Voicing Assimilation and the Prosodic Cycle

JEFFREY T. RUNNER
Univ. of Massachusetts at Amherst
and Univ. Autònoma de Barcelona

1. Introduction to the Problem[1]

Recent cross-linguistic research on voicing has reduced many of the voicing effects found across languages to two simple rules. The first is the mechanism which accounts for final devoicing in a language like German. The second is the rule which accounts for the voicing agreement commonly found in consonant clusters, known as voicing assimilation. Starting with final devoicing, the basic idea is that for some languages, the feature [voice] delinks from the rime position of a syllable. As we see in (1), we can think of this in two slightly different ways:

(1) Final Devoicing:
   a. Rime Delinking (Mascaró 1987, Mester & Itô 1989): [voice] is not licensed (i.e. delinks) in rime position.
   b. Onset Licensing (Lombardi 1991, Gussmann 1992): [voice] is licensed only in onset position (otherwise cannot link).

Mascaró (1987) and Mester & Itô (1989) suggest that for some languages the feature [voice] is not licensed in the rime position of a syllable; thus an underlying [voice] feature delinks in that position. Lombardi (1991) and Gussmann (1992), on the other hand, suggest that a positive licensing mechanism can account for these phenomena; the feature [voice] is licensed only in onset position, otherwise it cannot link to the structure. In either case, if an underlyingly voiced segment ends up in rime position, its voicing feature is not licensed and it is not linked. I will not choose between these two hypotheses; what is important for this paper is that there is some mechanism which results in a segment lacking a [voice] specification.

As for the second rule, voicing assimilation, most of the above authors agree that it ideally is the context-free feature-filling rule spread [voice], as in (2).

(1) I would like to thank Juli Carter, Joan Mascaró, Josep Quer, Lisa Selkirk, Suzanne Urbanczyk, and the members of 3rd Year Seminar at U.Mass and the Seminari Fonologia at UAB for helpful discussion and/or support; special thanks to John McCarthy. This work was supported by a NSF graduate fellowship; I am responsible for all errors.

(2) Voicing Assimilation: Spread [voice]

It is the nature of this rule that I will be most concerned with here. What is interesting is that, for the most part, (2) can be maintained for the languages that show voicing agreement. The problem is that there is a subset of these languages for which the rule of voicing assimilation appears to be context sensitive. The rule is constrained to apply only across certain prosodic boundaries, specifically syllable boundary or prosodic word boundary. In other words, voicing assimilation is blocked from applying solely within one of these prosodic domains. This complication forces the above authors either to give up the context free nature of voicing assimilation or to accept certain assumptions about the feature [voice] which turn out not to be maintainable. I will argue that voicing assimilation is the context free rule in (2) but that it is a cyclic rule of the prosodic phonology. As a cyclic rule it must obey a version of the Strict Cycle Condition, what I call the Prosodic Cycle. As it turns out, then, the apparently context sensitive nature of voicing assimilation will follow from the Prosodic Cycle. The blocking effects are simply Strict Cycle effects.

Before getting to the particulars of my account, in the remainder of this section, I will lay out the specific problems to be faced; then I will discuss several proposals that have been made to account for these problems, pointing out their strengths but rejecting them for their weaknesses (Sections 2 and 3). Section 4 lays out the Prosodic Cycle account, showing how it overcomes the problems of the previous accounts while maintaining their strengths. Independent evidence that the Prosodic Cycle is needed in phonology is given in Section 5, providing further support for the account proposed. Some conclusions and open questions are addressed in the final section.

