucht	'arance'
	[y]ierig	'greedy'	broo/dz/aag	broo[ts]aag	'breadaw'
			wee/ty/ierig	wee[tx]ierig	'eager to know'
			roo/vy/ierig	roo[fɣ]ierig	'eager to rob'
	[v]ijver	'pond'	vi/sv/ijver	vi[sf]ijver	'fishpond'

Three effects must therefore be accounted for: regressive voicing in obstruent-stop clusters, devoicing in obstruent-fricative clusters, and syllable final devoicing. Traditional analyses account for progressive devoicing by a rule of progressive [-voice]-assimilation, fed by syllable-final devoicing. In the constraint-based analysis proposed here, we will distinguish IDENT (Vo/Pres) and the more specific IDENT (Vo/Pres/STOP), which requires that (only) presonorant stops retain the underlying voice value. By the subset principle IDENT (Vo/Pres/STOP) will be ordered above IDENT (Vo/Pres). Al (Vo, C*) and IDENT (Vo/Pres/STOP) will be ordered first. They will select candidates with voice-linked (assimilated) structures in which the voicing value will be determined by the last element if it is a stop, and it will be left undetermined if the last element is a fricative: *vo[zb]it* from *vo/sb/it* 'fox bit', but *roo[dv]os* and *roo[tf]os* from *roo/dv/os* 'red fox'. In order to choose *roo[tf]os* over *roo[dv]os* we might invoke $*Vo$ (OBSR), but also $*Vo/CODA_\sigma$, as can be seen in (22). We will argue below that the second option is preferable. First, we illustrate the effect of this ordering with *roo[dv]os* 'red-fox bit', which shows devoicing of obstruent-fricative sequences (/dv/ → [tf]) and regressive assimilation of [-voice] for obstruent-stop sequences (/sb/ → [zb]).

- (22) Dutch progressive assimilation and regressive assimilation: *roo[dv]os* 'red fox bit'

roo/d+v/o/s+b/it	Id(Vo/ Pres/Stop)	Al(Vo, C*)	*Vo/ Coda $_\sigma$	Id(Vo/ Pres)	*Vo/ Obst
roo[dv]o[sb]it		**1	*		**
roo[dv]o[zb]it			**1		****
\varnothing roo[tf]o[zb]it			*	*	**
roo[dv]o[sp]it	*1		*	*	**
roo[tf]o[sp]it	*1			**	**

So far, we can account for regressive assimilation and progressive assimilation in fricative-final obstruent clusters, but we still have to make sure that final devoicing and preservation of contrasts in presonorant position for obstruents when they are not in clusters are also correctly predicted. Consider *zondigheid* 'sinfulness'. Both presonorant /z/ and /d/ remain faithful to their [+voice] value. Internal /y/ and final /d/ are both syllable final and must devoice. In (23) we illustrate all these cases; we omit Al (Vo, C*) since it is irrelevant.

(23) Dutch obstruents and fricatives in onset and in coda *zandighet*'simfulness'

/z/on/d/i/y/hei/d/	Id (Vo/ Pres/Si)	*Vo/ Coda _g	Id (Vo/ Pres)	*Vo/ Obs
[z]on[d]i[y]hei[d]		*!*		****
⇐ [z]on[d]i[x]hei[t]				**
[s]on[d]i[x]hei[t]			*!	*
[z]on[t]i[x]hei[t]	*!		*	*

We can now show that both *Vo/CODA_g and IDENT (Vo/PRES) are necessary. Assume that we only have IDENT (Vo/PRES/STOP), IDENT (Vo/PRES), *Vo/OBS, and IDENT (Vo). In order to get progressive devoicing, as in *vo/dv/os* → *voɔ[tʃ]os* (via *voɔ[tv]os*), and regressive voicing, as in *vo/sb/it* → *voɔ[zb]it*, we need faithful stop onsets and unfaithful stop fricatives. Hence the ordering could be that in (24a). However, in order to preserve the voicing of single fricatives in cases like /z/ *ondig* → [z] *ondig*, we need the ordering in (24b):

- (24) a. Ident (Vo/PRES/Stop) >> *Vo/OBS >> Ident (Vo/pres)
 b. Ident (Vo/PRES) >> *Vo/OBS
 c. Ident (Vo/PRES/Stop) >> *Vo/Coda_g >> Ident (Vo/PRES) >> *Vo/OBS