I will illustrate how (1) and (2) work with an example from Dutch:[2]

(3) Dutch (from Lombardi 1991: 42):

a.	hui[z]en	'houses'
b.	hui[s]	'house'
c.	hui[sk]ammer	'living room'
d.	hui[zb]aas	'landlord'

In (3) we can see the effects of final delinking and voicing assimilation in Dutch. We see that underlying /z/ maintains its [voice] feature in onset position in (a). In (b) the same segment is in the rime of its syllable and it shows up as voiceless. This is because of final devoicing: [voice] delinks from rime position. Now, in (c) and (d) we see that the underlying /z/ in rime position surfaces in agreement with the following segment. Starting with (d), we assume that final delinking in (1) has applied causing the underlying /z/ to lose its [voice] feature. But voicing assimilation in (2) comes along and spreads the feature of the following [b] back onto the [z]. What about (c)? One possible story is that it is the same as (d) except with [-voice]. Then, after final delinking, which results in a segment with no [voice]

(2) I should mention that I am mainly concerning myself with regressive voicing assimilation. Progressive assimilation is also found but appears to have somewhat different properties (but see Mascaró 1987 for discussion).

feature, voicing assimilation spreads the [-voice] feature from [k] back onto the [s]. I will argue later that this is not correct. Following Mester & Itô (1989), Cho (1990) and Lombardi (1991), I will suggest that [voice] is a privative feature. What that means is that there is no feature [-voice] and that a segment that has no specification for [voice] is interpreted as voiceless. I will get back to that below. But for now, let us look at (c). If [voice] is privative then nothing more needs to be said. Final devoicing delinks the [voice] feature on underlying /z/ and thats it. The following [k] has no voicing feature and the cluster is voiceless.

Something to note about Dutch is that voicing assimilation applies only within words, not across word boundaries, and it is triggered only by obstruents. That means that sonorants appear not to play a role in voicing assimilation in this language. Along with the authors above, I assume that sonorants are underlyingly unspecified for [voice] and that a default rule assigns them their [voice] specification. Then, for Dutch we can simply say that voicing assimilation applies before sonorants are specified for [voice]. With no [voice] feature, they cannot trigger voicing assimilation.

In languages like Catalan, Crakow-Poznań Polish and Sanskrit, voicing assimilation is triggered by obstruents within words, like Dutch, and also across word boundaries.

(4) a. Catalan: bul[β]ós 'bulbous' --bul[p] 'bulb'
ca[bd]ell '(wool) ball'; perce[ps]ió 'perception'
ca[p] 'no'--ca[b z]ona 'no zone'

b. Cracow: wó[t] 'gen.pl.'--wo[d]a 'water'--wo[tk]a 'votka'
pro[ś]ic 'request'--pro[źb]a 'id.n.'
wró[g z]niszczył (/g z/) 'the enemy destroyed'
ja[g z]awsze (/k z/) 'as always'

c. Sanksrit: /tad/--[tat]; /labh-sye/--[lap-sye]
/dik-gadah/--[dig-gadah]
/jyok/ /j ī̄va/--[jyog jī̄va]

In Catalan, for example, we see in (4a) that underlying /b/ in 'bul[β]ós' devoices to [p] in rime position. Word internal obstruent clusters always agree in voicing, as in 'ca[bd]ell' and 'perce[ps]ió'. Unlike Dutch, obstruents which come together across a word boundary also agree in voicing as we can see in the pair 'ca[p]' vs. 'ca[b z]ona'. The same basic facts hold for Cracow-Poznań Polish and Sanskrit as illustrated in (4b) and (c).

Voicing assimilation is also triggered by sonorants in these languages. The interesting problem is that such assimilation is possible only across certain prosodic boundaries.

(5)		VA	no VA	boundary (.)
a.	Catalan:	a*d.l*eta	a.*pl*icar	syllable (σ)
		'athlete'	'to apply'	
b.	Cracow:	jag.*ń*idy	pi*s*.*m*o	word (ω)
		'as never'	'writing'	
c.	Sanskrit:	[ta*d.n*amas]	[va*c*ya]	word (ω)
		'that homage'		

In Catalan, voicing assimilation from a sonorant is possible across a syllable boundary but it is impossible within a syllable itself. So, we find the contrast in (5a): 'a[d.l]eta' in which the [d] is underlyingly /t/ has undergone voicing assimilation, triggered by [l]. But in *a.[pl]icar* voicing assimilation is impossible. The relevant difference between the two forms is syllable structure. In *atleta* the [d] and the [l] are separated by a syllable boundary. In *aplicar*, both [p] and [l] are within the same syllable. It appears, then, that voicing assimilation triggered by sonorants is sensitive to syllable structure in Catalan.

In Cracow-Poznań Polish, a similar restriction appears. The difference is that voicing assimilation triggered by sonorants is allowed only across prosodic word boundary. It is blocked from applying solely within a word. Thus, we observe the contrast in (5b): we find voicing assimilation in 'ja[g.ń]idy', where [g] and [n] are in separate words. In that example the sonorant triggers voicing assimilation across the word boundary. But voicing assimilation is blocked in *pi[sm]o*. Here the sonorant and the target are in the same word. Voicing assimilation triggered by a sonorant cannot apply solely within a word, it must apply across a word boundary. The facts of Sanskrit are parallel to those of Crakow as (5c) illustrates.

The asymmetry between obstruents and sonorants as triggers of voicing assimilation needs some explanation since it does not follow trivially from the analysis in (1) and (2). Why is it that voicing assimilation triggered by obstruents is context free and voicing assimilation triggered by sonorants appears to require a context? Do we have two separate rules? I will discuss two recent approaches to these questions and argue that neither can be maintained. I will then pursue the idea that voicing assimilation is a cyclic rule of prosodic phonology and that the apparent blocking effects displayed in (5) are simply strict cycle effects, or effects of the Prosodic Cycle.

2. Binary Voicing

I will begin with the Binary Voicing account. Mascaró (1987) makes the standard assumption that the feature [voice] is a binary feature. That means that both [+voice] and [-voice] are phonologically active features. That assumption, combined with several others regarding the ordering of default rules, derives the blocking effects we saw in (5). I will illustrate with Catalan.

(6) Catalan:

	Delinking	Default	Spread	Surface
a.	a.*t.*leta	a*t.*leta	a*d.*leta	a*dl*eta
	-v	+v	+v	'athlete'
b.	a.*pl*audir	a.*p* *l*audir	a.*p* *l*audir	a*pl*audir
	-v	-v+v	-v+v	'applaud'

We see in (6a) that at the point at which final devoicing, or delinking, applies, underlying /t/ has the feature [-voice]. Final delinking removes the voice feature since it is in the rime position of the syllable. Then, default voice applies; this is the rule which supplies sonorants with their [voice] feature. Default assigns the feature

[+voice] to the [l]. After default applies, voicing assimilation spreads the [+voice] from the [l] to the empty position to its left. In this way [t] becomes [d].

In (6b), things are slightly different. We see that when final delinking applies, the [p] is not in rime position so nothing happens. As before, default applies voicing the [l]. When it is time for voicing assimilation, though, there is no target. This is because the [-voice] feature on [p] blocks the spreading of the [+voice] from [l].

On Mascaró's account, final delinking directly "feeds" voicing assimilation. So in (6a), where the obstruent was in the rime and underwent final delinking, we found voicing assimilation. This is because final delinking provided the target for assimilation. In (6b), however, final delinking was not able to apply because the obstruent was in the onset. Therefore no target was created and voicing assimilation was blocked. This is how he accounts for the fact that voicing assimilation always applies across syllable boundaries in Catalan.

We see that voicing assimilation applies after default voice has applied to sonorants. This is because sonorants trigger assimilation. This differs from Dutch in (3) where sonorants do not play a role in voicing assimilation. There it was assumed that assimilation applied before default voice. So we see that languages can differ with respect to the ordering of voicing assimilation and default voice, a point that will be exploited below.

The account in (6) crucially relies on the feature [-voice] to block spreading in (b). Thus, Mascaró's account relies on the feature [voice] being binary. The problem is that recent work on voicing, by Mester & Itô (1989), Cho (1990) and Lombardi (1991), casts doubt on this view of the feature [voice]. These researchers argue that [voice] is a privative feature. This means that there is no phonologically active feature [-voice], only the feature [voice]. If they are correct we have a more restrictive theory since one feature is better than two, and therefore it is worth pursuing. I will give a quick overview of the arguments they discuss.