Clearly, (24a) and (24b) show contradictory orderings. The introduction of *Vo/CODA in (24c) allows preservation of the underlying voice value in stop onsets by high ranking of IDENT (Vo/PRES/STOP), and devoicing of all obstruent codas. Since the assimilation constraint ALIGN (Vo, C*) forces agreement of [±voice] in clusters, we obtain regressive and progressive effects correctly. This covers all stop onsets and all clusters. We are left with single fricatives in onsets. Since IDENT (Vo/PRES/STOP) and *Vo/CODA_g do not apply to them, their voicing value will follow from IDENT (Vo/PRES) >> *Vo/OBS, which will determine agreement in voice with their underlying value.⁹

⁹ In most northern dialects of Dutch, there is no phonological opposition between voiced and voiceless fricatives. Obviously, the analysis proposed here is not meant to cover these variants. For the dialects that do make the distinction it is predicted that voiced clusters ending in a fricative consonant may appear in onsets. Although such onsets are not part of the native vocabulary, they sometimes appear in loans, such as *Sveilana* [zv], *Sveboda* [zv], *jungle* [dʒ], *jingle hell* [dʒ], *Ge(s)undheit* [gz] 'cheers' etc. Indeed, in the speech of the Dutch co-author of this paper, all these clusters remain voiced, including [zv], which is more commonly nativized as [sw].

PROGRESSIVE ASSIMILATORY EFFECTS IN DUTCH: MORPHOLOGICALLY CONDITIONED PROGRESSIVE ASSIMILATION

Dutch has another type of progressive assimilation. The process is an internal sandhi process, active inside past tense verb forms, of which it affects the imperfect and the past participle. The progressive assimilation effect in past participles is visible when the latter are used as inflected, pronominal adjectives. The phenomenon is illustrated in (25) below:

(25) Morphologically conditioned progressive assimilation.

infinitive	2/3p sg pres ind	imperf g/pl(n)	past part	
maken	ma[k+t]	ma[k+t]e(n)	gema[k+t]e	'make'
krabben	schra[p+t]	schra[p+t]e(n)	geschra[b+d]e	'scratch'
kussen	kul[s+t]	kul[s+t]e(n)	geku[s+t]e	'kiss'
stoppen	sto[p+t]	sto[p+t]e(n)	gesto[p+t]e	'stop'
razen	raa[z+t]	raa[z+d]e(n)	geraa[z+d]e	'rage'
beven	bee[f+t]	bee[v+d]e(n)	gebee[v+d]e	'tremble'
halen	haal[t]	haal+[d]e(n)	gehaal+[d]e	'get'
knorren	knor+[t]	knor+[d]e(n)	geknor+[d]e	'grunt'
kammen	kam+[t]	kam+[d]e(n)	gekam+[d]e	'comb'
rennen	ren+[t]	ren+[d]e(n)	geren+[d]e	'run'
kanoën	kanoo+[t]	kano+[d]e(n)	gekano+[d]e	'canoe'
skiën	skie+[t]	skie+[d]e(n)	geskie+[d]e	'ski'

In the past tense forms, the suffix-initial consonant adapts to the voice value of the stem-final obstruent. In previous studies on voice assimilation, the unexpected behaviour of the past tense suffix has been dealt with in various manners. Trommelen and Zonneveld (1979) interpret the similarity of this assimilation pattern with the one observed in fricative-final clusters as the consequence of a similar underlying representation: the passed tense suffix derives from lexical /ðə/. Others have proposed an archiphonemic (underspecified) representation of the suffix-initial consonant, supplemented by a rule that predicts its phonetic voice value from the voice property of the stem-final segment (vowels and sonorants included) (cf. Wetzels 1986:126). The most concrete analysis posits a rule of progressive [-voice] assimilation which specifically targets the past tense suffix, lexically represented as /da/. We will show that the last approach most readily translates into the constraint-based analysis proposed so far.

Being sensitive to the voice value of the stem-final consonant, the past tense suffix represents a potential violation of *Id* (*Vo/PRES/STOP*), which is ranked highly in the (de)voicing grammar of Dutch. The essence of the conflict could be defined as follows: the grammar of Dutch prefers to maintain the lexical voice value of stem-final consonants in verbs at the price of creating a violation of onset-stop faithfulness: *maa/k+t/d/e* → *maa[k+t]_e, kraa/b+d/e* → *kraa[b+d]_e*. If this view of the facts is correct, a constraint-based analysis readily comes to mind. We need the constraint in (26):