Laryngeal neutralization usually results in a voiceless segment. Lombardi (1991) points out that if laryngeal neutralization is thought of as delinking of the laryngeal node, it does not make much sense that after delinking, another rule must apply, providing the segment with the feature [-voice]. For example, something I did not mention with respect to the binary voice account in (6), is that after spreading, another default rule must apply to fill in [-voice] on unspecified obstruents. This is to ensure that an utterance-final obstruent is interpreted as [-voice]: for example, in the pronunciation of Catalan 'ca[p]' in isolation. If [voice] is privative, then it follows immediately that a segment with no laryngeal node must be "voiceless".

Another reason to question the existence of [-voice] was noticed by Mester & Itô (1989). Cooccurrence restrictions on [+voice] are quite common; but they are rare, or nonexistent, on [-voice]. If [-voice] is a phonologically active feature we expect it to show cooccurrence restrictions like other features.

A further expectation for [-voice], which is not fulfilled, is that no language has sonorants contrasting for [voice]. If [-voice] is a phonologically active feature, we expect that it might appear on sonorants underlyingly. Lombardi (1991) convincingly shows that the few apparent counterexamples can be better understood as sono-

rants contrasting for aspiration. If [-voice] does not exist then it follows that sonorants cannot have this feature underlyingly.

Cho (1990) discusses a rule in Sanskrit which, like many phonological rules, is sensitive to double-linking of features, that is, inalterability. This rule applies to singly-linked segments but is blocked by doubly-linked segments. So, the output of place assimilation blocks the rule, as does the output of some voicing assimilation. However, interestingly, only the output of [+voice] assimilation blocks this rule. It applies to a voiceless segment in a voiceless consonant cluster. This is mysterious under the theory of binary voicing since both [+voice] consonant clusters and [-voice] consonant clusters should be doubly-linked and block the rule. If [voice] is privative then we can understand why only voiced clusters are linked. Voiceless clusters are simply the result of final delinking. So again, the binary theory makes the wrong predictions.

Finally, [-voice] assimilation, the strongest argument for the phonologically active feature [-voice], can also be handled quite nicely in the theory of privative voicing. As I suggested with respect to the Dutch example (3c), *hui[sk]ammer* (/zk/), if there is no feature [-voice], then final delinking of underlying /z/ results in a surface voiceless consonant cluster. No spreading is needed.

The question then becomes how does the theory of privative voicing handle the cases like those in (6), which crucially rely on the feature [-voice] to block voicing assimilation? I will now discuss one such analysis but will argue that it, too, suffers because it gives up the context free nature of voicing assimilation.

3. Context Sensitive Voicing Assimilation

Lombardi (1991) assumes the basic analysis that we have been discussing. That is, some sort of final delinking rule and context free voicing assimilation as in (1) and (2). Further, she argues for privative voicing, so she cannot use [-voice] to block spreading in Catalan, Cracow, and Sanskrit as in the binary analysis in (6). So, what would she do about these languages? She only specifically addresses this problem with respect to Cracow-Poznań Polish and for this language she assumes that, besides context-free voicing assimilation at the word level, Cracow has a language-specific context-sensitive rule which spreads [voice] across prosodic word boundaries, as in (7a). The same account can be extended to Sanskrit. Further, to account for Catalan, a language-specific context-sensitive rule of voicing assimilation would have to be assumed to apply only across syllable-boundaries as in (7b).

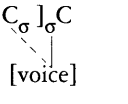
(7) a. Cracow/Sanskrit VA

Word level:

Spread [voice]

Phrase level:

b. Catalan VA



So, Lombardi would have to deal with the problematic cases by assuming special language-specific context-sensitive rules. Notice that [-voice] is no longer needed because the environment for voicing assimilation is stipulated in the rule. Also, note

that for Cracow and Sanskrit, word-level voicing assimilation must apply *before* default voice, since sonorants do not trigger voicing assimilation within words. Phrase-level voicing assimilation must apply *after* default, because both sonorants and obstruents trigger this rule. For Catalan, she must assume that voicing assimilation applies after default, since both sonorants and obstruents trigger it. We see again that languages appear to differ with respect to the ordering of voicing assimilation and default.

There are three simple problems with this account. First, while maintaining privative voicing which, in itself allows a more restrictive theory, by allowing such language-particular formulations of context-sensitive voicing assimilation we lose any restrictiveness we gained by eliminating the feature [-voice] in the first place.

Secondly, unlike Mascaró's account, where final delinking directly fed voicing assimilation by providing a target, it is merely coincidence on Lombardis account that the output of final delinking is the input for voicing assimilation since each is stipulated separately. So, for Catalan, for example, she argues that there is syllable-final delinking of [voice] but she still must stipulate that voicing assimilation spreads into that vacated syllable-final position and no other. This is a suspect redundancy.

Thirdly, the fact that in every case the stipulated environment is a prosodic boundary suggests some generalization is being missed.

What we are left with, then, is two accounts which suffer in different ways: Mascaró's account, which maintains context-free voicing assimilation at the expense of privative voicing, and Lombardis account, which maintains privative voicing at the expense of context-free voicing assimilation. In what follows I will show that it is possible to maintain both context-free voicing assimilation and privative voicing.

4. The Prosodic Cycle

My proposal is simply that voicing assimilation is a rule which applies on prosodic domains, as in the theory of prosodic phonology of Selkirk (1978, 1980, 1986) and Nespor & Vogel (1982, 1986). What makes voicing assimilation different from previously recognized rules of prosodic phonology is that it applies cyclically on successively larger prosodic domains. Then, as a cyclic rule, it is constrained by a version of the Strict Cycle Condition, what I will call the Prosodic Cycle.

This proposal really has two parts: the prosodic phonology part and the cyclic phonology part. The basic idea behind prosodic phonology, as argued in the work of Selkirk and Nespor & Vogel, is that some phonological rules apply on prosodic domains, like syllable (s), prosodic word (w), phonological phrase (F), etc. In fact, their point is that unless these prosodic domains are recognized as domains for rule application, the proper formulation of the phonological rules is impossible. Thus, a rule of prosodic phonology can be stipulated to apply solely within a certain prosodic domain which means it cannot see information in other adjacent domains. A second assumption of prosodic phonology is that prosodic constituents obey the prosodic hierarchy. That means they are arranged hierarchically and each is exhaustively included within a superordinate constituent. So, for example, all syllables are

dominated by prosodic words and all prosodic words are dominated by phonological phrases, etc. (e.g. $[_{\phi}[_{\omega}[_{\sigma}X]]]$).

My proposal is that voicing assimilation is a rule which applies on prosodic domains, but one which applies cyclically. That means that it applies on the syllable domain then on the prosodic word domain then on the phonological phrase domain, etc. As a cyclic rule, however, it must obey the prosodic version of the Strict Cycle Condition, which I formulate in (8).

(8) Prosodic Cycle (PC) (adapted from Mascaró 1976, Kiparsky 1982):
   a. Cyclic rules apply only to derived representations.
   b. Def.: A representation γ is *derived* w.r.t. rule R in cycle j iff g meets the structural analysis of R by virtue of information introduced on j not available on cycle j-1.

The Prosodic Cycle simply states that cyclic rules must apply to derived representations. A representation is derived if on a particular cycle, the structural description for a cyclic rule is met by virtue of new information introduced on that cycle. An example is given in (9).

(9) Rule R: A « B / __ C
   a. Cycle 1, apply R: $[_{\delta}[_{\alpha} \ldots A_1\ C_1 \ldots A_2][_{\beta}\ C_2 \ldots]]$
   b. Cycle 2, apply R: $[_{\delta} \ldots A_1\ C_1 \ldots B\ C_2 \ldots]$

Given the cyclic rule R, if we are given the representation in (a), on the first cycle nothing happens. A_1 and C_1 do not involve new information. A_2 and C_2, of course, cannot see each other yet because they are in different domains. On the second cycle, again A_1 and C_1 do not undergo the rule R for the reasons just given. But now, on this cycle, A_2 and C_2 can see each other so R can apply changing A_2 to B.

The basic intuition is that while R is applying to a it cannot see information in adjacent domain β. When R is applying on superordinate domain δ, it can now see into both domains α and β simultaneously— the new environment created is eligible for R to apply to. However, R cannot go back into α or β to apply to either of them alone.