(26) *IDENT* ([-voice]/STEM)¹⁰

Constraint (26) is a faithfulness constraint which requires the stem of the output to preserve its lexical [-voice] value. Notice that the maximization of the Input/Output relation defined in (26) may only concern the feature 'voiceless'. If the constraint were defined over both 'voice' and 'voiceless', a wrong prediction would be made with regard to the forms in the second column of (25). These forms show that, in the grammar of Dutch, Final Devoicing is a stronger requirement than Voice Faithfulness for verb-stem final obstruents. Since constraint (26) is ordered above *IDENT* (*Vo/PRES/STOP*), a grammatical form like *bee[f+t]*, which corresponds to lexical *bee/v+t/*, is predicted to violate *IDENT* ([-voice]/STEM) fatally. Instead, also by virtue of *ALIGN* (*Vo, C**), the form *bee/vd/* would be preferred, in contradiction with the facts. The ordering paradox can be avoided by restricting the *IDENT* constraint for verb roots to [-voice] obstruents. The limited scope of (26) is not surprising for several reasons. The fact that faithfulness constraints may specifically refer to (verb) roots was suggested in McCarthy and Prince (1995) and is by now common practise in OT. Furthermore, as we have seen above, [-voice] is a primitive of universal grammar, just like [+voice]. Since faithfulness constraints may affect any individual feature, there is no reason to assume that [-voice] could not be individually selected. Also, the only past tense forms that really violate *IDENT* (*Vo/PRES/STOP*) are the ones that contain a voiceless stem-final obstruent. None of the other forms in (25) conflicts with *IDENT* (*Vo/PRES/STOP*). Therefore constraint (26) covers the conflicting feature only. It is also impossible to generalize the constraint to word-internal affixation, which generally shows the normal regressive effects: *bedo[v]en* 'to promise', *bedo[ft]* 'the) promise'; *lel[v]* 'dear'

¹⁰ A similar, although too general constraint is proposed in Van de Vijver (1997).

lel[fst] 'dearest'; *zwa[k]* 'weak', *zwa[kt]* 'weakness', *zwa[kst]* 'weakness'; *ou[d]* 'old', *ou[st]* 'oldest'.

In the following tableau some relevant candidates are evaluated:

(27)

	a. <i>bee/v+t/d/e</i>	<i>Al</i> (<i>Vo, C*</i>)	<i>IDENT</i> ([-voice]/STEM)	<i>Id</i> <i>Vo/PRES/St</i>	* <i>Vo/Coda</i>
	<i>bee[f+t]e</i>	*!	*	*	
	<i>bee[f+t]e</i>		*!	*	*
	<i>bee[v+t]e</i>				*
	b. <i>bee/v+t/</i>				
	<i>bee[v+t]</i>	*!			*
	<i>bee[v+d]</i>				*!
	<i>bee[f+t]</i>				
	c. <i>maa/k+t/d/e</i>				
	<i>maa[k+t]e</i>	*!			
	<i>maa[g+t]e</i>		*!		*
	<i>maa[k+t]e</i>			*	
	d. <i>maa/k+t/</i>				
	<i>maa[k+t]</i>				
	<i>maa[g+t]</i>		*!		**
	<i>maa[k+t]</i>	*!			*

Since *IDENT* ([-voice]/STEM) exclusively involves verbs, and only in a very specific manner, it does not interfere with the evaluation of other words. The results obtained for regressive voice assimilation and of progressive voiceless assimilation remain completely intact.

CONCLUSION

In this paper we have established that the phonological variation involving the [voice] feature is the result of two independent mechanisms, but which can simultaneously occur in languages: prosodically con-

trolled devoicing and voice assimilation. The typology of (de)voicing effects that we have established show striking similarities cross-linguistically, which we have been able to express in the constraint-based framework of Optimality Theory. Both devoicing and assimilation have been interpreted as constraint hierarchies, which closely mirror the universal prosodic hierarchy. The assimilation constraint AL (VO, C*) is essentially non-directional, and can affect [+voice], [-voice], or both. The usual regressive assimilation effects are obtained by a constraint that defines the voice values of obstruents in release position as being universally prominent. High ranking of IDENT (VO/PRES) and AL (VO, C*) will cause general regressive assimilation. Typological differences among languages result from the way in which the assimilation and devoicing constraints are hierarchically ordered. Progressive assimilation effects can be obtained by allowing the IDENT (VO) constraint to refer not only to syllable positions, but also to segment classes, as in Dutch fricative devoicing, or by having more specific constraints ranked higher than IDENT (VO/PRES), as in progressive assimilation in Dutch past forms.

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