I share with Mascaró and Lombardi one other assumption, which is argued for in detail in Myers (1987). I assume that languages can differ as to "when" default rules apply; in this case when default [voice] applies to sonorants. In fact, that turns out to be *the* relevant difference between Catalan on the one hand and Cracow and Sanskrit on the other. This assumption combined with the proposal that voicing assimilation is a cyclic rule of prosodic phonology derives the problematic blocking effects found in Catalan, Cracow and Sanskrit. (10) illustrates the basic surface configurations we are concerned with.

(10) Abstract Surface Configurations (p a prosodic domain):

a. Rule application okay:	b. Rule application blocked:
$[_{\pi} \ldots][_{\pi} \ldots]$	$[_{\pi} \ldots\ldots]$

Rule application is allowed across a certain prosodic boundary as in (a) but it is blocked from applying solely within that domain as in (b).

Starting with Catalan, the basic analysis is that voicing assimilation applies cyclically, starting with the syllable. Default [voice] applies to sonorants fairly early on in Catalan: at the prosodic word-level. This creates Prosodic Cycle effects showing up on the syllable.

(11) - VA applies cyclically on prosodic domains, starting with s.
- default applies early on (ω-level).
- PC ("strict cycle") effects are found on the σ.

	VA on σ	Default	VA on ω	Surface
a.	((a*t*)(*l*e)(ta))	(a*tl*eta)	(a*d l*eta)	a*dl*eta
	|	|	\/	'athlete'
		v	v	
b.	((a)(*pl*au)(dir))	(a*pl*audir)	(a*pl*audir)	a*pl*audir
		|	|	'applaud'
		v	v	

In (11a), underlyingly neither [t] nor [l] has any [voice] feature so on the syllable cycle, there is no [voice] to spread and nothing happens. Besides that fact, [t] and [l] are in different syllables so they are invisible to each other on that cycle. After the syllable cycle, default [voice] applies. This assigns [voice] to [l]. On the prosodic word cycle, voicing assimilation applies again, which means [voice] tries to spread. We now have the perfect environment: [l] has a [voice] feature and [t] is an available target. Most importantly, [t] and [l] are visible to each other *on this cycle* since before they were separated by a syllable boundary. Therefore, they count as "new information" to each other. So, [l] spreads its [voice] feature to [t] deriving the correct form 'a[dl]eta'.

In (11b) there is a difference. Working through the derivation we see that, underlyingly, both [p] and [l] are unspecified for [voice]. On the syllable cycle, then, voicing assimilation applies. Nothing is there to spread so nothing happens. Default applies, voicing [l]. On the prosodic word-cycle, voicing assimilation again applies. While there is a [voice] feature present to spread, spreading would be a violation of the Prosodic Cycle. This is because such spreading would be entirely within the syllable, a domain already cycled out of. Thus, voicing assimilation is blocked from applying; [p] remains [p] and we get the correct surface form, *a[pl]audir*.

The analysis of Cracow works the same. The only relevant difference is at what point in the derivation default applies. In Cracow, this is at the phonological phrase level, which creates Prosodic Cycle effects on the prosodic word.

(12) Cracow-Poznań Polish:
- VA applies cyclically, as in Catalan.
- default applies later (Φ-level).
- PC effects are found on the ω.

	VA on σ	VA on ω	default	VA on Φ
a.	(((ja*k*))((*ń*i)(dy)))	((ja*k*)(*ń*idy))	(ja*kń*idy)	(ja*g ń*idy)
			|	\/
			v	v
b.	(((pi*s*)(*m*o)))	((pi*sm*o))	(pi*sm*o)	(pi*sm*o)
			|	|
			v	v

Surface: (a) ja[gń]idy 'as never'; (b) pi[sm]o' writing'.

In (12a), voicing assimilation applies on the syllable and prosodic word cycles with no effects since [n] is not yet voiced and [k] and [n] are still invisible to each other. After the prosodic word cycle, default applies, assigning the feature [voice] to [n!]. On the phonological phrase cycle of voicing assimilation, [k] and [n] are now visible to each other and [n] is voiced so spreading applies. [k] becomes [g] and we derive the correct result.

(12b) begins the same way: voicing assimilation applies on the syllable and the word with no effect. After default applies, voicing [m], voicing assimilation applies on the phonological phrase level. However, it is blocked from spreading from [m] to [s] because that would violate the Prosodic Cycle. [m] and [s] are in the same domain, the prosodic word, which voicing assimilation has already affected. Thus, [s] remains voiceless and the word-internal contrast is maintained.

We can see that the Sanskrit derivation in (13) proceeds like the Cracow one:

(13) Sanskrit:
- VA applies cyclically.
- default applies at the Φ-level.
- PC effects found on the ω.

	VA on σ	VA on ω	default	VA on Φ
a.	(((ta*t*))((*n*a)(mas)))	((ta*t*)(*n*amas))	(ta*t*namas)	(ta*d* namas)
			v	v
b.	(((va*c*)(*y*a))	((va*c*ya))	(va*c*ya)	(va*c*ya)
			v	v

What makes this account different and preferable to previous accounts is that the only relevant difference between Catalan, on the one hand, and Cracow and Sanskrit, on the other, is reduced to at what stage in the derivation VA interacts with default [voice]; this difference is derived from cross-linguistic variation of default rule application, an independently supported and perhaps easily parametrizable notion (Myers 1987). There is no need for language-specific context-sensitive rules and privative [voice] is maintained.

Now, if voicing assimilation were the only phonological rule found to apply cyclically on prosodic domains, we would find little justification for something like the Prosodic Cycle. In the following section I will outline one of at least two other cases I have found, of phonological rules which apply cyclically on prosodic domains and for which something like the Prosodic Cycle is required in order to derive the correct results.

5. Independent Evidence for the Prosodic Cycle

Welden (1977) discusses syncope in Cairo Arabic. This is a rule which deletes an unstressed high vowel in a doubly-open syllable (VC_CV). According to Welden, syncope behaves differently depending on whether it applies at the word level or the phrase level.

(14) a. Word-level
- only [i] deletes
- must precede stress assignment

fih*i*m+it	→ fihmit	'she understood'
š aay*i*f+u	→ šayfu	'he sees him'
kut*u*b+i	→ *kutbi	'my books'

b. Phrase-level
- both [i] and [u] delete
- must follow stress assignment

9andaha k*i*taab	→ 9andaha ktaab	'she has a book'
fi k*u*tub+ha	→ fi ktubha	'in her books'

As illustrated in (14a), word-level syncope deletes only [i] and must precede stress assignment (see Welden 1977: 165). In (14b) we see that phrase-level syncope affects both [i] and [u] and this time it must follow stress assignment (p. 165). To account for these differences, Welden assumes there are two different rules applying at different levels: one rule applying at the word-level and deleting only [i] and a second rule at the phrase level which deletes both [i] and [u]. Crucially, her formulation of phrase-level syncope must include word boundaries to block it from reapplying solely within a word. In other words, she writes the strict cycle effects directly into the phrase-level rule, analogously to Lombardi's formulations of voicing assimilation.

However, if syncope is a cyclic rule which applies on prosodic domains, then with one other assumption, the correct effects are derived and the analysis is greatly simplified. Syncope deletes [+high] vowels. We assume that underlying [i] is [+high] but that underlying [u] is not marked [+high] underlyingly, perhaps distinctively marked as [+round]. Then only [i] is elegible for syncope on the word-cycle. [u], since it has no [+high] feature, is invisible to syncope at this level. Later, [u] has its height filled in by default and phrase level syncope affects both [i] and [u], that is, all [+high] vowels. Crucially, after [u] is assigned the feature [+high], it cannot then undergo "word-level" syncope. That is, syncope on the phrase level obeys the Prosodic Cycle by not applying to domains it has already affected.

So, the miniconclusion, after looking at Cairo Arabic syncope, is that the Prosodic Cycle is independently needed for phonological rules other than voicing assimilation. This provides independent evidence for the account of voicing assimilation given above.

6. Conclusions

The analysis presented above supports the following conclusions: voicing assimilation is the context-free rule "spread [voice]", which applies cyclically on prosodic domains; the Prosodic Cycle constrains cyclic rule application in prosodic phonology; and the more restrictive theory of [voice] can be maintained: [voice] is a privative feature.

These conclusions leave open a number of interesting questions, however: (i) is the PC reducible to the SCC?, (ii) why is prosodic phonology cyclic? and (iii) how

does prosodic phonology interact with lexical phonology? While I do not have space here to do these questions justice, I will speculate a bit about the directions we can look in for the answers.

A recent version of the SCC, that of Kiparsky (1985), is stipulated to constrain cyclic rules in lexical phonology only (p. 89). On his view however, only lexical phonological rules are cyclic, so the requirement that the SCC constrain only those (lexical rules) is redundant. If that stipulation is removed, we could have a SCC more like the PC advocated here: a general constraint on cyclic phonological rules. I suggest, then, that there is just one SCC which constrains all cyclic phonology.

Why is prosodic phonology cyclic? If Kiparsky (1985) is correct, the reason that lexical phonology is cyclic is that phonological rules are "sandwiched" in between cyclic morphological structure building operations, we could extend the analogy between lexical and prosodic phonology in the following way: as in lexical phonology, prosodic phonological rules are in some sense "sandwiched" in between prosodic structure building operations. Thus, syllables are built, some phonology applies; words are built, some more phonology applies, etc. This would derive the cyclicity of prosodic phonology in the same natural way it is derived in lexical phonology.

How lexical phonology and prosodic phonology interact seems to be the most interesting and puzzling question this study leaves us with. The claim made here, that default rules may apply at different stages in the prosodic derivation in different languages, suggests that perhaps the interaction between lexical and prosodic phonology differs from language to language; thus, one language may "do" e.g. syllable-level phonology while certain lexical information is still underspecified, while another language may have filled in such lexical information before applying syllable-level rules. In some sense the lexical and prosodic derivations can coincide in different ways depending on the language. I leave these interesting issues open for future research in hopes that the questions having at least been asked, some progress has been made.

References

Cho, Y.-M.Y., 1990, "A typology of voicing assimilation", in *Proceedings of the Ninth West Coast Conference on Formal Linguistics*, 141-155, Stanford Linguistics Association, Stanford.

Gussmann, E., 1992, "Resyllabification and delinking: The case of Polish voicing", *LI* 23.1, 29-56.

Kiparsky, P., 1982, "Lexical morphology and phonology", in I.-S. Yang (ed.), *Linguistics in the Morning Calm*, 3-91, Hanshin, Seoul.

———, 1985, "Some consequences of lexical Phonology", *Phonology Yearbook* 2, 85-138.

Lombardi, L., 1991, Ph.D. dissertation, U. Mass.-Amherst, G.L.S.A.

Mascaró, J., 1976, *Catalan phonology and the phonological cycle*, Ph.D. dissertation, MIT.

———, 1987, "A reduction and spreading theory of assimilatory processes", ms., Universitat Autònoma de Barcelona.

Mester, R.A. & J. Itô, 1989, "Feature predictability and underspecification: palatal prosody in Japanese mimetics", *Lg* 65, 258-293.

Myers, S., 1987, *Tone and the structure of words in Shona*, Ph.D. dissertation, U. Mass.-Amherst, G.L.S.A.

Nespor, M. & I. Vogel, 1982, "Prosodic domains of external sandhi rules", in H. van der Hulst & N. Smith (eds.), *The structure of phonological representations* (Part 1), 225-55, Foris, Dordrecht.

———, 1986, *Prosodic phonology*, Foris, Dordrecht.

Selkirk, E. O., 1978, "On prosodic structure and its relation to syntactic structure", in T. Fretheim (ed.), *Nordic prosody II*, Trondheim: TAPIR, 111-140 (1981).

———, 1980, "Prosodic domains in phonology: Sanskrit Revisited", in M. Aronoff & M.-L. Kean (eds.), *Juncture (Studia linguistica et philologica 7)*, 107-29, Anma Libri, Saratoga, California.

———, 1986, "On derived domains in sentence phonology", *Phonology Yearbook* 3, 371-405.

Welden, E, 1977, *Prosodic aspects of Cairo Arabic phonology*, Ph.D. dissertation, U. Texas, Austin.